MAY 2024 | VOLUME 04 | ISSUE 05

(ISBN : 978-81-965582-9-1)

AgriGate

GROW WITH EVERY PAGE!

An International Multidisciplinary Monthly e-Magazine

Dedicating our workers day to one of the most important links in the value chain, Our farmers,

Happy Workers' Day

without them we would definitely go hungry.

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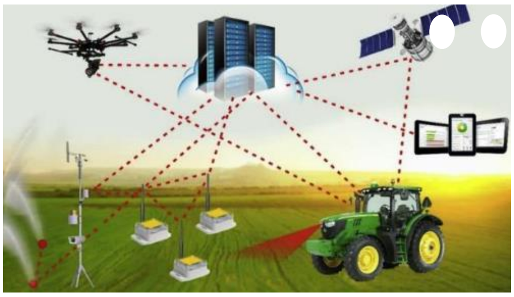

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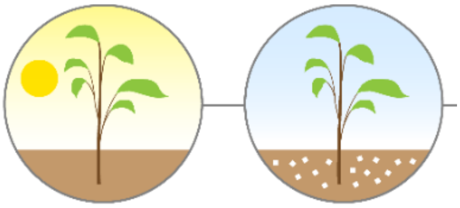

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From the Desk of Editor-in-chief

May 2024|Vol. No. 04 |Issue No. 05

I would like to introduce the launch of **"AgriGate - An International Multidisciplinary Monthly e-Magazine Volume 04 Issue No. 05 – May 2024"** with immense pleasure. Our team is privileged to dedicate this issue to **Mothers**. **International Mother's Day** is celebrated on 12th May of every year to honour and show appreciation towards loving and caring mothers of the whole world. The **International Day of plant health** falls on same day of May in every year. This day observes various events and programs to raise awareness about plant health for food protection, economic development and a sustainable environment.

The main objective of the magazine is to provide a publishing platform to young researchers and scientists as well as an information hub for the enthusiast, progressive farmer and also common readers. We envisage providing an online platform that appreciates illuminating articles on various topics related to agriculture and allied sciences monthly that will appraise and update the students, farming community and the whole society at large on the updates in agriculture.

Last but not the least, I wholeheartedly thank the editorial team, authors as well as anonymous reviewers for contributing to the release of this issue.

Our team welcomes your constructive feedback and suggestions to improve delivering fruitful content to hungry minds.

Dr R Shiv Ramakrishnan
Editor-in-chief
AgriGate Magazine

Volume: 04 Issue No: 05

GREEN MANURING FOR SUSTAINABLE AND CLIMATE SMART AGRICULTURE

Article ID: AG-VO4-I05-01

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Introduction

Improved soil nutrient availability, physio-chemical and biological properties, carbon capture and sequestration, soil retention, water retention, habitat provision for biodiversity, and sustainable food production are just a few of the environmental and economic benefits that green manuring can offer, particularly in areas where soil qualities are marginal for crop production. Due to the heavy reliance on chemical pesticides and fertilizers, extensive agricultural growth has resulted in grave issues with limited soil microbial diversity and poor soil health. It is necessary to increase farmers' willingness to grow green manuring crops through incentives, education, and awareness, as this willingness has decreased over the past few decades.

Green manuring

There are two types of green manuring procedures that are extensively used: (1) on-site (in situ) green manuring and (2) green leaf manure. The first is a way of cultivating short-lived plants on the agricultural field and mulching them onsite within 60-80 days of growth. The second method involves bringing leaves or young shoots of shrubs or trees planted along borders or in waste areas to the land, applying them to the soil, and mulching them before crop production.

Ecological fertilizer

Any green manure crop can be ploughed beneath or added to the soil by green manuring. In Punjab, green manure crops such sunhemp, dhaincha, cowpea, and mungbean are frequently planted. Table 1 lists the nutritional levels of many green manure crops that are frequently grown in Punjab.

Table 1: Nutrient content of different green manure crops commonly grown

Crop	**Botanical Name**	**Green biomass production (q acre-1)**	**Nutrient content (%) on air dry basis**		
			N	**P**	**K**
Sunnhemp	*Crotolaria juncea*	60- 80	2.30	0.50	1.80
Dhaincha	Sesbania bispinosa	80-100	3.50	0.60	1.20
Cowpea	Vigna unguiculata	80-100	1.70	0.28	1.25

Productivity of different crops of green manure depends on climate, crop growth and cultivation activity, Productivity of different crops for green manure in Uttar Pradesh is given in following Table 2

Crop	**Quantity of Green Material (Ton/ha.)**	**Nitrogen Percentage**	**Nitrogen Percentage (kg/ha.)**
Sanai	*20-30*	*0.43*	*86-129*
Dhaincha	*20-25*	*0.42*	*84-105*
Urad	*10-12*	*0.41*	*41-49*
Moong	*8-10*	*0.48*	*38-48*
Gwar	*20-25*	*0.34*	*68-85*
Cow Pea (Lobhiya)	*15-18*	*0.49*	*74-88*
Kulthi	*8-10*	*0.33*	*26-33*
Nile	*8-10*	*0.78*	*62-78*

Which crops to use with green manuring?

1. Leguminous crops such as jantar/dhaincha, sunhemp, cowpea, moong, mash, etc. are the best choice for green manuring. These crops' roots include nodules that can draw nitrogen from the atmosphere and store it in the soil.

2. The crop of green manure ought to be expanding quickly and yielding more organic matter.
3. The crop of green manure needs deep roots in order to draw nutrients that have been placed deep down into the upper layer.
4. Crops grown with green manure ought to require less water.

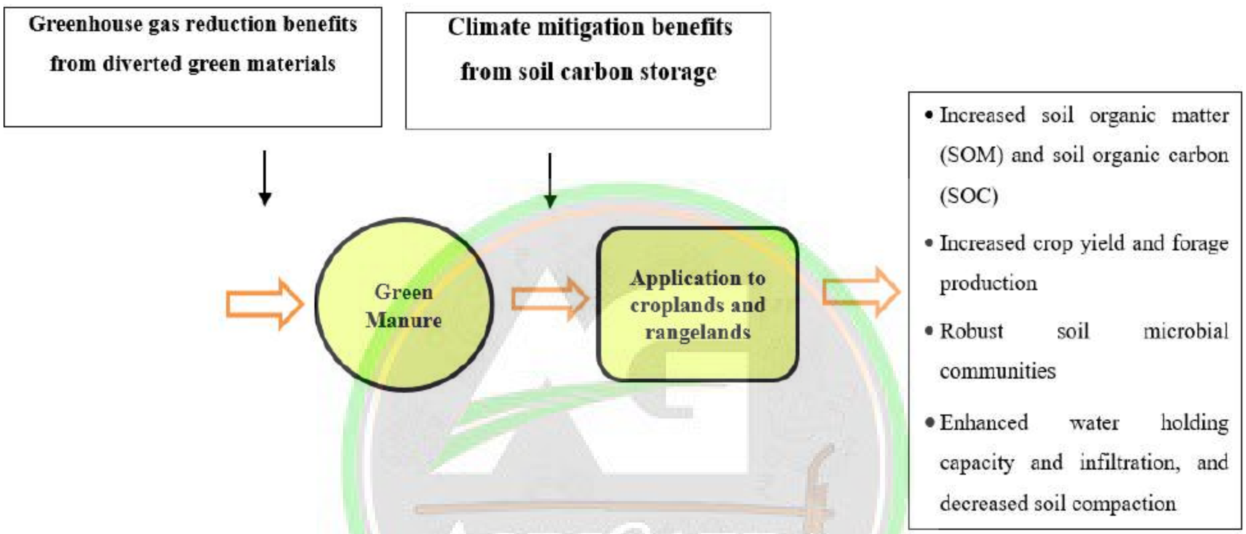
Green manure in sustainable agriculture

Using green manure as an alternative to artificial fertilizers is critical for sustainable agriculture. Green manure, an exciting aspect of sustainable agriculture, can help market gardeners, home gardeners, and large agricultural enterprises alike. Market gardeners must make the most of their soil while increasing its health because they typically aim to maximize productivity on a small plot of land. Small-scale market gardeners are not the only ones that use green manure. On larger farms, it can also be used to improve soil health and productivity. Sustainable production methods are part of organic agriculture, and they help to restore the natural balance that has been disrupted by poor farming practices. It is a distinct style of agriculture that achieves soil fertility through green manuring and crop rotation as opposed to synthetic chemical pesticides and fertilizers, which are environmentally hazardous agricultural production inputs. Using green manure on agricultural areas has numerous economic and environmental benefits. Green manure solutions must be used as a new agricultural approach to ensure long-term growth. Green manure technologies have been shown to provide farmers with a variety of benefits, including financial rewards, carbon sequestration, nitrogen fixation, increased SOC content, biodiversity protection, and so on. High ecosystem service values and low farmer economic earnings may encourage widespread adoption of an ecological compensation system as a new method for sustainable farming.

Soil deterioration is a significant impediment to plant growth and increased productivity. Agrochemicals such as pesticides and fertilizers are the primary causes of soil degradation. Agrochemical accumulation pollutes the environment and poses health dangers. The loss of organic matter, the accumulation of contaminants in the soil, the fall in crop yield, and the loss of soil fertility are all examples of soil quality deterioration. Agriculture's future seems dismal due to extensive tillage, continuous cropping, and significant pesticide use. To combat soil deterioration and achieve sustainable agriculture, we must use green manure, vermicompost, compost, bio fertilizers, amrit-jal, vermiwash, and other methods. Green manuring is one of the most effective ways to improve soil health and meet future crop nutritional needs.

Green manure in climate smart agriculture:

- Diverting green manure to reduce greenhouse gas emissions
- Green manuring can lower nitrate production and pollution.
- Green manure properly at high temperatures can kill pathogens.
- Green manure that may otherwise create negative environmental impacts such as surface water pollution.



Advice for growing green manure

For green manuring under Punjabi conditions, Punjab Agricultural University, Ludhiana, has recommended the Punjab Dhaincha-1 variety of dhaincha; PAU 1691 and Narinder Saini-1 of sunhemp; and CL-367 and cowpea-88 of cowpea types. Green manure crops are sown after 20 kg of sunhemp or dhaincha or 12 kg of cowpea seeds that have been steeped in water for eight hours. To maximize the benefits of green manuring in low-phosphorus fields, fertilize with phosphorus at the time of green manure crop sowing (75 kg of single superphosphate per acre), rather than paddy fields. It also increases the soil's ability to fix nitrogen, which promotes the growth of green manure crops. When the crop begins to flower approximately 6–8 weeks after sowing, the green manure crop is ripe and requires about 3–4 irrigations. By June 10-15, the crop that was sowed between April and May is ready to be picked. Use a rotavator to plough the green manure crop one day prior to paddy transplantation and ten days prior to maize seeding.

Multipurpose use	Wider ecological adaptability	Fast growing and short duration
Tolerance to shade, flood, drought	Tolerance to adverse temperatures	Timely release of nutrients
Photoperiod insensitivity	Pest and disease resistance	High seed viability
High seed production	High N accumulation rates	High N sinks in underground plant parts
Efficiency in use of water	Early onset of biological N-fixation	Easy to incorporation

Figure 1. Desirable Characteristics of Green Manuring Crops

Advantages of green manuring

1. One affordable and efficient method of enhancing soil health is by green manuring.
2. Green manuring lessens soil erosion and enhances soil structure and water-holding ability.
3. Green manuring increases the concentration of plant nutrients in the surface soil, increases the availability of nutrients in the soil, and encourages a deeper root system for nutrient uptake.
4. Adding 6-7week-old cowpeas, dhaincha, or sunhemp 1-2 days prior to paddy transplanting in the second week of June helps save around 25 kg of nitrogen per acre for rice.
5. Green manuring lessens the weed issue for crops that come after.
6. Alkaline soil reclamation is aided by green manuring.
7. Green manuring is a useful tool for controlling root knot nematodes.

Limitations to cultivating green manure crops:

1. Farmers in intensive farming systems may not want to dedicate 6-8 weeks to planting green manure crops.
2. Lack of water supplies/resources.
3. Lack of good quality
4. Farmers in areas where rice is grown after wheat face challenges due to photoperiodism sensitivity during the peak summer months of May and June.
5. Green manure crop seeds do not germinate well, and incorporation may be challenging and expensive.
6. Farmers are hesitant to use organic fertilizers because to their less rapid impact.

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DIFFERENT PLANTING SYSTEMS OR LAYOUTS OF HORTICULTURAL ORCHARDS/PLANTS

Article ID: AG-VO4-I05-02

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Introduction

The arrangement of plants in a systematic form for facilitate the various practices such as weeding, fertilization and spraying etc which are essential for the plants to successfully grow.

Different systems of planting

1. **Vertical row planting system**
   - ✓ Square system
   - ✓ Rectangular system
   - ✓ Cluster system
2. **Alternate row planting pattern**
   - ✓ Triangular system
   - ✓ Quincunx system
   - ✓ Hexagonal system
   - ✓ Contour system
3. **Free style system**

Square system of planting

It is most common and easiest system of planting. In this system, plant to plant and row to row distance is kept similar. The plants are planted at each corner of the squares.

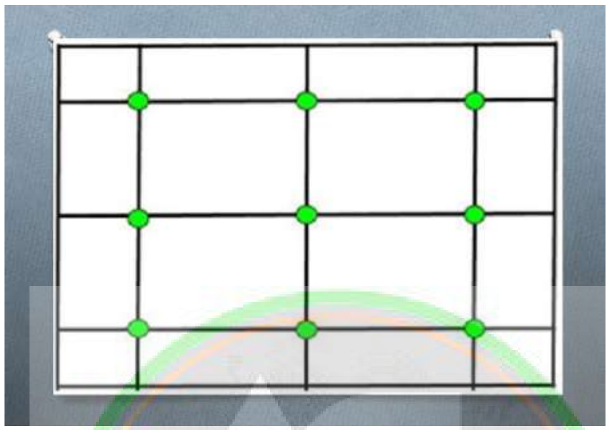
$$\text{Total number of plants} = \frac{\text{Total Area of the land}}{\text{Plant to Plant distance} \times \text{Row to Row distance}}$$

Advantages

- It is one of the most easy and cheapest systems of planting.
- Intercultural practices can be done in both directions.

Disadvantage

The centre of the square remains unutilized.



Square system of planting

Rectangular system of planting

It is just similar to square system but in this system, row to row distance is kept more than plant to plant distance. The plot is divided into rectangles instead of squares. The plants are planted at each corner of the rectangles.

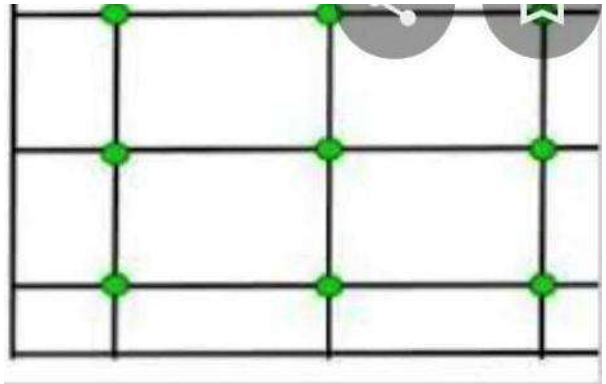
$$\text{Total number of plants} = \frac{\text{Total Area of the land}}{\text{Plant to Plant distance} \times \text{Row to Row distance}}$$

Advantages

- It is also simple and easiest system of planting.
- More space between rows to rows.
- Plants get proper space and sunlight.
- Highly used in HDP.

Disadvantage

A greater loss of income in case of no practice of intercropping is disadvantage of this system.



Rectangular system of planting

Cluster system-Accommodates almost twice number of plants than square system.

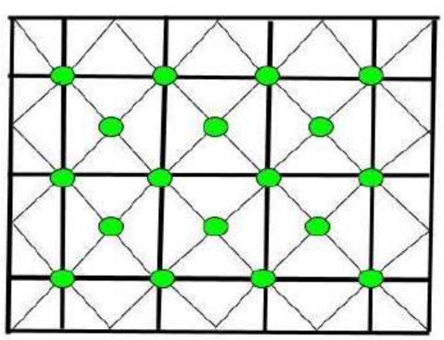
Quincunx system of planting

It is also known as diagonal and filler system of planting. It is just similar to the square system except an additional plant is planted at the centre of square. The main crop is called primary crop and filler crop is called secondary or supplementary crop. Fruit plants such as papaya, phalsa, banana, kinnow, guava, peach, pomegranate and plum are planted as filler/additional crop. In this system, we can get almost double of plants than square system.

$$\text{Total number of plants}=2\times\left\{\frac{\text{Total Area of the land}}{\text{Plant to Plant distance}\times\text{Row to Row distance}}\right\}$$

Advantages

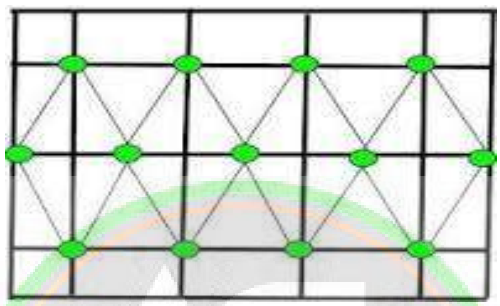
- Generate of additional income.
- Proper utilization of space.



Quincunx system of planting

Triangular system of planting

It is based on the principle of isolateral triangle. It is also similar to the square system except the plants are planted in the alternate rows in the middle of the two corners of the square. In this system, we can accommodate slightly lesser number of plants (11 per cent) than square system. Economically it is not beneficial and layout is very difficult to prepare. Intercultural practices are also very difficult in this system. It is mostly used for High Density of Planting (Ex. Mango cv. Amrapali)



Triangular system of planting

Hexagonal system of planting

It is also known as septule system or equilateral system of planting. In this system, the plants are planted at the corners of the triangles having all sides equal in length. The one corner of six equilateral triangles (uniform in length) meets at a point and forms hexagon. The seventh plants we can be planted at the middle of triangle.

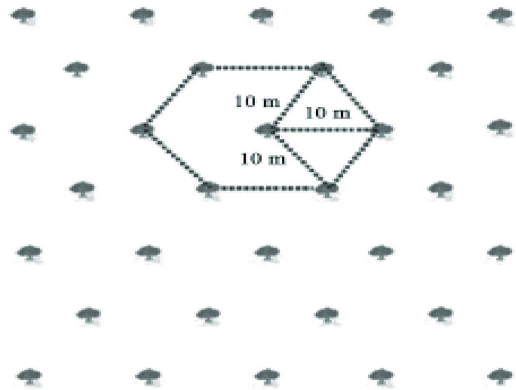
Features

- It is very difficult layout to prepare.
- It is mainly used where land is so costly.
- It is mainly used near at city.
- 15 per cent more plants can be accommodate than square system.

$$\text{Total number of plants} = \frac{\text{Total Area of the land}}{\text{Area occupied a single plant}}$$

Area occupied a single plant= $3/4 \times A^2 \times 2$

Where A is spacing between plants/length of a side of triangle.



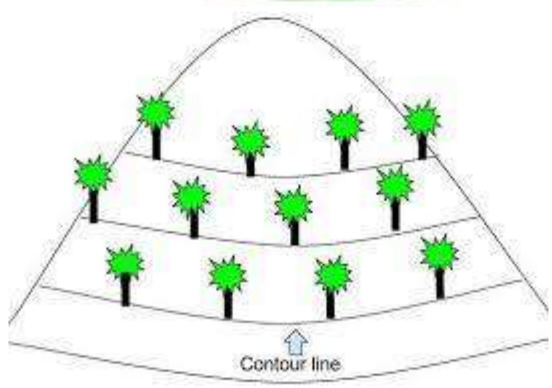
Hexagonal system of planting

Contour system of planting

It is mainly applied in hilly areas or where slope is more than 10 per cent. This system is useful for minimize the soil erosion.

$$\text{Total number of plants} = \frac{N \times \text{Unit area}}{D\,(H+V)}$$

Where, N = Number of hedges
D= Distance between plants
H= Distance between hedges
V= Vertical distance between rows



Contour system of planting

Free style system of planting

It is also known as wild style system of planting. If the plants are planted without following any regular geometrical layout or design then it is consider as free style system of planting. For example Homestead lands, public land and waste lands etc.

NOTE- Single Hedge Planting System-Apple and Pineapple
Double hedge planting system-Pineapple

AgriGate- An International Multidisciplinary e-Magazine

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ADVANCES IN GRAFTING TECHNIQUES IN VEGETABLE CROPS FOR HIGHER PRODUCTIVITY

Article ID: AG-VO4-I05-03

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Introduction

'Grafting is a technique of uniting two living plant parts to grow as a single plant'. It is a method of asexual plant propagation widely used in agriculture sector, where the tissues of one plant are encouraged to fuse with those of another. Grafting is most commonly used for the propagation of trees and shrubs grown commercially. In most of the cases, one plant is selected for its roots, which is called as rootstock, while other plant is selected for its stems, leaves, flowers, or fruits and is called as scion. The scion contains the desired genes to be duplicated in future production by the stock/scion plant. Grafting can be practiced in a number of vegetable crops. However, because of the added expense, it is typically associated with cucurbits and members of the Solanaceae family such as brinjal and tomato.

History of vegetable grafting

Grafting of woody plants has been common for centuries, but herbaceous grafting has only become popular recently in agricultural system. The cultivation of grafted vegetable plants began in Korea and Japan at the end of the 1920's when watermelon plants were grafted onto squash rootstock. Since this time, this technique has spreaded throughout Asia and Europe.

Currently, 81% of Korean and 54% of Japanese practice grafted vegetable cultivation. The use of this cultural technique is mainly carried out for intensive cropping systems like greenhouse and tunnel production. This technique is especially popular for vegetable production in the orient and has moved to the Mediterranean region as well, where the use of grafting has been proposed as a major component of an integrated management strategy for managing soil borne diseases and increasing crop productivity. Tomato grafting became popular in the 1960's as a way to reduce certain diseases caused by soil borne plant pathogens such as *Raletonia solanacearum*. Grafted tomato transplant production has increased in Spain from less than one million plants in 1999-2000 to over 45 million plants in 2003-2004. Grafted tomato is also cultivated in France and Italy, and over 20 million tomato plants were grafted in Morocco in 2004 as a way to reduce soil borne disease and increase crop production. The ratio of the production area using grafted plants to the total production area in Japan is 90% for water melon and cucumber, 79% for brinjal and 58% for tomato as per the survey reported by the Japanese government in 2011. In India, grafting work has been started in IIHR Bangalore to select best rootstocks for water logged conditions by Dr RM Bhatt and his associates. The Momordica cochinchinensis, a dioecious vegetable crop is being utilizing for grafting with male as rootstock and female plant as scion in the NBPGR regional station, Trissur, Kerala. CSKHPKV, Palampur has also initiated work on vegetable grafting and identified more than 22 rootstocks of tomato, brinjal, chilli, and cucurbits for importing resistance to bacterial wilt and nematodes. At present, grafting is used to offer not only protection from certain diseases, but also tolerance to abiotic stress like flooding, drought and salinity.

Objectives of vegetable grafting

The main objective of vegetable grafting is to control soil borne diseases and improving abiotic stress tolerance in the production of tomato (Solanum lycopersicum L.), brinjal (Solanum melongena L.), pepper (Capsicum annuum L.), watermelon (Citrullus lanatus [Thunb.] Matsum. & Nakai), muskmelon (Cucumis melo L.) and cucumber (Cucumis sativus L.) in many areas of Asia and Europe (Lee and Oda 2002; Lee et al. 2010; Louws et al. 2010).

Detail of the objectives of grafting for some vegetable crops is listed as below***:***

Crop	**Objectives**
Cucumber	Tolerance to Fusarium wilt and low temperature

Melons	Tolerance to Fusarium wilt, Phytophthora disease, wilting due to physiological disorders, low temperature and drought tolerance
Tomato	Tolerance to Bacterial wilt and nematodes
Brinjal	Tolerance to Bacterial wilt, nematodes and low temperature

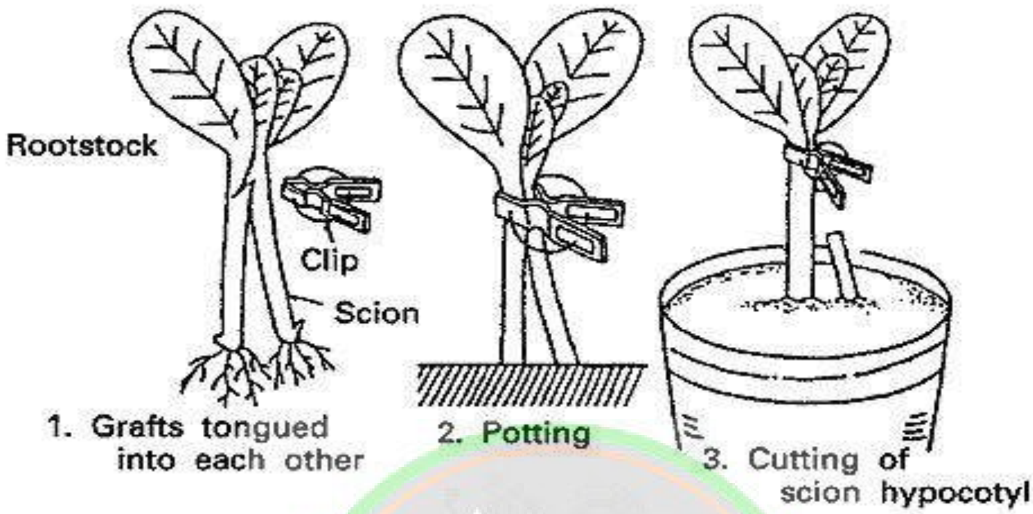
Importance/Advantages of using grafted plants

1. The primary advantage of grafting for vegetable production is that you can utilize particular rootstocks that reduce the likelihood of infection by a pathogen, are tolerant of certain abiotic stresses, or can add to plant vigor and ultimately higher fruit yield.
2. This technique can be effective against a variety of fungal, bacterial, viral and nematode diseases.
3. Grafting has been highly effective at overcoming abiotic stresses such as soil salinity, temperature extremes and excessive soil moisture.
4. Grafting has also been utilized in order to reduce the effects of flooding in areas where a wet season may occur.
5. Grafting with tolerant rootstock has been highly effective at producing a saline-tolerant plant and research indicates that several rootstocks prevented the translocation of sodium and chloride into the shoot.
6. Many of the most economically important vegetable crops like tomato, squash, cucumber, and watermelon are highly sensitive to thermal stress in the roots throughout vegetative development and reproduction. Whether using rootstock tolerant of hot or cold temperatures, the use of heat- or cold-tolerant resistant rootstock could lead to the extension of the growing season in either direction, resulting in better yield and economic stability through the year.
7. Research has shown that possible mechanisms for increased yield are likely due to increased water and nutrient uptake among vigorous rootstock genotypes.
8. Stomatal conductance was improved in tomato when grafted onto vigorous rootstock.
9. Nutrient uptake for macronutrients such as phosphorus and nitrogen was also enhanced by grafting.

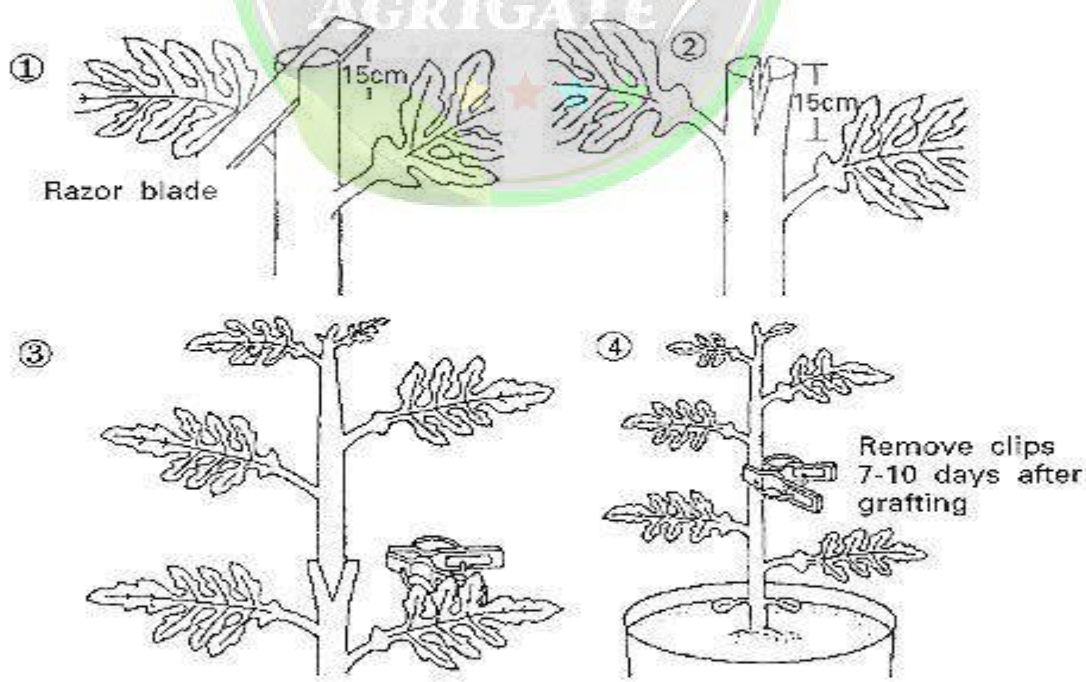
Grafting methods for different types of fruit-bearing vegetables

1. Tomato

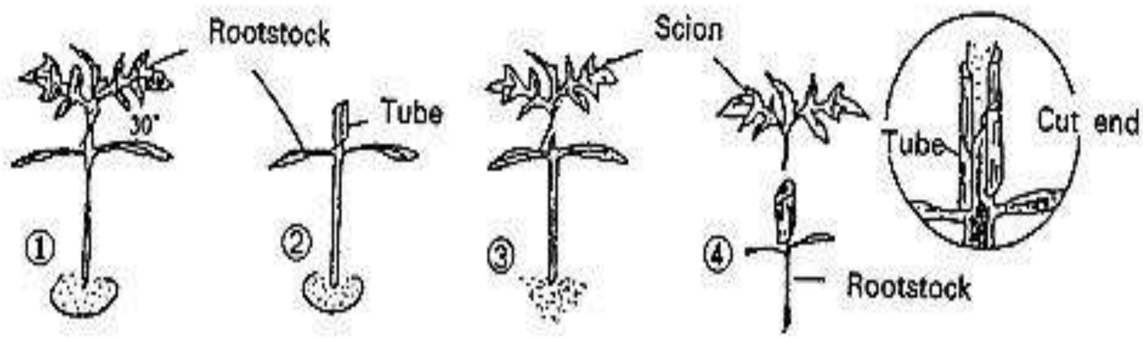
Approach/tongue Grafting: It is done by cutting opposing and complementary notches in the stem of the rootstock and scion. The complementary notches are fit together and held with a spring clip or some type of tape. Once the graft union has healed, the root system is cut from the scion plant and the shoot is removed from the rootstock plant.



Cleft Grafting: It is carried out when the plants are slightly larger and a V-shaped cut is made in the stem of the scion. The scion is then inserted into the rootstock, which has a vertical slice cut down the center of the stem. The rootstock and scion are then held together by a spring clip while the graft union forms.



Tube Grafting or **Japanese Top-Grafting:** This technique is carried out when the plants are very small and the rootstock and scion are held together with a 1.5–2 mm silicone clip or tube.



2. Brinjal

Eggplant is grafted mainly by cleft or tube grafting. The growth rate differs according to the species of rootstock used. The number of days from sowing to grafting varies accordingly.

Cleft Grafting: Cleft grafting of eggplant is a similar process to that done for tomato.

Tube Grafting: The time schedule and grafting methods for tube grafting of brinjal are similar to those used for tomato plants. However, the seeds of *S. torvum* must be sown a few days earlier than those of the other rootstock species.

Cucurbits

Approach/Tongue Grafting:

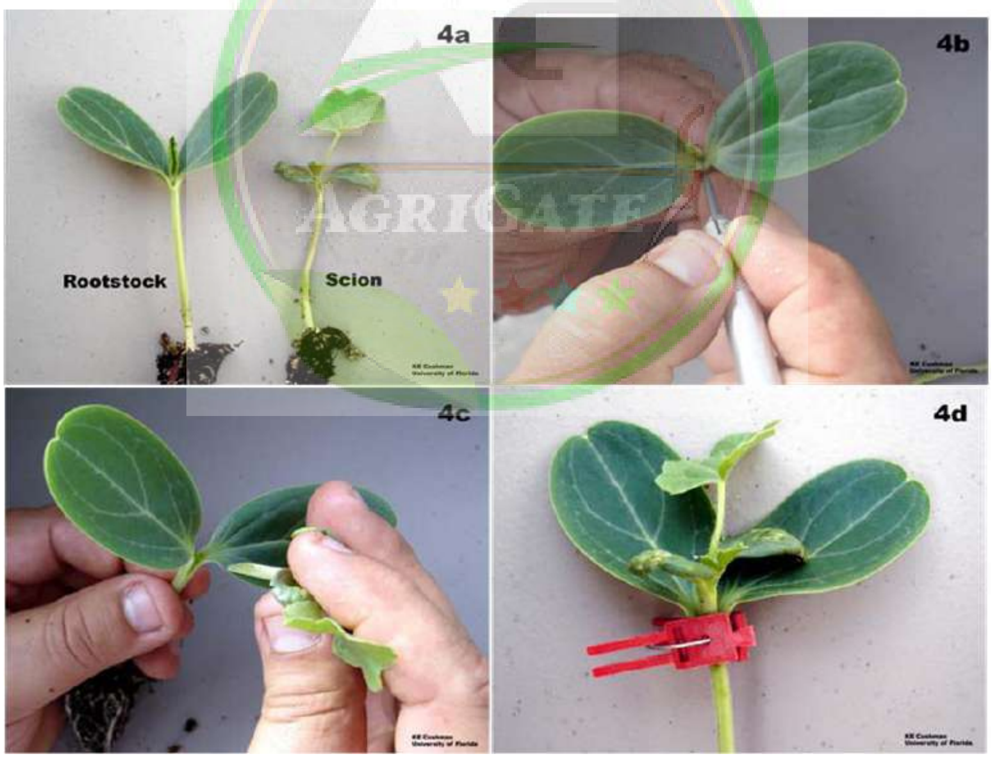
The survival rate of grafted cucurbitaceous plants is higher if approach/tongue grafting is used. This is because the root of the scion remains until the formation of the graft union. In this method, seeds of cucumber are sown 10-13 days before grafting, and pumpkin seeds 7-10 days before grafting, to ensure uniformity in the diameter of the hypocotyls of the scion and rootstock. The shoot apex of the rootstock is removed so that the shoot cannot grow. The hypocotyls of the scion and rootstock are cut in such a way that they tongue into each other, and the graft is secured with a plastic clip. The hypocotyl of the scion is left to heal for 3-4 days and then crushed between the fingers. The hypocotyl is cut off with a razor blade 3-4 days after being crushed.

Splice grafting:

First, the rootstock growing tip is cut at a 45^{o} angle. The cut removes true leaves, meristem tissue, and one of the cotyledons. Next, the hypocotyl of the scion is cut at the same angle as the rootstock. The scion is then attached to the rootstock with a grafting clip. This method is most suitable for melon rootstocks, as it works best when the rootstock and scion have similar hypocotyl diameters. Hybrid squash rootstocks also are grafted with this method because it is simple to perform. However, since hybrid squash rootstocks generally have thicker hypocotyls compared to melon scions, scion seeds may be planted earlier than rootstock seeds. It is important to note that grafting needs to be completed soon after plants are cut to prevent the surfaces of both scion and rootstock from drying out in order to improve the survival rate of grafted plants.

Hole insertion grafting

In this method, true leaves and meristem tissue are removed at the growing tip of the rootstock. Next, a slit is made across the growing point from the bottom of one cotyledon to the other side of the hypocotyl. A shaved stick such as a toothpick or bamboo barbecue skewer can be used as the insertion tool. Leave the stick inserted in the growing point, while cutting the scion hypocotyl at both sides into a V shape. The scion is then inserted into the slit while the stick is removed. Hole insertion grafting produces high-quality grafted transplants because it maximizes the contacting surface area between rootstock and scion and affords protection of the graft union with both rootstock cotyledons**.** Another advantage of this method is that it does not require grafting clips, which reduces the grafting cost as well as the labor involved in collecting clips after healing. Hole insertion grafting works best for hybrid squash rootstocks, as they normally have thicker hypocotyls than those of melon scions. Due to the concern of hollow hypocotyls, rootstocks with more than two expanded true leaves should be avoided



Healing and Acclimatization

Grafting should be carried out in a shady place sheltered from the wind, to avoid wilting of the grafted plants. Before grafting, expose the scion and rootstock to sunshine for two to three days and withhold water from the plants to avoid spindly growth. It should be make sure that the scions and rootstock have stems of a similar diameter. All these will improve the survival rate of grafted plants. The healing and acclimatization are very important for grafted plants to survive. Grafted plants are usually healed and acclimated in a plastic tunnel. After grafting, keeping the grafted plants at about 30°C and with more than 95% relative humidity for three days of healing promotes the survival ratio. Gradually, the relative humidity is then lowered and the light intensity is increased. During healing and acclimatization, it is important to keep a constant air temperature in the tunnel, in order to maintain high humidity. If wilting is observed, foliar spraying of grafted plants with water is effective in helping them survive. The shading materials and films should be adjusted according to the daily weather, with more shade on a fine day.

Future Prospects

Grafting is extremely laborious and time-consuming, and growers are trying to reduce the labor input required. Attempts have been made to mechanize grafting operations since 1987. Tube grafting was developed to reduce the time required for manual grafting by at least one-half. Healing has also been mechanized. The survival ratio is consistently high when the newly developed healing chambers are used. Healing chambers in which the environment is artificially controlled are now being used by many nurseries which produce grafted plugs. As grafting operations and the healing of grafted plants become easier, grafted vegetable crops may become popular all over the world. Since plants gain disease tolerance and vigor by grafting, grafting of vegetables may be useful in the low-input sustainable horticulture of the future.

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Volume: 04 Issue No: 05

ADVANCED IN POST HARVEST HANDLING OF DRAGON FRUIT

Article ID: AG-V04-I05-04

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Introduction

- Common name ; Dragon fruit
- Scientific name : *Hylocereus costaricensis*
- Family : Cactaceae
- Chromosome number :2n=22

Biology

- Dragon fruit is a perennial cactus .
- Fruit type – **Globorous berries.**
- Pulp colour –Reddish purple or white or yellow in colour with small black seeds .
- Long day plant .
- Night blooming flower is named as "Nobel Women" or "Queen of Night" .
- Fruit is generally known as " **Pithaya**".
- Pithaya means **"The scaly fruit".**

Uses of Dragon Fruit:

- Young stem of yellow dragon fruit is edible .
- Fresh flower buds are eaten as vegetables .
- Dragon fruit helps to prevent against cough and asthma .
- The fruit contains high amount of **Vitamin – C** .

- It is rich in flavonoids .
- Dragon fruit act against cardio related problems .
- Dragon fruit improves eyesight and prevent hypertension .
- It helps in reduction of blood sugar level .
- Dragon fruit is an high preferred fruit to type 2 diabetes patients .

Fig.1. Dragon fruits

Post Harvest Handling of Dragon Fruit:

1. **Optimum temperature:**
   - 6 to 10 °C based on the type and variety.
   - Generally optimum temperature for yellow pithaya is 6°C
2. **Rate of respiration :**
   - **41 to 49 CO_2**
3. **Response to ethylene :**
   - Ethylene involves only in fruit ripening , but not involved in the fruit colour development .
4. **Optimum relative humidity :**
   - The optimum relative humidity of dragon fruit is 85 to 90 %
5. **Rate of ethylene production :**
   - 0.09 µl C_2H_4/ kg /hour during fruit growth and development .

- Ethylene production doesn’t increases during ripening .

Post Harvest Handling

1. **Harvesting**
    - Dragon fruit harvested at fully ripened stage but still firm .
    - Bright coloured dragon fruit is harvested .
2. **Cleaning**
    - After harvesting , the fruit is cleaned to remove the dirt or debris .
    - It is done using water and soft brush .
3. **Sorting**
    - Fruit should be graded based on size, shape, colour and quality .
    - Damaged or over ripe fruit should be separated .
4. **Packaging**
    - Dragon fruit is packed in ventilated container or crates .
    - Packaging should be sturdy to prevent brushing along transportation .
5. **Storage**
    - Dragon fruit should be stored in cool and dry place .
    - The ideal storage temperature is 10 to 14 °C.

Fig .2. Different storing temperature of dragon fruit

6. **Transportation**
    - Dragon fruit should be handled with care to prevent brushing or damage .
    - Proper ventilation in transport vehicles is important to maintain the fruit quality.

7. **Ripening**
    - Dragon fruit is an climatric fruit .
    - Ripening can be slowed down by storing fruit at lower temperature .
8. **Quality control**
    - Regular checks should be conducted to ensure the fruit quality.
    - Ang signs of rotting or mold should be discarded .

Value Addition

1. Dragon fruit jam .
2. Dragon fruit peel candy

Fig :3 Dragon fruit peel candy

3. Dragon fruit jelly .
4. Dragon fruit juice .

Fig .4. Dragon fruit juice

5. Dragon fruit wine .

Fig .5. Dragon fruit wine

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AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

THE EVOLVING ROLE OF DRONES IN AGRICULTURE: CURRENT APPLICATIONS AND FUTURE PROSPECTS

Article ID: AG-VO4-I05-05

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Abstract

Drones have become crucial utensils in modern agriculture, offering farmers a wide range of applications to streamline processes, improve efficiency, and enhance sustainability. Since precision agriculture drones were used for crop health monitoring, seed sowing, fertilizer applications, irrigation management, pest management and livestock monitoring. Drones revolutionize traditional farming practices with their advanced capabilities. This paper provides an overview of the current applications of drones in agriculture and highlighting their role through optimizing crop management practices and promoting sustainable water conservation efforts and other sectors of agriculture. Additionally, it explores the advantages of drone technology in agriculture, such as increasing the use efficiency, cost savings, enhanced data-driven, decision-making, and environmental sustainability. The prospects of drone technology in agriculture are promising tools. Despite the challenges and limitations, including regulatory difficulties and integration with existing conventional farming practices. Advancements in drone technology, integration with other agricultural technologies, potential for autonomous operations and swarming capabilities, and adoption of technology in developing countries and small-scale farming represent emerging trends that are set to reshape the agricultural landscape. By embracing drone technology and advocating for sensible regulations, farmers can cultivate a

more sustainable, efficient, and resilient agriculture in future.

Introduction

In modern agriculture, drones have emerged as invaluable resources for farm operations and other agricultural applications. Farmers are progressively connecting the power of drones to streamline processes, *viz.*, reduce the cost of input applications towards enhancing crop yields. Equipped with sophisticated cameras, sensors, and various payloads, drones offer farmers access to crucial data and insights, empowering them to make informed decisions about their crops and land management practices. Drone technology has swiftly transitioned into an adaptable and cost-effective tool for agricultural purposes. This rapid growth underscores the versatility of drones, also known as unmanned aerial vehicles (UAVs), to meet out the diverse applications in the agricultural sector. From monitoring crop health to conducting field surveys, drones have become indispensable tools for modern farmers seeking to optimize their operations and achieve sustainable agricultural practices. As drone technology continues to evolve, it promises to revolutionize the way farmers approach crop management and agricultural production, driving innovation and efficiency of applications. Over time, the understanding of drone technology has evolved, and there isn't a single universally accepted definition. However, the International Civil Aviation Organization (ICAO) has characterized a drone as "an aircraft without a human pilot aboard" (ICAO, 2020).

Current Applications of Drones in Agriculture

Drones are growing into the agricultural sectors, offering farmers a bird's-eye view for precision crop monitoring and targeted applications like pest control and Fertilizer and Pesticide applications. Ultimately leading to increased efficiency and sustainability.

Precision crop monitoring and management:

Drones possess the capability to capture high-quality aerial images of agricultural fields. These images, when combined with data obtained from multispectral sensors, enable farmers to assess crop health, identify nutrient deficiencies, and detect early signs of potential pest or disease outbreaks. Armed with this information, farmers can make knowledgeable decisions regarding resource allocation, implementation of targeted interventions, and formulate comprehensive crop management strategies. Additionally, drones have the capacity to generate detailed maps of crops, offering farmers valuable insights into crop health and development. This facilitates schedules indications of areas with varying yield levels, assists in planning irrigation and fertilization schedules, and optimizes overall crop management practices. As highlighted in a study conducted by Wang et al. (2020), drones equipped with multispectral and thermal sensors proved to be effective in accurately mapping soil moisture distribution and nutrient levels within a cornfield.

Pest detection and control

Pest management through drones is a crucial application. There have been notable developments in the use of drones in agricultural pest control, especially with the creation of lightweight versions for insect identification. Recent research presented a model that enhances pest detection from drone-captured imageries, even in the difficult situations like poor resolution and noise by combining Transformer and super-resolution sampling approaches. Because the camera adjusts for light intensity, each pixel in the image may capture and display minute details. A picture is made up of consecutive bands of spectrum. Plant diseases detection and monitoring through hyperspectral imaging techniques is another application, these strategies enhanced the object categorization by exploring spectral features from imageries. This model is a useful tool for farmers and agronomists because of its exceptional recall rates and accuracy. (Bai, Yuzhe, et al.2023).

Irrigation management and water conservation:

Utilizing Remote sensing technology in drone sectors, play a pivotal role in irrigation management, water resources monitoring and water conservation efforts in agriculture. Now a days drones are equipped with advanced sensors (Multispectral and Hyperspectral), they gather critical data on soil moisture levels and crop health and A biotic stresses of crops with high precision and efficiency. By analysing this data, farmers can optimize irrigation schedules, ensuring irrigation need is to be applied only where and when needed. This targeted approach minimizes water wastage, reduces irrigation costs, and promotes sustainable water management practices, contributing to overall water conservation efforts in precision agriculture. Drones with thermal sensors may also be used to detect regions that need watering and track soil moisture levels. This can save water wastage and increase crop yields by helping farmers adjust their irrigation systems. Drones fitted with thermal sensors were able to identify soil moisture levels in a peanut field with an accuracy rate of over 90%, according to research by Hassler, S. C., & Baysal-Gurel, F. (2019). According to Kaivosoja, Jere, et al. (2021) precision farming mainly focuses the use of UAV (unmanned aerial vehicle) imaging technology underpins the applicable reference measurement methodologies by enabling the identification of pests, weeds, diseases, and mapping. Infestations of pests and diseases are frequently linked to unfavourable moisture conditions in the soil and plants, such as dryness or an abundance of water. Unlike the identification of weeds, pests and diseases, UAV applications relating to soil moisture regimes often rely on the thermal part of the spectrum, however multispectral or visual reflectance data are also frequently employed.

Livestock monitoring and management:

Livestock monitoring and management have undergone a transformative shift with the integration of drones with other available technologies. These unmanned aerial vehicles (UAV) or drones are revolutionizing traditional farming practices by providing efficient and remote monitoring of farm animals. Here are some key points about the role of drones in livestock management.

Enhancing Animal Welfare: Drones allow farmers to remotely track and care for their animals. Livestock tracking becomes easier, enabling close monitoring of well-being, calving seasons, and grazing patterns. Beyond welfare, drones offer time-efficient mustering and enhanced security through discreet tags that aid in locating stolen animals and disaster recovery efforts. (https://www.airstandards.org/drones-in-livestock-monitoring/)

Efficiency and Cost-Effectiveness: Drones eliminate the need for manual inspections on foot or by vehicle. They quickly identify issues such as animals straying from the herd, signs of distress, or potential predators. Health assessments using thermal imaging cameras detect variations in body temperature, enabling early detection of sick or injured animals.

Pasture Management and Breeding Programs: Drones provide valuable data for improved pasture management, identifying overgrazing, erosion, and weed infestations in around farm premises. They also monitor livestock behaviour, aiding in breeding programs. Additionally, drones streamline counting and inventory management for financial planning and regulatory compliance.

Disaster Preparedness and Response: During emergencies, drones play a crucial role by providing real-time information to locate and assess livestock. Their ability to enhance farm efficiency and improve animal welfare makes them indispensable in modern livestock monitoring. By leveraging aerial monitoring and advanced data collection capabilities, drone's stand-in a sustainable future in agriculture. Farmers can optimize operations, save resources, and ensure the well-being of their livestock by embracing this transformative technology.

Crop Inputs & Protection applications:

Crop pesticide and fertilizer spraying and have witnessed a remarkable transformation with the integration of drones. These unmanned aerial vehicles are revolutionizing traditional farming practices, offering efficiency, precision, and cost-effectiveness. Here's how drones are reshaping crop management:

1.Fertilizer Spraying:

- Drones play a crucial role in applying fertilizers and insecticides to Agricultural and Horticultural crops. Their flexibility allows swift movements and precise manoeuvring to reach targeted locations and improving the input use efficiency to crops.
- By spraying nutrients directly on top of crops, drones enhance plant health and longevity. They keep insects, pests, and worms at bay, contributing to higher yields and healthier produce.(Ivezić, Aleksandar, et al. (2023)

2. Soil Health Monitoring:

- Drones aid in analysing soil health assessment through collect data from sensors. This information used for monitoring, enabling farmers to assess, control, and maintain different type of soil conditions.
- This information guides decisions related to nutrient management, irrigation, crop management, and its ultimately optimizing agricultural productivity. (Ivezić, Aleksandar, et al. (2023)
- In the dynamic landscape of agriculture, drones have become indispensable tools, bridging the gap between technology and sustainable farming practices

Advantages of Drone Technology in Agriculture

1. Increased Efficiency and Productivity:

- Drones revolutionize agricultural practices by collecting real-time data over large areas.

- They monitor crop health, detect anomalies, and assess field conditions more efficiently than manual methods.
- Rapid data acquisition enables better decision-making, leading to increased productivity for farmers. (Torres-Sánchez, J., López-Granados, F., & Peña, J. M. (2015)).

2. Cost Savings through Optimized Resource Utilization:

- Drones precisely apply fertilizers, pesticides, and water management, minimizing waste and reducing input costs.
- By eliminating manual labour, drones save time and expenses, making agriculture more economically viable.

3.Enhanced Data-Driven Decision Making:

- Drone-collected data provides valuable insights for farmers. From crop health assessments to yield predictions, this information empowers informed decisions.
- Precision agriculture tailor's actions based on real-time data, optimizing resource allocation.

4.Environmental Sustainability and Reduced Chemical Usage:

- Targeted chemical application by drones minimizes environmental impact. They identify specific areas requiring treatment, conserving resources.
- Sustainable farming practices benefit from reduced chemical usage, promoting a greener future for agriculture. (Zhang, Q., & Kovacs, J. M. (2012))

Challenges and Limitations

1.Regulatory Hurdles and Airspace Restrictions:

- Drone technology faces regulatory challenges related to flight permissions, safety protocols, and airspace management. Compliance with local and national regulations is essential for widespread adoption.
- As drones become more prevalent in agriculture, policymakers must strike a balance between safety and innovation to unlock their full potential.

2.Initial Investment Costs and Technology Adoption Barriers:

- The upfront cost of purchasing drones and associated equipment can be prohibitive for small-scale farmers. Additionally, training and integrating drone technology into existing practices require time and resources.

- Overcoming financial barriers and providing accessible training programs are crucial for democratizing drone adoption in agriculture.

3.Data Privacy and Security Concerns:

- Collecting and transmitting data through drones raise privacy and security issues. Ensuring data encryption, secure storage, and compliance with privacy laws is critical.
- Striking a balance between data-driven insights and safeguarding farmers' privacy is essential for building trust in drone technology.

3.Integration with Existing Farming Practices:

- Farmers must adapt their workflows to incorporate drone data effectively. Integrating drone insights with other precision agriculture tools can be challenging.
- Education, technical support, and seamless integration strategies are necessary for maximizing the benefits of drones in modern farming.

Future Prospects and Emerging Trends:

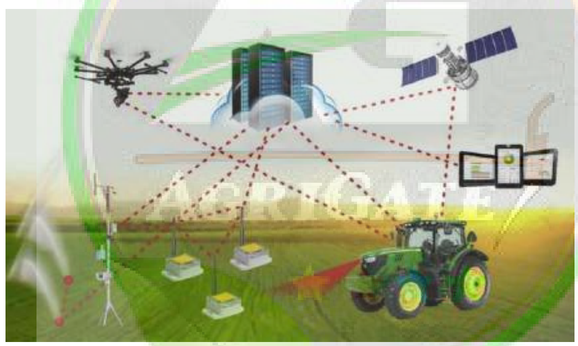
Advancements in Drone Technology:

Drone technology is poised for significant advancements, particularly in the integration of AI, machine learning, and sensor capabilities. These innovations will enable drones to process and analyse vast amounts of data in real-time, enhancing their ability to perform complex tasks such as crop monitoring, pest detection, and yield prediction with unprecedented accuracy and efficiency..

For instance, AI algorithms can empower drones to autonomously identify crop diseases or nutrient deficiencies based on image analysis, allowing farmers to take timely corrective actions. Furthermore, ongoing research in sensor technology promises to equip drones with enhanced capabilities for environmental monitoring, such as detecting soil moisture levels or measuring atmospheric conditions. These advancements hold great potential to revolutionize precision agriculture practices and contribute to sustainable food production systems

Integration with Other Agricultural Technologies:

The integration of drones with other agricultural technologies, such as IoT (Internet of Things) and robotics, is set to reshape farming practices in the coming years. By leveraging IoT sensors deployed throughout the farm, drones can gather and transmit real-time data on soil conditions, weather patterns, and crop health, enabling farmers to make data-driven decisions remotely. Additionally, the synergy between drones and robotics holds promise for automating labour-intensive tasks, such as planting, harvesting, and weed control, thereby increasing operational efficiency, and reducing labour costs. Collaborative efforts in integrating these technologies will create interconnected agricultural ecosystems where drones serve as integral components of smart farming solutions, driving productivity and sustainability in the industry.



Potential for Autonomous Operations and Swarming Capabilities:

The future of drone technology in agriculture lies in autonomous operations and swarming capabilities, where fleets of drones work together seamlessly to accomplish complex tasks across large agricultural landscapes. Autonomous drones equipped with advanced navigation systems and obstacle avoidance algorithms can navigate terrain independently, performing tasks such as field mapping, crop scouting, and infrastructure inspection with minimal human intervention. Moreover, the concept of drone swarms holds immense potential for optimizing agricultural operations on a larger scale. By coordinating their actions and sharing data in real-time, swarms of drones can cover extensive areas more efficiently and effectively than individual drones, leading to improved productivity and scalability in agricultural applications.

Adoption of Drones in Developing Countries and Small-Scale Farming:

The adoption of drones in developing countries and small-scale farming operations represents a promising trend that could democratize access to advanced agricultural technologies and improve livelihoods for rural communities. Drones offer cost-effective solutions for smallholder farmers to overcome challenges such as limited resources, labour shortages, and inadequate infrastructure. With their ability to provide actionable insights and precision farming capabilities, drones empower farmers to optimize inputs, increase yields, and mitigate risks associated with climate variability and environmental degradation. Additionally, initiatives focused on capacity building, technology transfer, and policy support are essential for facilitating the widespread adoption of drones in these contexts, unlocking their full potential to drive inclusive and sustainable agricultural development.

Other applications:

1. **Autonomous Swarm Farming**:
    - Autonomous drone swarms will work together to perform tasks like planting, pollination, and crop monitoring. These coordinated fleets can cover large areas efficiently, improving crop yields and reducing labour costs.
2. **AI-Driven Precision Agriculture:**
    - Drones equipped with AI algorithms will analyse multispectral imagery to detect crop stress, disease, and nutrient deficiencies. Real-time insights will guide precise interventions, optimizing resource use.
3. **Beyond Visual Line of Sight (BVLOS) Operations:**
    - Regulatory advancements will enable BVLOS flights, allowing drones to cover vast agricultural landscapes. BVLOS operations enhance monitoring, delivery, and data collection.
4. **Crop Health Sensing and Prescription:**
    - Drones equipped with hyperspectral cameras will assess crop health at a subfield level. Customized prescriptions for irrigation, nutrient management, and pest control will enhance sustainability.
5. **Drone-Enabled Pollination:**

As natural pollinators decline, drones will play a vital role in crop pollination. Robotic bees and other pollinator drones will ensure fruit and seed production.

6. **Energy Harvesting Drones:**
    - Solar-charging drones will extend flight times, enabling prolonged monitoring and data collection. Energy-efficient designs will reduce reliance on traditional power sources.
7. **Integrated Drone-Drone Communication:**
    - Interconnected drones will share data, collaborate on tasks, and optimize operations. Communication protocols will enhance efficiency and decision-making. These trends signify a promising future for agriculture, where drones continue to revolutionize farming practices and contribute to sustainable food production. (Kumar, A., Rani, M., Aishwarya, & Kumar, P. (2022).

Conclusion

In summary, the integration of drone technology in agricultural sectors promises transformative benefits. From precision farming to pollination, drones enhance efficiency, reduce costs, and promote sustainability. As we look ahead, consider the following steps.

1. **Stay Informed**: Keep well-up to date of emerging trends and research in agricultural drones. Explore scientific journals, industry reports, and conferences.
2. **Collaborate**: Engage with experts, farmers, and drone manufacturers. Collaborative efforts drive innovation and practical solutions.
3. **Advocate for Regulation**: Advocate for sensible regulations that balance safety and innovation. Support policies that enable BVLOS operations and promote responsible drone use.
4. **Learn and Adapt**: Familiarize yourself with drone technology. Understand its applications, limitations, and potential. Adapt your farming practices to leverage this powerful tool. By embracing drone technology, we can cultivate a more sustainable, efficient, and resilient agricultural landscape for generations to come.

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AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

RESIDUE MANAGEMENT IN WHEAT BASED CROPPING SYSTEM: PROBLEMS AND PROSPECTS

Article ID: AG-V04-I05-06

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Introduction

The Crop residue is defined as the vegetative crop material left on the field after a crop is harvested, pruned or processed. Crop residues are a tremendous natural resource, not waste materials is good source of organic matter. The removal of crop residue leads to low soil fertility and there by decreased crop production.

Why crop residue management?

The Ministry of New and Renewable Energy (MNRE), Govt. of India has estimated that about 500 Mt of crop residues are generated every year. About 25% of N and P, 50% of S and 75% K uptake by cereal crops are retained in the crop residues, making them valuable nutrient source (Dobermann and Witt, 2000). Crop residue can supplement inorganic fertilizers and for better soil health.

Wheat based cropping system

One of the major cropping system in wheat based cropping system is wheat-rice cropping system. The rice-wheat based cropping systems (RWCS) in South Asia have significantly contributed in enhancing the food grain production and achieving the food self-sufficiency and food security.

What happen with the crop residue?

- Crop residues are removed from the field to serve multiple purposes in the household.
- Eaten by roaming cattle or allow to graze by farmer itself.

- Burned: where farmer is not only cleaning his field, but also 'cleaning his pockets' by burning the potential fertility of his soil
- Remained unmanaged with uneven distribution.

Table 1: The Rice-Wheat System in the South Asia

Country	Area under R-W based system (M ha)	Share of Area under R-W based system(%)		Contribution of R-W (%)	
		Rice	Wheat	Total cereal production	Total national calorific intake
India	10.3	33	40	85	60
Pakistan	2.3	72	19	92	62
Bangladesh	0.5	5	85	100	94
Nepal	0.6	35	84	71	63

Timsina and Connor (2001)

Table 2: Global Availability of Crop Residue

Crops	Asia	Africa	S. America	World
R-straw	771804	25968	24153	844782
R-husk	154361	5194	4831	168956
Wheat	379788	27395	25539	946734
Barley	34097	6753	2141	208229
Sugarcane	53855	8561	41880	125227
Cotton	6378	315	69	6801
Oats	2424	342	1604	51604
Corn	166205	38729	54626	604031

Sidhu and Beri (2004)

MANAGEMENT OF CROP RESIDUE

- Residue burning
- Baling and removing loose straw
- Surface retention and mulching
- Residue incorporation

- Residue shredding (cutting into small pieces)

Table 3: Nutrient content in crop residues

Crop residue	Nutrient (%)		
	N	P	K
Rice	0.61	0.18	1.38
Wheat	0.48	0.16	1.18
Maize	0.52	0.18	1.35
Pearl millet	0.45	0.16	1.14
Potato tuber	0.52	0.21	1.00
Groundnut (pods)	1.60	0.23	1.37
Sugarcane	0.40	0.18	1.28
Pulses	1.60	0.51	1.75

Reddy *et al*., (2003)

On-farm burning of crop residues

- Residues are wealth in some places and some other, these are waste.
- Burning of crop residues causes environmental pollution, is hazardous to human health
- About 80% of crop residues are burned on-farm (IARI report, 2012)

Crop residue management by farmers in India

(Source: National Policy for Management of Crop Residues)

- ✓ Burnt open field (82 %)
- ✓ Thrown away (1 %)
- ✓ Incorporated in soil (1 %)
- ✓ Composted (5 %)
- ✓ Used as cooking fuel (2 %)
- ✓ Used as fodder (7 %)
- ✓ Sold (2 %)

Why do farmers burn residues in field?

- Use of combine harvesters
- Declining number of livestock
- Long period for composting

- Clearing of fields for next crop
- Scattered, collection is time and labour consuming
- No economic alternate use
- Fast way of controlling weeds, insects and diseases

Table 4: Residue generated, residue surplus and burned in Major States

S.N.	States	Residue generation (MT)	Residue surplus (MT)	Residue burned (MT)
1	**Andhra Pradesh**	43.89	6.96	2.73
2	**Bihar**	25.29	5.08	3.19
3	**Chhattisgarh**	11.25	2.12	0.83
4	**Gujarat**	28.73	8.90	3.81
5	**Haryana**	27.83	11.22	9.08
6	**Karnataka**	33.94	8.98	5.66
7	**Madhya Pradesh**	33.18	10.22	6.91
8	**Maharashtra**	46.45	14.67	7.42
9	**Orissa**	20.07	3.68	1.34
10	**Punjab**	50.75	24.83	19.65
11	**Rajasthan**	29.32	8.52	1.78
12	**Tamil Nadu**	19.93	7.05	4.08
13	**Uttar Pradesh**	59.97	13.53	11.92
14	**West Bengal**	35.93	4.29	4.96

(Source: National Policy for Management of Crop Residues)

Why crop residues should not be burned?

Negative consequences of burning

- Loss of C, nutrient and energy
- Emission of pollutants
- Adverse impacts on soil health
- Adverse impacts on human health

Positive consequences of soil application

- Reservoir of nutrients

- Improves soil health
- Conserves water, controls weeds
- GHGs mitigation
- Enhances crop yield and quality

Table 5: Nutrients lost through residue burning

Nutrients	Kg/t of rice residue	Kg/t of wheat residue	% lost during burning
C	414	400	80
N	6.00	5.00	82
P	1.00	0.80	44
K	15.0	10.0	40
Ca	2.80	3.00	52
Mg	12.0	1.20	47
S	1.40	1.40	81

Gupta *et al.*, (2004)

Pusa Decomposer

Recently, the scientists have developed a bio-decomposer technique called 'PUSA Decomposers' for converting crop stubble into compost. The Indian Agricultural Research Institute (IARI) in Pusa (New Delhi) has developed a low-cost technology as a possible solution to managing crop residue. Dr. Ashok Kumar Singh, Director, IARI said, "We were working on this product for the past 5 years. This product will fulfill two objectives - make soil fertile and fight the pollution menace." The decomposers are in the form of capsules made by extracting fungi strains that help the paddy straw to decompose at a much faster rate than usual. The fungi helps to produce the essential enzymes for the degradation process. It involves making a liquid formulation using decomposer capsules and fermenting it over 8-10 days and then spraying the mixture on fields with crop stubble to ensure speedy bio-decomposition of the stubble. Time to Decompose- It takes around 20 days for the degradation process to be completed.

Significance of Pusa Decomposer

- The decomposer improves the fertility and productivity of the soil as the stubble works as manure and compost for the crops and lesser fertilizer consumption is required in the future.

- The soil loses its richness due to stubble burning and it also destroys the useful bacteria and fungi in the soil, apart from causing harm to the environment.
- It is an efficient and effective, cheaper, doable and practical technique to stop stubble burning.
- It is an eco-friendly and environmentally useful technology and will contribute to achieve Swachh Bharat Mission.

Baling and Removing the Straw

Used for

- Livestock feed,
- Fuel,
- Building materials,
- Livestock bedding,
- Bedding for vegetables cultivation and
- Mulching for orchards and other crops
- Limitation: removes only loose straw

Surface Retention and Mulching

- It is a practice that leaves straw residues from a previous crop on the soil surface without any form of incorporation.
- It helps to protect the fertile surface soil against wind and water erosion. This method is prevalent in no-till or conservation tillage practice where at least 30% of soil surface is covered with crop residue.

Crop Residue Incorporation

- Crop residue is incorporated completely or partially into soil mostly by ploughing.
- Above ground portion chopped into small size and can be incorporated by power-tiller.
- Incorporation of straw increase soil organic matter and soil N,P and K content as compared to other management option.

Problems in use of crop residue

- High C:N ratio of crop residue
- Less nutrient content as compare to chemical fertilizers
- Bulky in nature

- Labour consuming for transportation of residues to field
- Chance of disease and weed dissemination
- More problematic in combine harvest fields (consists of standing stubbles and loose straw)
- High tonnage left in the field
- It is difficult to manage the entire left over straw (7-8 t/ha) with existing tools and implements

Challenges

- Huge volume of crop residue;
- Collection & Storage;
- Time window between harvesting and sowing of two (next) crops;
- Awareness, Dissemination of Technology, Capacity Building of Technical Manpower and those of farmers;
- Cost-effective mechanization, availability of appropriate machinery;
- Effective utilization of crop residue;
- Technology up-gradation

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Volume: 04 Issue No: 05

AZOLLA PRODUCTION AND THEIR BENEFITS IN AGRICULTURE

Article ID: AG-VO4-I05-07

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Abstract

Azolla is a freshwater fern that belongs to the *Azollaceae* family. It is easy to grow and is highly productive. It can fix atmospheric nitrogen by the symbiotic association of *Anabaena azollae*. *Azolla* has been applied to the rice field as a classic fertilizer and weed suppressor. It is a good source of protein and contains almost all essential amino acids and minerals. Various research has been done and is still ongoing to determine the capability of *Azolla* as a phytoremediator and to be used as a sustainable bioenergy source. The presence of a symbiotic cyanobacterium, *A. azollae*, which occupies the dorsal lobe of the leaves, contributes to the system's nitrogen-fixing capabilities. As a result of this characteristic, it has been widely used as a biofertilizer for rice plants. Apart from that, it may be used for a variety of other things, such as food and feed, biofuel production, and heavy metal accumulation. Because it has so many uses, promoting and using the *Azolla-Anabaena* system in sustainable agriculture would be helpful and good for the environment. *Azolla* can grow on water depth of 20 cm, the nutrient concentration of 812.5 ppm, pH of 7 and under 100% sunlight exposure. Dried *Azolla* had 6.38% moisture, 27.1% crude protein, 6.37% crude fat, 14.29% ash, 34.29% crude fibre, 45.86% carbohydrate and 349.17 kcal/100 g energy. *Azolla* could be used as a sustainable biomass source to produce animal feed (high protein content) and bioenergy (high fibre content).

Key words: Azolla, symbiotic cyanobacterium, Animal feed.

What is Azolla?

Azolla is a rapidly growing floating plant. It grows in paddy farming as a green manure crop, just like blue green algae. This green input increases agricultural output by boosting soil carbon and nitrogen content, as well as fertility. Blue green algae develop symbiotically on the Azolla surface. Azolla supplies the carbon source and environment for algal growth, resulting in a high protein plant. It is typically produced in paddy fields or shallow ponds in tropical and subtropical climes. Heterosporous free-floating freshwater ferns called Azolla sp. coexist harmoniously with nitrogen-fixing blue-green algae called *Anabaena azollae*. Azolla is seen as a possible source of nitrogen for rice crops when used as a biofertilizer. The genus Azolla contains six species that are extensively spread throughout temperate, sub-tropical, and tropical regions of the world, long before it was used as green manure.

Methods of cultivation

Azolla requires 30% sunlight; too much sunlight may kill the plant, thus choose a somewhat shaded spot when building the cultivation pond. The area under the tree is preferred. It is possible to construct little concrete tanks if you choose to cultivate an Azolla on a big scale. If not, you are free to create any size pond you like. Azolla plastic beds are now available on the market; they are handier and easier to use. After levelling and excavating the earth for the pond, cover the area with plastic sheeting to stop any water loss. Verify that the pond is 20 cm or deeper. Evenly spread some dirt across the pond's plastic sheet. To a pond of 2 m by 2 m, add 10–15 kg of soil. For azolla to grow healthily, phosphorus is required. Super phosphate and cow dung slurry can be used together. Cow poo makes more nutrients available. Use 4–5-day-old cow dung. After that, add enough water to the pond to cover it by about 10 cm, allowing the Azolla Plant to float freely on its short path. Then, leave the pond empty for two to three days to give the components time to settle. Add Azolla culture to the pond after two to three days by gently rubbing Azolla between your palms. It facilitates Azolla's faster multiplication by breaking it up into smaller parts. After a two-week start of harvesting, form a pond of 2M X 2M size, you can harvest 1kg Azolla each day

Benefits of Azolla

Feed for livestock

Azolla is a great source of nutrients for cattle since it has a high content of proteins, amino acids, vitamins (A, B12, and beta carotene), and minerals. Azolla also contains less lignin. Animals can therefore easily digest. Feeding Azolla to poultry birds has been shown to enhance broiler chicken weight and boost layers' egg output. In animals, adding 1.5–2 kg of Azolla to regular feed resulted in an overall 15%–20% increase in milk output..

Biofertilizer

Nitrogen from the atmosphere is fixed by azolla and stored in leaves. It is therefore applied as green manure. Rice farmers have witnessed and praised the cultivation of Azolla in paddy fields, which has increased rice yield by 20%.

Weed Control

In paddy fields, azolla plants are used to control weeds since they may create a thick coating on water's surfaces. Azolla acts as organic mulching in paddy farms, creating a thick layer that covers the entire farm and prevents weeds from growing. It also prolongs the period of soil moisture retention by decreasing the rate of water evaporation.

Mosquito Control

Azolla possesses another ability. Because Azolla inhibits mosquito reproduction, it is frequently referred to as a "mosquito fern."

Advantages of Azolla

- It has the ability to grow in wild and under controlled environmental conditions
- Ability to fix atmospheric nitrogen
- Suppresses the growth of weeds in the farming lands
- It can be used as a substitute for the chemical nitrogen fertilizers
- For the cultivation of Azolla less investment is needed
- Azolla can be grown within a small are in the farm along with other crops

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Volume: 04 Issue No: 05

UNVEILING THE SILENT THREAT: UNMASKING THE CASSAVA MOSAIC DISEASE IN INDIA

Article ID: AG-VO4-I05-08

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Introduction

The first report of cassava mosaic disease (CMD) in India originated from Kerala in the 1950s (Abraham, 1956; Malathi et al., 1985). The virus was first identified from the samples collected from Kerala and named as *Indian cassava mosaic virus* (ICMV). Another virus species *Sri Lankan cassava mosaic virus* (SLCMV) was identified from infected cassava samples from Sri Lanka. Later, SLCMV was also reported from cassava plant material collected from Kerala.

Geographic distribution

Surveys across various Indian states, including Kerala, Tamil Nadu, and West Bengal, revealed a widespread presence of cassava mosaic disease with varying disease incidences. Notably, a study in Tamil Nadu reported a high incidence exceeding 90%, with SLCMV being the predominant strain, although mixed infections with ICMV were also detected (Kushawaha et al., 2018). Sequence analysis indicated minimal genetic diversity within these strains, suggesting limited viral evolution.

Effect on crop growth and yield

Cassava mosaic disease (CMD), caused by cassava mosaic geminiviruses (CMGs), disrupts chlorophyll functionality within cassava leaves, leading to chlorosis. The subsequent decline in photosynthate production restricts plant growth and tuber development, resulting in yield reductions or complete crop failure in a particular season. CMD represents a significant constraint to cassava production due to its detrimental impact on crop yields. Unlike the significant yield losses observed in Africa due to CMD, the disease in India appears to have a milder impact, with yield reductions typically ranging between 10-15%. The effect of SLCMV infection on the root yield of cassava was attributed to 16–33% when infected cuttings were used as a planting material (Uke et al., 2021).

Disease severity and the emergence of new viruses

CMD severity exhibits a statistically significant correlation with multiple variables including host plant age, cultivar susceptibility, infecting virus strain, and environmental conditions. Notably, infection of 1-3 month-old plants with SLCMV resulted in moderate to severe mosaic, while 5-7 month-old plants displayed only mild chlorosis. Interestingly, whitefly-mediated transmission resulted in less severe disease compared to infection via infected cuttings. Furthermore, research suggests a significant proportion of infected plants may remain asymptomatic. Collectively, these findings support SLCMV as the predominant CMD-causing agent in South and Southeast Asia, exhibiting a potentially greater pathogenic fitness compared to ICMV. Though ICMV and SLCMV co-exist in cassava fields in the Indian subcontinent, in mixed infections, SLCMV suppresses ICMV.

This dominance of SLCMV might be the reason for the prevalence of SLCMV over ICMV in cassava fields (Karthikeyan et al., 2016). In Asia, no new cassava-infecting geminivirus species have been reported other than SLCMV and ICMV. The overlapping occurrence of SLCMV and ICMV in the cassava fields of South India and their presence in other host plants, which serve as reservoirs of various geminiviruses. The long-distance spread of CMD mainly occurs due to the movement of contaminated plant materials and the local spread can be affected by the whitefly vectors. Though ACMV has not yet been reported from Asia except for an odd incident in Oman (Khan et al., 2013), the recovery of ACMV from cotton plants in Pakistan hints at the risk of interspecific recombination. If Asian and African CMGs get an opportunity to co-exist in the same host, the emergence of highly virulent CMGs could happen. Thus, proper surveillance measures should be imposed to curtail the spread of the disease.

Effective Disease diagnosis techniques

Prompt and accurate detection of Cassava Mosaic Geminiviruses (CMGs) is crucial for controlling their spread and minimizing crop losses. The primary diagnostic approaches employed as stomatological, serological and molecular methods.

Symptomatology

Cassava mosaic disease (CMD) exhibits well-defined foliar symptomatology. These symptoms encompass distortion of the leaf lamina, chlorotic mottling with mosaic patterns and a significant reduction in overall plant size compared to healthy controls. A prominent symptom observed in field settings is a mosaic patterning on the leaves, manifesting with color variations ranging from pale green to a whitish-yellow hue. The degree of chlorosis on the leaf surface can vary considerably, ranging from less than 5% to near complete coverage (100%). Another frequently observed characteristic is a pronounced narrowing of the leaflet base. However, it is noteworthy that symptom expression can exhibit seasonal and varietal dependence. The manifestation of symptoms in cassava plants is influenced by two primary factors, the infecting virus species and environmental conditions. Studies have demonstrated that co-infection with multiple viruses can exacerbate symptom severity. The expression of foliar disease symptoms is also modulated by soil fertility and water availability. Viral diseases in certain regions suggest that low temperatures are associated with the development of more severe symptoms, whereas high temperatures are linked to attenuated symptoms.

Fig. 1. Field symptoms of cassava mosaic disease caused by *Cassava Mosaic Virus* observed in organic field, KRISAT

Serological Techniques

Serological methods, like Double Antibody Sandwich Enzyme-Linked Immunosorbent Assay (DAS-ELISA) and Triple Antibody Sandwich ELISA (TAS-ELISA), have proven successful in detecting and differentiating CMGs. These techniques enabled the creation of the first CMG distribution map for Africa. Additionally, antisera development facilitated the detection of specific CMGs, such as Indian Cassava Mosaic Virus (ICMV), in both symptomatic and asymptomatic plants using TAS-ELISA, Dot Immunobinding Assay (DIBA), Immunosorbent Electron Microscope (ISEM) and Tissue Blot Immunoassay (TBIA). While ELISA offers advantages in cost-effectiveness and large-scale screening, it may not always detect asymptomatic infections.

Nucleic acid-based Techniques

Polymerase Chain Reaction (PCR) assays, including Immunocapture PCR (ICPCR), Spot Capture PCR (SC-PCR), and Print Capture PCR (PC-PCR), have demonstrated comparable effectiveness in ICMV detection. Furthermore, nucleic acid spot hybridization using a non-radioactive CP gene probe proved to be a highly sensitive method for ICMV diagnosis. Amplification techniques targeting conserved regions like AC1 and AV1 have been employed for ICMV and SLCMV detection in field samples across India and Southeast Asia. Multiplex PCR allows for the identification of mixed infections, while Real-time PCR facilitates virus detection and quantification even in asymptomatic plants.

Viruses causing Cassava mosaic disease

There are several geminiviruses have been reported to cause cassava mosaic disease all around the world.

Abbreviation	Name of the virus	Reference
ICMV	Indian Cassava Mosaic Virus	Hong et al., 1993
SLCMV	Sri Lankan Cassava Mosaic Virus	Saunders et al., 2002
ACMV	African Cassava Mosaic Virus	Stanley and Gay 1983
EACMV	East African Cassava Mosaic virus	Hong et al. 1993
SACMV	South African Cassava Mosaic Virus	Berrie et al. 2001
EACMKV	East African cassava mosaic Kenya virus	Bull et al., 2006
EACMZV	East African cassava mosaic Zanzibar virus	Maruthi et al. 2004
EACMCV	East African cassava mosaic Cameroon virus	Fondong et al. 2000
EACMMV	East African cassava mosaic Malawi virus	Zhou et al. 1998

Transmission and epidemiology

Cassava mosaic disease (CMD) dissemination primarily occurs through infected planting material. Due to the vegetative propagation nature of cassava, farmers often rely on hardwood stem cuttings, frequently reusing their own material or acquiring it from informal sources like neighbors, local markets. The absence of a well-established seed system in many cassava-growing regions leads to a lack of certification and quality control for planting material, resulting in a high prevalence of diseased cuttings. Additionally, cassava mosaic geminiviruses (CMGs) are efficiently transmitted by whiteflies (Hemiptera: Aleyrodidae). These vectors facilitate the movement of the virus within and between cassava fields, further amplifying disease spread.

Management

Management of cassava mosaic disease (CMD) in India requires a multi-pronged approach. While resistant cultivars are being developed, current strategies focus on reducing disease spread. This includes phytosanitation, employing disease-free planting material obtained through tissue culture techniques, and rogueing, the removal of infected plants to minimize inoculum sources. Additionally, controlling whitefly vectors through appropriate management practices can further limit disease transmission.

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Volume: 04 Issue No: 05

MAIZE FOR FOOD AND NUTRITIONAL SECURITY IN MODERN ERA

Article ID: AG-V04-I05-09

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Introduction

Maize is the staple food in several countries in Latin America, Africa including several parts in Asia, providing sustenance to millions of people. Together, the three main global staple grains - wheat, rice, maize - make up an important part of the human diet. Among them, maize is widely accepted as food, feed and fodder crop worldwide. It is one of the most versatile crop having wider adaptability and grown in diverse seasons and ecologies for various purposes. It is also known as queen of cereals because of its highest genetic yield potential and productivity among the cereal food crops. It is the only grain crop with many types like normal yellow/ white grain, sweet corn, baby corn, popcorn, quality protein maize (QPM) and fodder maize etc. Maize holds promise to satisfy all the four 'F's *i.e* food, feed, fodder and fuel. It serves several purposes namely, nutritional requirements of human as food, livestock and cattle as feed and raw material for numerous industries. Maize is the principal energy source in poultry diets across the globe including India because of its high-energy value, palatability, presence of pigments and essential fatty acids. In Nutshell, it is the only cereal crop that is used for both human nutrition and livestock feed. It has attained a position of industrial crop globally as 83% of its production in the world and 76% in India is used as feed or by starch and bio-fuel industries. Lately the significance of maize is increasing and its popularity among the farming community is increasing. It has been considered as crucial candidate crop for bioethanol production and crop diversification for sustainable future. The trend in maize area, production and productivity has witnessed a kind of silent revolution during last one and decades (1, 2, 3). The demand of baby corn, sweet corn and popcorn is also increasing every year. Thus, maize hold immense potential to ensure food and nutritional security of the country.

Nutritional value of maize

Field corn is a great source of protein, containing essential amino acids but lacks two essential amino acids lysine and tryptophan (4). In general, maize grain contains 14.9 % moisture, 11.1 % protein, 3.6 % fat, 2.7 % fibre, 66.2 % other carbohydrates and 1.5% minerals (5). In addition to its high fiber (2.7g) and protein content (9-14%), maize is also rich in important vitamins (vitamin B1(thiamine- 0.35mg), vitamin B2(riboflavin- 0.14mg), vitamin B3 (niacin- 2.10mg), vitamin B5 (pantothenic acid- 0.27mg), total vitamin B6- 0.28mg, vitamin B7 (biotin-0.70mg) and minerals such as vitamin C (7mg), vitamin B6, magnesium (31.9mg), and potassium (250mg). One of the most significant advantages of corn is that it does not contain gluten, and this is quite important for people who have celiac disease and cannot consume wheat. However, QPM contains better-balanced amino acid composition including the presence of high amount of essential amino acids like lysine (> 2.7%) and tryptophan (> 0.70 %) and low amount of leucine. It is the most effective and attractive measure to meet quality protein needs and raise the human nutritional status. In that cases, maize especially biofortified QPM is the only solution to meet their dietary requirements.

The protein quality of maize has improved with the identification of mutant allele *opaque2* and its mobilization in the genetic background of field corn leading to development of quality protein maize (QPM), a special type of maize that has doubled the amount of two most important essential amino acids *viz.*, lysine and tryptophan. Recently, the identification of another mutant allele *opaque16* and pyramiding of both *opaque* 2 and *opaque* 16 along with other alleles determining higher provitamin A, Fe, and Zn and reduced phytic acid content paved the way for biofortification of maize into a super nutri-cereal. The recent advances in biofortification of maize crop augers well which can provide effective solutions to decades old persistent challenges like malnutrition problem of the country (4). Thus, it is not just any ordinary cereal but a nutri-cereal - a term used to describe cereals that are rich in nutrients and have numerous health benefits. Therefore, promotion of such biofortified maize not only helps to address malnutrition problem of the country but also ensures nutrition security of the country in sustainable manner in long-run.

Adaptability of maize:

Maize crop is perceived to have a higher production and ability to grow worldwide, it thrives to eliminate hunger and solve the public nutrition crises with native, sustainable superfoods. Thus, maize is now at the beginning of new agricultural revolution and its status is likely to become more apparent in near future. Because, maize can be grown in different types of soil and climates, making it a versatile and most adaptable crop that can thrive in various regions. It is the only emerging crop having *wider adaptability under varied agro-climatic conditions like some of the* millets.

Value addition of maize:

Maize is the single most cereal exists in many different types depending on its nutritional benefits. It can be used in a variety of food products in many ways for its different types like field corn, QPM, sweet corn, baby corn and popcorn. Maize directly/indirectly and provide large opportunity for value addition. Field corn and QPM maize flour are used for preparation of numerous types of food items and dishes like tortillas, crunchy snacks (pasta, biscuits, cake, laddoo, sev etc. The products developed from QPM can replace fancied and highly priced industrial foods. Further, specialty corn like sweet corn and baby corn are being used for preparation of variety of vegetable based seasonings and the nutritional value are comparable to different vegetables. Popcorn is also used is a popular snack food and enjoyed around the world. The field corn can be ground into flour for bread or tortillas. The value added products can be prepared in villages and thus could be a great source of rural entrepreneurship. Thus, maize is a versatile crop which can be used in a variety of dishes.

Discusssion

It is well known information that with the Government of India (GoI) initiative, United Nation declared year 2023 as the International Year of the Millet (IYM). The Ministry of Agriculture & Farmers Welfare, Government of India aims to promote the cultivation and consumption of millet to ensure benefits of millets should reach the entire world. Millets are an ancient crop of the mankind and hold a lot of importance in the world agriculture. The declaration of IYM lead to popularization of several millets like Jowar, Bajra, Ragi as neutral millets and Brown top, Kodu, Proso, Barnyard, Foxtail, as positive millets because of their incredibly beneficial effects to the digestive system as well as their healing effects of chronic conditions like diabetes. Millets offers several health advantages and also plays an important role in strengthening farmers livelihood.

In order to ensure the food and nutritional security of the country, the strategies must be comprehensive and sustainable in their approach. In this context, effort has been made with an opinion to weigh the merits of maize and to promote and popularize its cultivation to ensure food and nutritional security of the country. The first question comes to mind is, can millets solely provides the probable solution as nutri-cereals in terms of nutrition, versatility, adaptability and sustainability? The second question is, can we also weight the biofortified maize or QPM along with millets in relative terms to ensure food and nutritional security in sustainably in long-run? The above questions are pertinent in the context of increasing population. With the population of 8.6 billion people in 2030 and 9.8 billion in 2050, it is anticipated that by the time, there would be a 70% rise in food demand worldwide. Global food demand for cereal equivalents (CE) is expected to be approximately 10,094 million tons in 2030 and 14886 million tons in 2050. Meanwhile, production of CE is expected to be marginally suplusing at 10120 million tons in 2030 and 15970 million tons in 2050. China and India are consuming a significant portion of the world’s food supply (6). The FAO's most recent projection for global cereal production in 2022 was revised in February by 8.3 million tonnes to 2 765 million tonnes, however it is still 1.7% less than in the previous year (7). Maize hold immense potential to ensure food and nutritional security of the country. Thus maize hold potential to satisfy the food requirements as well as human nutrition along with number of health benefits as in case of millets. The versatility of maize with respect to its types, utilization pattern, nutritional value needs to be recognized as a valuable addition to the nutri-cereals as other millets.

Maize can offer numerous advantages to smallholding farmers. The superiority of maize is evident in terms of yields, adaptability, versatility in utilization, types of maize and nutritional value which suggests the potentiality biofortified QPM as one of the substitute in the diet of midday meal in India. The policy decision in this regard could be rewarding to improve overall health status of children’s and can offset malnutrition problem in India. Further, it is also an excellent choice for vegetarians and being gluten free it is beneficial for patients with celeic disease. The present opinion is one of the humble initiative to bring clarity in the value of maize to the public domain. Thus, promoting the consumption of maize can have a positive impact on both the environment and society. Promotion of maize can contribute to the development of rural communities. The Governments can brainstorm in this direction to take action to improve the nutritional status of millions of children, financial health and livelihood status of farmers, including those who are socially disadvantaged, so they can progress alongside the nation.

Table 1. Nutrient composition of millets compared to fine cereals (per 100g)

Food Gain	Carbo-hydrates	Protein (g)	Fat (g)	Energy (Kcal)	Crude Fibre (g)	Mineral (g)	Ca (mg)	P (mg)	Fe (mg)
Rice (raw, milled)	78.2	6.8	0.5	345	0.2	0.6	10	160	0.7
Wheat (whole)	71.2	11.8	1.5	346	1.2	1.5	41	306	5.3
Maize (dry)	66.2	11.1	3.6	342	2.7	1.5	10	348	2.3
Pearl millet	67.5	11.6	5.0	361	1.2	2.3	42	296	8.0
Sorghum	72.6	10.4	1.9	349	1.6	1.6	25	222	4.1
Finger millet	72.0	7.3	1.3	328	3.6	2.7	344	283	3.9
Kodo millet	65.9	8.3	1.4	309	9.0	2.6	27	188	0.5
Proso millet	70.4	12.5	1.1	341	2.2	1.9	14	206	0.8
Foxtail millet	60.9	12.3	4.3	331	8.0	3.3	31	290	2.8
Little millet	67.0	7.7	4.7	341	7.6	1.5	17	220	9.3
Barnyard millet	65.5	6.2	2.2	307	9.8	4.4	20	280	5.0

Source: Nutritive Value of Indian Foods, NIN, 2007

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Volume: 04 Issue No: 05

TOXINS OF PLANT ORIGIN

Article ID: AG-VO4-I05-10

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Introduction

Toxins of plant origin refer to various chemical compounds produced by plants that can be harmful or toxic to humans, animals or other organisms. Plants produce toxins for various purposes, including defending themselves against herbivores, competing with other plants and inhibiting the growth of pathogens. Here are some common toxins found in plants:

I. Alkaloids
II. Glycoalkaloids
III. Cyanogenic glycosides
IV. Lectins
V. Oxalates
VI. Saponins
VII. Tannins
VIII. Myristicin and Safrole
IX. Cucurbitacins

I. Alkaloids

Alkaloids are a diverse group of naturally occurring nitrogen-containing chemical compounds found in plants, many of which have pharmacological effects on humans and animals. While some alkaloids have beneficial properties and are used in medicine or as stimulants, others can be toxic if ingested in large quantities. They have diverse effects on humans and animals, ranging from stimulant effects (e.g., caffeine, nicotine) to highly toxic effects (e.g., strychnine, atropine, morphine). Here are some examples of toxic alkaloids found in plants:

1. **Strychnine**: It is a highly toxic alkaloid that acts as a potent convulsant. Ingestion of strychnine can lead to severe muscle spasms, respiratory failure and death. Found in the seeds of the strychnine tree (*Strychnos nux-vomica*) and the Saint Ignatius' bean (*Strychnos ignatii*).
2. **Atropine**: It is a tropane alkaloid with anticholinergic properties (a type of medication that blocks the neurotransmitter called acetylcholine). Ingestion of atropine-containing plants can cause symptoms such as dry mouth, blurred vision, rapid heart rate and hallucinations. It is found in several plants, including deadly nightshade (*Atropa belladonna*) and jimsonweed (*Datura stramonium*).
3. **Colchicine**: It is known for its cytotoxic effects and is used medicinally in the treatment of gout and familial Mediterranean fever. Ingestion of colchicine can cause severe gastrointestinal symptoms, multi-organ failure and even death. It is a toxic alkaloid found in the autumn Crocus (*Colchicum autumnale*) and other plants in the Colchicaceae family.
4. **Aconitine**: Ingestion of aconitine can lead to symptoms such as nausea, vomiting, dizziness and cardiac arrhythmias, which can be fatal. It is a highly toxic alkaloid found in plants of the Aconitum genus, also known as monkshood or wolfsbane.
5. **Nicotine**: it is best known for its addictive properties, ingestion of large quantities of nicotine can cause nausea, vomiting, seizures and respiratory failure. It is an alkaloid found in the tobacco plant (*Nicotiana tabacum*) and other members of the Solanaceae family.
6. **Caffeine**: Caffeine is a widely consumed alkaloid found in coffee beans, tea leaves and cacao pods. While moderate consumption of caffeine is generally considered safe for most individuals, ingestion of large amounts can lead to symptoms such as restlessness, insomnia, tremors and cardiac arrhythmias.

These are just a few examples of toxic alkaloids found in plants. It's important to remember that the toxicity of alkaloids can vary widely depending on factors such as the dose ingested, individual sensitivity and the specific chemical structure of the alkaloid.

II. Glycoalkaloids

Glycoalkaloids are toxic compounds found in members of the nightshade family (Solanaceae), such as potatoes, tomatoes and eggplants. The most well-known glycoalkaloids are solanine and chaconine, which can cause gastrointestinal disturbances and neurological effects if ingested in large quantities. While these plants are commonly consumed as part of the human diet, which can be toxic if consumed in large quantities. Here's more detail about toxic glycoalkaloids:

1. **Solanine**: Solanine is a glycoalkaloid found in species of the nightshade family, particularly in green potatoes and potato sprouts. It acts as a natural pesticide to protect the plant from pests. Ingestion of solanine in high concentrations can cause symptoms such as gastrointestinal disturbances (e.g., nausea, vomiting, diarrhea), headache, dizziness and in severe cases, neurological symptoms such as confusion, hallucinations and paralysis.
2. **Chaconine**: Chaconine is another glycoalkaloid found alongside solanine in nightshade plants like potatoes. It exhibits similar toxic effects to solanine when consumed in large quantities.
3. **Tomatine**: Tomatine is a glycoalkaloid found in green tomatoes and other members of the Solanaceae family. While tomatine is generally less toxic than solanine, it can still cause gastrointestinal upset and other symptoms if consumed in large amounts.

The toxicity of glycoalkaloids depends on factors such as the amount ingested, individual sensitivity and the specific plant variety. The concentration of glycoalkaloids tends to be higher in green potatoes and potato sprouts compared to mature potatoes. Proper storage and preparation methods, such as avoiding consumption of green or sprouted potatoes and peeling them before cooking, can help reduce the risk of glycoalkaloid toxicity.

III. Cyanogenic glycosides

Cyanogenic glycosides are natural plant compounds found in the Rosaceae, Fabaceae, and Poaceae families and in many plants including cassava, almonds and stone fruits (e.g., cherries, apricots). When ingested, these compounds can release cyanide, which is toxic to humans and animals. These compounds are named for their ability to release cyanide when they undergo enzymatic breakdown. Cyanide is a highly toxic compound that interferes with cellular respiration, leading to cellular suffocation. Here's more information about toxic cyanogenic glycosides:

1. **Amygdalin**: Found in seeds of fruits such as apricots, peaches, cherries and almonds, as well as in some beans and grains, amygdalin releases cyanide when metabolized. While the amount of cyanide released from amygdalin is relatively small, consumption of large

quantities of amygdalin-rich seeds or pits can lead to cyanide poisoning. Symptoms of cyanide poisoning include headache, dizziness, nausea, vomiting, rapid breathing, rapid heart rate, confusion and in severe cases loss of consciousness and death.

2. **Prunasin**: Prunasin is another cyanogenic glycoside found in various stone fruits, including cherries, peaches, plums and apricots. Similar to amygdalin, prunasin releases cyanide when metabolized, although the concentration of cyanide released is generally lower. The ingestion of large quantities of stone fruit seeds or pits containing prunasin can still lead to cyanide poisoning.
3. **Dhurrin**: Dhurrin is a cyanogenic glycoside found in sorghum, cassava and certain bamboo species. In cassava, which is a staple food for millions of people in tropical regions, dhurrin is concentrated in the bitter varieties of cassava roots. Improper processing of cassava, such as inadequate soaking, fermentation and cooking can result in the retention of cyanogenic glycosides, leading to cyanide poisoning.

Cyanogenic glycosides are naturally present in many plants as a defense mechanism against herbivores and pathogens. In most cases, the levels of cyanogenic glycosides in edible plant parts are not harmful if consumed in moderation and properly processed. However, ingestion of large quantities of cyanogenic glycoside-containing plants, especially those with high levels of cyanogenic glycosides and inadequate processing, can pose a risk of cyanide poisoning. To mitigate the risk of cyanide poisoning, it is essential to follow proper food preparation methods, such as soaking, fermenting and cooking, to reduce cyanogenic glycoside content in foods like cassava. Additionally, avoiding the ingestion of large quantities of stone fruit seeds or pits can help prevent cyanide poisoning from amygdalin and prunasin-containing fruits.

IV. Lectins

Lectins are a diverse group of proteins that bind to carbohydrates and are found in many plant foods, especially legumes (e.g., beans, lentils) grains (wheat, rice) and certain vegetables (tomatoes, potatoes). While lectins serve various biological functions in plants, including defense against pests and pathogens, some lectins are toxic and can cause gastrointestinal distress or interfere with nutrient absorption to humans if consumed in large quantities or if they are not properly cooked or prepared. Here's more information about toxic lectins:

1. **Phytohemagglutinins**: Phytohemagglutinins are a type of lectin found in raw or undercooked legumes, particularly red kidney beans. These lectins can cause gastrointestinal distress, including nausea, vomiting, diarrhea and abdominal pain, if beans are consumed without adequate cooking. Cooking beans at high temperatures (boiling for at least 10 minutes) effectively destroys phytohemagglutinins, making them safe to eat.
2. **Ricin**: Ricin is a highly toxic lectin found in the seeds of the castor (*Ricinus communis*). Ricin is one of the most potent plant toxins known and can cause severe toxicity if ingested, inhaled or injected. Symptoms of ricin poisoning include nausea, vomiting, diarrhea, abdominal pain, seizures, organ failure and death. Ricin has gained notoriety as a potential bioterrorism agent due to its toxicity.
3. **Wheat Germ Agglutinin (WGA)**: Wheat germ agglutinin is a lectin found in wheat and other grains. While WGA is generally not considered as toxic as some other lectins, it can still have adverse effects on the digestive tract and immune system. Some research suggests that WGA may contribute to intestinal inflammation and permeability, potentially exacerbating conditions like irritable bowel syndrome (IBS) and celiac disease.

It's important to note that lectins are a diverse group of proteins and not all lectins are toxic or harmful. In fact, some lectins may have health benefits, such as anti-cancer properties and immune modulation. Additionally, the toxicity of lectins can vary depending on factors such as the specific type of lectin, the dose consumed and individual sensitivity. Proper cooking methods, such as boiling, soaking and fermenting, can help reduce lectin content in foods and mitigate the risk of lectin-related toxicity. Additionally, consuming a varied diet that includes a balance of different plant foods can help minimize exposure to any single potentially harmful lectin.

V.Oxalates

Oxalates or oxalic acid are naturally occurring compounds found in many plants, including spinach, rhubarb and beets. Oxalates are generally considered harmless in small quantities; they can become problematic when consumed in large amounts or by individuals with certain health conditions. In high concentrations, oxalates can bind with calcium and form insoluble crystals, which may contribute to kidney stone formation in susceptible individuals.

Calcium Oxalate:

The most common form of oxalates found in plants is calcium oxalate. This compound forms insoluble crystals when it binds with calcium, leading to the formation of kidney stones in susceptible individuals. Foods high in oxalates include spinach, rhubarb, beets, nuts, seeds, chocolate, tea and certain fruits and vegetables. Individuals prone to kidney stones or with a history of calcium oxalate kidney stones are often advised to limit their intake of high-oxalate foods to help prevent stone formation.

Oxalate Poisoning:

While rare, oxalate poisoning can occur when large quantities of foods high in oxalates are ingested at once. Symptoms of oxalate poisoning may include abdominal pain, nausea, vomiting, diarrhea and in severe cases kidney damage. Poisoning can occur from consuming large amounts of rhubarb leaves, which contain high concentrations of oxalates and other toxic compounds.

Nutrient Absorption Interference:

Oxalates can also bind to minerals such as calcium and magnesium, forming insoluble complexes that reduce their absorption in the intestines. This may lead to nutrient deficiencies over time, particularly if someone relies heavily on foods with high oxalate content and has poor calcium intake from other sources.

While oxalates are naturally present in many plant foods and are generally safe for most people when consumed in moderation, individuals with certain health conditions, such as kidney stones, kidney disease or calcium-related disorders, may need to limit their intake of high-oxalate foods. Additionally, proper food preparation methods, such as boiling, blanching or cooking can help reduce oxalate content in some foods.

VI. Saponins

Saponins are naturally occurring compounds found in various plants, particularly in legumes including beans, peas and certain vegetables. Saponins are triterpene glycosides, meaning they consist of a sugar molecule attached to a non-sugar (aglycone) moiety. The aglycone portion of saponins is responsible for their biological activity. They have diverse biological functions in plants, including defense against pests and pathogens, some saponins can be toxic or harmful to humans and animals if consumed in large quantities or if not properly processed. They can cause gastrointestinal irritation and disrupt cell membranes in high concentrations. Here's more information about toxic properties of saponins:

1. **Hemolytic activity**: Many saponins have detergent-like properties and can cause hemolysis, the rupturing of red blood cells, when consumed in sufficient quantities. This can lead to symptoms such as nausea, vomiting, diarrhea and in severe cases, anemia or organ damage.
2. **Gastrointestinal disturbances**: Consumption of foods high in saponins may cause gastrointestinal disturbances in some individuals, including abdominal pain, bloating and flatulence.
3. **Interference with nutrient absorption**: Saponins may also interfere with nutrient absorption in the intestines by forming complexes with dietary proteins and minerals, such as iron and calcium, reducing their bioavailability.
4. **Toxicity in livestock**: Some saponin-containing plants, such as certain species of legumes and grains, can be toxic to livestock if ingested in large quantities. Livestock poisoning from saponin-containing plants may manifest as symptoms such as diarrhea, colic and respiratory distress.

Despite the potential risks associated with saponins, it's important to note that many saponin-containing foods are safe for human consumption when consumed in moderation and properly prepared. Cooking, soaking and fermentation can help to reduce the saponin content of foods and mitigate their potential toxic effects. Additionally, some research suggests that certain saponins may have health benefits, such as anti-inflammatory and antioxidant properties.

VII. Tannins

Tannins are diverse group of polyphenolic compounds found in various plant foods and beverages, including fruits, nuts, seeds, tea, coffee, wine and some vegetables. While they are not typically acutely toxic, high intake of tannins can interfere with nutrient absorption and contribute to digestive issues. Here's more information about toxic properties of tannins:

1. **Gastrointestinal disturbances**: Consuming large quantities of foods or beverages high in tannins may cause gastrointestinal disturbances in some individuals, including nausea, vomiting, diarrhea and stomach cramps. This is particularly true for people with pre-existing gastrointestinal conditions, such as irritable bowel syndrome (IBS) or inflammatory bowel disease (IBD).

2. **Interference with nutrient absorption**: Tannins can bind to dietary proteins and minerals, such as iron and zinc, forming insoluble complexes that reduce their absorption in the intestines. Prolonged consumption of tannin-rich foods may lead to nutrient deficiencies over time, particularly in individuals with marginal nutrient status.
3. **Inhibition of digestive enzymes**: Tannins may inhibit the activity of digestive enzymes, such as amylase and trypsin, which are involved in the breakdown of carbohydrates and proteins, respectively. This inhibition can interfere with the digestion and absorption of nutrients from food.
4. **Potential toxicity in livestock**: Certain tannin-rich plants, such as acorns and certain tree leaves, can be toxic to livestock if ingested in large quantities. Tannin toxicity in livestock may manifest as symptoms such as gastrointestinal distress, liver damage and impaired growth.

Some research suggests that moderate consumption of tannin-rich foods, such as tea and red wine, may have health benefits, including antioxidant and anti-inflammatory effects.

VIII. Myristicin and Safrole

Myristicin and safrole are two compounds found in certain spices like nutmeg and mace, as well as in sassafras, these compounds can be toxic in high doses and have psychoactive effects.

1. **Myristicin**: It is a natural organic compound found in plants such as nutmeg, parsley, dill and celery seed. It is a psychoactive substance with hallucinogenic properties. In small amounts, myristicin is generally considered safe for consumption and is commonly used as a flavoring agent in food. However, consuming large quantities of myristicin, such as that found in concentrated extracts or misuse of spices like nutmeg, can lead to toxic effects. Symptoms of myristicin toxicity may include nausea, vomiting, abdominal pain, dizziness, confusion, hallucinations and in severe cases, seizures or coma.
2. **Safrole**: It is a natural organic compound found in the essential oils of certain plants, including sassafras, nutmeg and cinnamon. It is commonly used as a flavoring agent in food and beverages. It has been classified as a carcinogen by the International Agency for Research on Cancer (IARC) due to evidence suggesting its carcinogenic potential in animal studies. In addition to its carcinogenic properties, high doses of safrole can cause liver damage and other toxic effects in humans.

Both myristicin and safrole are regulated by food safety authorities in many countries, and their use in food and beverages is subject to restrictions to minimize potential health risks. Individuals should exercise caution when using spices and essential oils containing myristicin and safrole and avoid consuming them in excessive amounts.

VIII. Cucurbitacin

Cucurbitacins are a group of naturally occurring structurally diverse triterpenes compounds found in plants of the Cucurbitaceae family which includes cucumbers, pumpkins, squash and melons. These plants are commonly consumed as part of the human diet, cucurbitacins can be toxic if consumed in large quantities or if certain wild or ornamental varieties are mistakenly ingested these compounds can cause gastrointestinal distress and even poisoning if consumed in large amounts. Here's more information about toxic properties of cucurbitacins:

1. **Bitterness**: Cucurbitacins are responsible for the bitter taste found in some varieties of cucumbers, squash and melons. While low levels of cucurbitacins are generally safe for consumption and may contribute to the flavor of certain foods, high concentrations can impart an extremely bitter taste and indicate potential toxicity.
2. **Toxicity**: Ingestion of high levels of cucurbitacins can lead to cucurbitacin poisoning, also known as "bitterness poisoning" or "cucurbit poisoning." Symptoms of cucurbitacin poisoning may include nausea, vomiting, diarrhea, abdominal pain, and gastrointestinal distress. In severe cases, cucurbitacin poisoning can cause dehydration, electrolyte imbalances and organ damage.
3. **Wild or Ornamental Varieties**: Some wild or ornamental varieties of cucurbits, particularly those with high levels of cucurbitacins, can pose a greater risk of toxicity if mistakenly consumed. These varieties may resemble edible cultivars but can contain significantly higher levels of cucurbitacins, leading to potential poisoning.

To reduce the risk of cucurbitacin poisoning, it is important to select and consume only cultivated varieties of cucurbits from reputable sources. Avoid consuming wild or ornamental varieties unless they have been positively identified as safe for consumption. Additionally, bitter-tasting fruits or vegetables should be discarded to avoid potential toxicity.

These toxins serve as defense mechanisms for plants against predators, but their consumption by humans or animals can lead to adverse effects ranging from mild gastrointestinal discomfort to severe poisoning or even death. It's important to note that many of these toxins are present in relatively small amounts in edible plants and are typically harmless when consumed in moderation as part of a balanced diet. However, proper preparation and cooking methods can help reduce their concentrations and mitigate their potential toxic effects.

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Volume: 04 Issue No: 05

THE CONTRIBUTION OF INNOVATION, RESEARCH AND TECHNOLOGY TO ACHIEVING FOOD SECURITY BY 2030

Article ID: AG-VO4-I05-11

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Abstract

Nine out of ten individuals suffer from malnutrition and most of these people reside in rural and underdeveloped nations. There is a alarming need to meet the nutritional requirement of these individuals. Food availability may be increased, for instance, via soil fertility improvement techniques, weather forecasting and irrigation technologies which are environment friendly, sustainable and also increases the food production. It is possible to solve the various aspects of food security using latest technology. Food accessibility can be addressed by post-harvest and agro-processing technologies. Food can be made more nutritious through biofortification and food instability can be lessened by climate-smart solutions based on science, technology and innovation, such as transgenic crops and early warning systems. Agriculture related to crops and livestock may be affected by new and developing technologies such as tissue engineering, micro-propagation and synthetic biology. Nevertheless, in order to fully utilise these technologies for ensuring food security, funding for R&D (research and development), infrastructure improvement and high human capital is necessary.

Keywords: Food security, Innovation, Environmental quality, Sustainable agriculture.

Introduction

Food Security, as the name implies, providing sufficient, safe and nutritious food to all people. It is one of the major global concerns historically and in the twenty-first century. Food security is usually framed in four dimensions namely : food availability, food accessibility, food utility and food stability (FAO, 2016a).Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life" (FAO, 2016b). Across all countries, people living in rural areas are the most exposed to food insecurity, owing to limited access to food and financial resources (FAO, 2015). Among them, 50 per cent are smallholder farmers, producing on marginal lands that are particularly sensitive to the adverse effects of weather extremes, such as droughts or floods. An additional 20 per cent are landless farmers, and 10 per cent are pastoralists, fishers and gatherers. The remaining 20 per cent live in the periphery of urban centres in developing countries. The demographics of hunger are tightly coupled with the demographics of poverty, where approximately 70 per cent of global poverty is represented by the rural poverty of smallholder farmers, many of whom are dependent on agriculture. The same applies to hunger and undernourishment that are prevalent in rural areas (IFOAM, 2015).

Challenges of Food security

1) **International trade:** In order to bring the production and supply of food products from agriculture in line with demand, international trade is needed. Because, it is feasible to obtain absolute and relative comparative cost advantages by trade which may improve the livelihoods of the farmers. Furthermore, trade evens out local production instability, which is expected to increase in times of weather extremes caused by climate change. However, trade can be a two edged sword, which can also result in worsening certain producers situations. World Trade Organization provides certain rules for international trade which have impact on agricultural production.

2) **Economic development:** Improving the income of smallholder farmers and providing social protection are key to the progress of any nation. Smallholder farmers are mostly challenged by the globalization and liberalization of markets, technological advances and climate change. Previously well-established systems of political, social, economic and environmental resilience are shifting. Food systems have also undergone a rapid transformation in recent years with

significant implications for people's diets due to various factors. Hence economic development is a major factor which helps in minimizing the hunger and poverty.

3) Environmental change and Agriculture: Agriculture is one of the largest drivers of environmental change and, at the same time, is the most affected by it. Agriculture is challenged by climate change with the related increase in natural disasters like droughts, floods, storms, pests and diseases which are the most relevant drivers of food insecurity. Furthermore, high dependence on a few crops to meet the food requirements, soil salinization, water scarcity, wind erosion, water erosion and loss of biodiversity create challenges for agricultural production.

Research and Innovative technologies to overcome food insecurity

Research and innovation can play a crucial role in producing more food by introducing plant varieties with improved traits, as well as optimizing the inputs needed to make agriculture more productive. Few such technologies include:

1. **Weather forecasting systems :** Famine early warning systems network (FEWSNET) created by United States agency for international development (USAID), cloud based global crop monitoring system called as Crop Watch and Sweden based Ignitia, UNITAR (United Nations Institute for Training and Research) and UNISAT (United Nations Institute for Satellite Applications) provides timely alerts on expected weather abnormalities, prepares monthly reports and maps of current or future food security. It also sends messages which helps the farmers to anticipate the rainfall for the next few hours. Other applications include mapping for disasters like droughts or floods, groundwater depletion and deforestation.

2. **Improved crop varieties :** Deploying of tissue culture techniques, micro-propagation and transgenic crops helps to meet the food insecurity problem. Plant tissue culture is one of the important biotechnology tool which helps in the cultivation of the crops with improved fibre, fuel and feed. Micro-propagation enables some rare and extinct species to be rescued and propagated. It also helps to face the challenges in food availability and allows to cope with fast growing human population in a restricted area of land. Transgenic refers to an organism or cell whose genome has been altered by the introduction of one or more foreign DNA sequences from another species by artificial means. Utilizing of transgenic crops offers a number of advantages such as tolerance to biotic and abiotic stresses, herbicide tolerance, insect and disease resistance and also minimizes the need of synthetic fertilizers.

3. Soil management : Increasing the use of biofertilizers and biopesticides instead of synthetic chemical fertilizers improves the soil physical and chemical conditions and thereby helps to attain higher productivity. Biofertilizers and biopesticides have emerged as environmental friendly approaches for supplementing the plant growth. These are organic products which contain concentrated forms of specific micro-organisms derived from the soil or the roots of the plants. They don't show any residual effect and are very target specific. The usage of bio-inputs help in restoring the fertility of soil and also provides a economical way to increase the yield of the crops, farmers income and also helps to balance the environment (Kavalekar *et al.*, 2013).

4. **Irrigation technologies :** About 70-80 % of freshwater is used for agriculture. Still many farmers don't have access to water due to water scarcity or insufficient human power to meet the water demand. Few solutions to face these challenges are using low cost drills to detect groundwater and make it accessible. Solar-powered or hydro-powered irrigation pumps could be effectively used to meet the irrigation needs in regions where manual irrigation pumps or motorized pumps with recurring fuel costs are out of reach or inadequate (Buluswar, 2014). Off-grid solar based EDR (electro dialysis reversal) systems removes minerals and salts from brackish water and helps in desalination. Low cost rain water storage systems are also a promising technology to address the irrigation needs (UNCTAD, 2010).

5. Technologies to access food : Biofortification which is the breeding of critical micronutrients and vitamins into staple crops has emerged as an effective approach for combating malnutrition in many developing countries. Biofortification as a global plant-breeding strategy is used for the enrichment of a variety of crops such as vitamin A-enriched cassava, maize, orange-fleshed sweet potatoes, iron and zinc-fortified rice, beans, wheat and pearl millet in over 40 countries. Not only this, value addition of the food which is grown in flood affected regions helps to improve the opportunities in selling the produce at higher prices and aids in better post harvest management.

Research and Innovation technologies for food security

Food security	Hurdles	Innovative techniques
Food availability	Abiotic and biotic stress	Growing salt tolerant crops, pest or disease resistant crops.
	Lower crop productivity	Tissue culture, micro-propagation, transgenic crops.
	Water scarcity	Micro-irrigation, water desalination

		techniques, irrigation scheduling and decision support systems, rain water harvesting, solar or hydro pumps.
	Loss of soil fertility	Organic fertilizers and pesticides, biogas digesters, soil micro-organism, enhancing nitrogen fixation
Food access	Post harvest loss	Fruit preservation technologies, nanotechnology, low cost solar dryers, crop threshers, agro-processing technologies
Food utilization	Lack of nutrients	Bio fortification and value addition
Food stability	Lack of weather information	Timely weather forecasting techniques, sensors to detect the crop stress, crop insurance

Development of innovative food systems

The food systems must become more inventive in order to utilize the science and technology for the numerous aspects of food security. This entails establishing a smallholder farmer-focused research agenda, putting money into human capacity, facilitating the development of food systems infrastructure, establishing suitable governance frameworks for agricultural innovation and enhancing the exchange of knowledge between farmers and scientists. An effective instrument for analyzing the ecology, infrastructure, and auxiliary systems that enable agricultural innovation is the agricultural innovation system (Fig 1). Farmers, research and education institutions, businesses (such as input suppliers, agricultural producers, processing, distribution, wholesale and retail), agricultural extension, government departments non-governmental and international players are among the important stakeholders. Designing and strengthening an agricultural innovation system involves promoting research and development, investing in infrastructure, building human capacity, creating an enabling environment and strengthening the knowledge flows, particularly among scientists and farmers. Innovative food systems should ideally support thrifty and pro-poor agricultural innovations, encourage smallholder farmers to participate in the process, acknowledge traditional and local knowledge systems, promote gender equity, and be directly connected to livelihoods and economic empowerment.

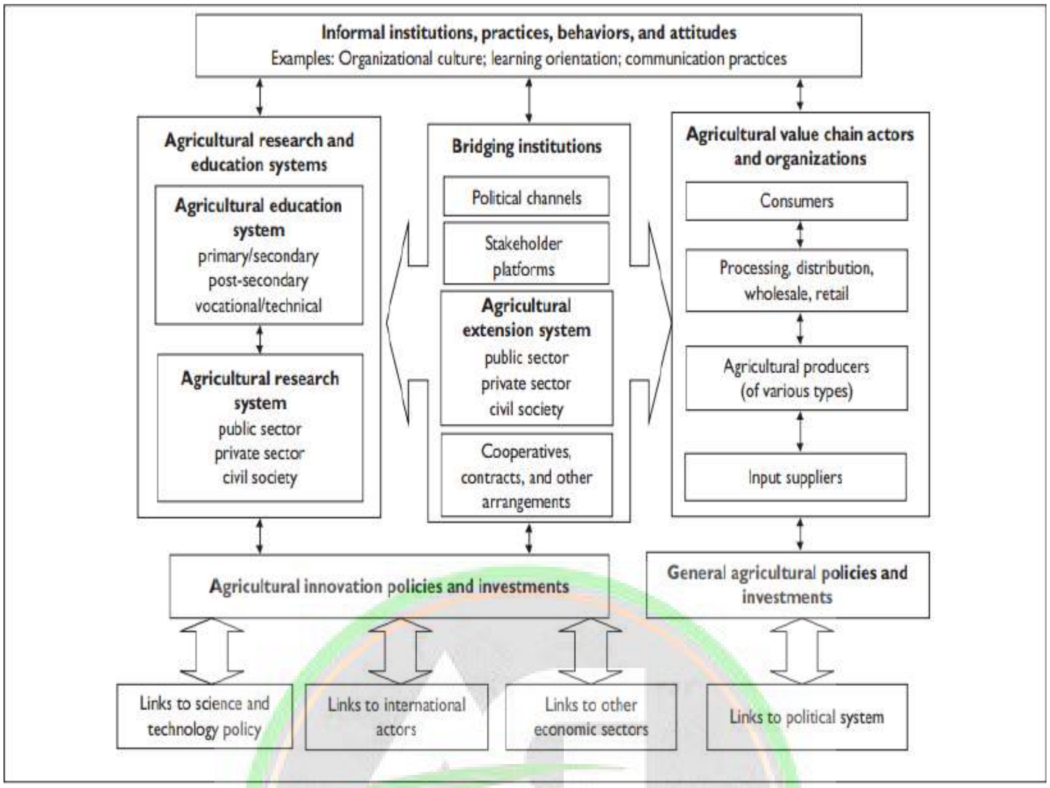

Fig 1: Framework of agricultural innovation system

Policymakers and other interested parties may use this analytical framework to examine the ways that the larger food system might be reinforced to facilitate the use of science and technology to address the issues related to food security.

Conclusion

Agriculture is at the heart of the discourse on employment, economic growth, and food security in many countries across the globe. There is now increasing recognition that agriculture needs to adopt sustainable practices to take into account the full costs and impacts of existing production practices. The emerging technologies have freed the farmers from the debt trap and have instilled in them a renewed sense of confidence to make farming an economically viable venture. Transgenic crops, biofortification, early warning systems, and advancements in soil and irrigation technology have unquestionably left a lasting impact on agriculture and food security worldwide. Over 40% of farmers worldwide have reaped significant benefits from these techniques, and this number is expected to rise significantly in the years to come. In short, research and innovation is undoubtedly, economically, socially, biologically and physiologically a profound need to meet the food security and food instability.

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Volume: 04 Issue No: 05

PROTEIN DEGRADATION MECHANISMS IN BIOLOGICAL ORGANISMS

Article ID: AG-VO4-I05-12

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Introduction

Proteins are complex macromolecules made up of amino acids linked together by peptide bonds. The structure and function of a protein are determined by its specific sequence of amino acids. Any change in this sequence can alter the protein's structure and function, potentially leading to diseases or disorders. They are essential biological molecules that perform an array of crucial functions in living organisms. They are crucial for the structure, function and regulation of the body's tissues and organs.

The importance of proteins in living organisms

1. Proteins serve as the building blocks of cells, tissues and organs. They provide structural support, integrity to cells and thereby help to maintain the shape and strength of various biological structures, including muscles, skin, hair, nails and connective tissues.
2. Many proteins act as an enzyme, which are biological catalysts that facilitate and regulate chemical reactions in cells. Enzyme plays a vital role in metabolism, energy production, digestion, cellular signaling and numerous other biochemical processes essential for life.
3. Certain proteins, such as hemoglobin in red blood cells, transport molecules like oxygen and carbon dioxide throughout the body. Other proteins, such as ferritin, store essential minerals like iron, ensuring their availability for cellular processes when needed.
4. Proteins serve as hormones, which are chemical messengers that regulate various physiological processes and maintain homeostasis. Hormonal proteins, such as insulin

and growth hormones, play crucial roles in metabolism, growth, development and reproduction.

5. Proteins are integral part of the body's immune system, serving as antibodies and immune system signaling molecules. Antibodies recognize and neutralize foreign invaders such as pathogens (e.g., bacteria, fungi, virus *etc*), while immune signaling proteins coordinate immune responses and inflammation to protect the body from infection and disease.
6. Proteins such as actin and myosin are essential for muscle contraction and movement. These proteins interact to generate the force required for muscle contraction, allowing organisms to move, maintain posture and to perform various physiological functions.
7. Proteins are involved in cellular communication and signaling pathways, transmitting signals from the external environment to the interior of cells and coordinating cellular responses. Signaling proteins regulate processes such as cell growth, differentiation, apoptosis and gene expression.
8. Proteins play a key role in gene expression and regulation, serving as transcription factors that bind to DNA and control the transcription of genes into messenger RNA (mRNA). These regulatory proteins influence which genes are turned on or off in response to internal and external signals, thereby influencing cellular functions and behaviors.
9. Proteins help maintain the balance of fluids in the body by exerting osmotic pressure, preventing excessive fluid buildup in tissues (edema).
10. Proteins are essential for tissue repair and regeneration. They contribute to wound healing, muscle repair, and the maintenance of skin, hair and nails.

Protein degradation and its importance

It is a crucial biological process that involves breaking down of proteins into smaller peptides or amino acids. This process is essential for regulating protein levels, removing damaged or misfolded proteins and recycling amino acids for the synthesis of new proteins. The key reasons highlighting the importance of protein degradation are as follows,

1. Protein degradation helps to regulate the abundance of specific proteins within the cells. By removing excess or unneeded proteins, cells can fine tune protein concentrations to meet their metabolic demands and respond dynamically to internal and external stimuli.
2. A Protein degradation mechanism helps to maintain the protein quality by eliminating misfolded, damaged or aberrant proteins. This ensures that only properly folded and

functional proteins are present in the cell, preventing the accumulation of toxic protein aggregates that can disrupt cellular processes and contribute to disease.

3. Protein degradation regulates the activity of signaling molecules involved in various cellular processes, including cell cycle progression, DNA repair, apoptosis and gene expression. Degradation of signaling proteins allows cells to finely tune signaling pathways and respond appropriately to environmental cues and stimuli.
4. Protein degradation plays a crucial role in metabolic adaptation by recycling amino acids from degraded proteins. These amino acids can then be used for protein synthesis, energy production or the synthesis of other biomolecules and thereby ensuring efficient resource utilization and metabolic flexibility.
5. Protein degradation is involved in cellular differentiation and development by regulating the turnover of proteins involved in cell fate determination, tissue morphogenesis and organ development. Proper control of protein degradation is essential for embryonic development, tissue remodeling and regeneration.
6. Protein degradation is integral to the immune response by regulating the turnover of immune signaling molecules, antigen processing and presentation, and the elimination of intracellular pathogens. Dysfunction of protein degradation pathways can impair immune function and increase susceptibility to infections and autoimmune diseases.
7. Protein degradation has been implicated in the aging process and longevity. Enhanced protein quality control mechanisms, including protein degradation pathways such as autophagy and the ubiquitin-proteasome system have been associated with increased lifespan and improved health span in various model organisms.
8. Dysregulation of protein degradation pathways has been linked to the pathogenesis of numerous diseases, including neurodegenerative disorders (e.g., Alzheimer's disease, Parkinson's disease), cancer, metabolic disorders and cardiovascular diseases. Understanding and targeting protein degradation pathways have therapeutic implications for the treatment of these diseases.

Protein degradation mechanisms

Protein degradation occurs through several mechanisms, primarily carried out by specialized cellular machinery. The overview of the protein degradation process is as follows,

1. **Ubiquitin-Proteasome System (UPS)**

- The UPS is the primary pathway for the degradation of short-lived or damaged proteins in eukaryotic cells.
- It involves the tagging of target proteins with a small protein called ubiquitin, which marks them for degradation.
- The ubiquitinated proteins are recognized and degraded by a large multi-subunit protein complex called the proteasome.
- The proteasome acts as a molecular shredder, breaking down ubiquitinated proteins into short peptides and releasing them for recycling.

Components of the UPS:

a. Ubiquitin: It is a small protein that becomes covalently attached to target proteins destined for degradation. This process, called ubiquitination, involves a cascade of enzymatic reactions mediated by three classes of enzymes: ubiquitin-activating enzymes (E1), ubiquitin-conjugating enzymes (E2) and ubiquitin ligases (E3). Ubiquitin contains multiple lysine residues that can form polyubiquitin chains, providing versatility in targeting proteins for degradation.

b. Proteasome: It is a large, multi-subunit protein complex responsible for degrading ubiquitinated proteins. The proteasome consists of a core particle, or 20S proteasome, and regulatory particles, or 19S regulatory particles (PA700 in mammals). The 19S regulatory particles recognize and bind to ubiquitinated proteins, unfold them, and translocate them into the central chamber of the 20S proteasome, where they are degraded into short peptides.

Mechanism of Protein Degradation:

a. Ubiquitination: Target proteins are tagged for degradation by the covalent attachment of ubiquitin molecules. This process involves the sequential action of E1, E2, and E3 enzymes, resulting in the formation of an ubiquitin chain linked to lysine residues on the target protein.

b. Recognition and unfolding: Ubiquitinated proteins are recognized and bound by the 19S regulatory particles of the proteasome. The 19S particles contain ATPases that unfold the substrate protein and translocate it into the central chamber of the 20S proteasome.

c. Degradation: Once inside the 20S proteasome, the substrate protein is degraded into short peptides by the proteolytic activity of multiple protease subunits. The resulting peptides are released into the cytoplasm for recycling.

Regulation of the UPS:

The UPS is tightly regulated at multiple levels to ensure its proper function and specificity. Regulation occurs through various mechanisms, including the activity of ubiquitin ligases, deubiquitinating enzymes (DUBs) that remove ubiquitin from substrates and post-translational modifications of UPS components. Additionally, UPS activity can be modulated by cellular signaling pathways, environmental cues, and changes in protein folding or stability.

Functions of the UPS:

a. Protein Quality Control: The UPS selectively degrades misfolded, damaged or aberrant proteins, preventing their accumulation and aggregation, which can lead to cellular dysfunction and disease.
b. Regulation of Protein Levels: The UPS regulates the levels of specific proteins involved in various cellular processes, including cell cycle progression, DNA repair, apoptosis, transcriptional regulation and signal transduction. This allows cells to respond dynamically to internal and external stimuli.
c. Cellular Signaling: The UPS plays a critical role in cellular signaling pathways by controlling the abundance and activity of key signaling molecules, such as transcription factors, cell cycle regulators and oncoproteins. Ubiquitin-mediated degradation can target signaling proteins for activation, inactivation, or degradation, influencing cellular responses to stimuli.
d. Antigen Presentation: The UPS is involved in the processing and presentation of antigens by major histocompatibility complex (MHC) molecules, which is essential for the immune system's recognition and response to pathogens and foreign invaders.

Importance of the UPS:

Dysregulation of the UPS has been implicated in various diseases, including neurodegenerative disorders, cancer, autoimmune diseases, and metabolic disorders. Therefore, understanding the mechanisms and regulation of the UPS has significant implications for human health and disease.

2. **Autophagy**
   - Autophagy is a cellular process that involves the degradation and recycling of cellular components, including proteins, organelles and macromolecules.
   - While autophagy primarily targets damaged or dysfunctional organelles and cellular debris, it also plays a crucial role in protein degradation, especially when the ubiquitin-proteasome system (UPS) is overwhelmed or impaired.
   - During autophagy, a double-membrane structure called the autophagosome forms around cellular material targeted for degradation. The autophagosome fuses with lysosomes, which contain hydrolytic enzymes, forming an autolysosome. Within the autolysosome, the engulfed material is broken down by lysosomal enzymes, and the resulting breakdown products, including amino acids, are released into the cytoplasm for reuse.

Contribution of autophagy to the protein degradation process:

1. **Selective autophagy of proteins:**

- Autophagy can selectively target specific proteins for degradation through specialized autophagic pathways known as selective autophagy.
- Selective autophagy receptors, such as p62/SQSTM1 and NBR1, recognize ubiquitinated proteins and organelles and facilitate their sequestration into autophagosomes for degradation.
- These receptors contain ubiquitin-binding domains that interact with ubiquitinated substrates, allowing them to be recognized and engulfed by autophagosomes.

2. **Bulk degradation of proteins:**

- In addition to selective autophagy, autophagy also contributes to the bulk degradation of proteins under conditions of nutrient deprivation, stress or prolonged fasting.
- During autophagy, portions of the cytoplasm, including soluble proteins, are engulfed by double-membrane structures called autophagosomes, forming autophagic cargo.
- Autophagosomes then fuse with lysosomes, acidic organelles containing hydrolytic enzymes, forming autolysosomes. Within autolysosomes, the engulfed material, including proteins, is degraded by lysosomal proteases, releasing amino acids for reuse by the cell.

3. **Regulation of protein homeostasis:**

- Autophagy helps maintain protein homeostasis by removing excess or aggregated proteins, preventing their accumulation and aggregation, which can lead to cellular dysfunction and disease.

- Autophagy also contributes to the turnover of long-lived proteins and ensures the quality control of newly synthesized proteins, thereby regulating cellular proteostasis.

4. Interaction with the Ubiquitin-Proteasome system:

- Autophagy and the UPS are interconnected pathways that coordinate protein degradation and maintain cellular homeostasis.
- Under normal conditions, the UPS primarily targets short-lived or misfolded proteins for degradation, while autophagy handles the turnover of long-lived proteins and organelles.
- However, under conditions of proteotoxic stress or impairment of the UPS, autophagy can be upregulated to compensate for the increased load of misfolded or aggregated proteins.

5. Implications for Health and Disease:

- Dysregulation of autophagy-mediated protein degradation has been implicated in various diseases, including neurodegenerative disorders, cancer, metabolic diseases, and aging.
- Defective autophagy can lead to the accumulation of protein aggregates, oxidative damage, and cellular dysfunction, contributing to the pathogenesis of diseases such as Alzheimer's disease, Parkinson's disease and Huntington's disease.

By removing damaged proteins and organelles, autophagy plays a key role in cellular quality control and contributes to the prevention of protein aggregation and cellular dysfunction. Understanding the mechanisms and regulation of autophagy-mediated protein degradation has significant implications for human health and disease.

3. **Lysosomal Degradation**

    - Lysosomal protein degradation is a cellular process that involves the degradation of proteins within lysosomes,
    - Lysosomes are membrane-bound organelles containing a variety of hydrolytic enzymes, including proteases, nucleases and lipases.
    - Lysosomal degradation involves the direct targeting of proteins to lysosomes for degradation. It is essential for maintaining cellular homeostasis, regulating protein turnover and eliminating unwanted or damaged proteins.
    - This pathway is particularly important for the turnover of long-lived proteins, extracellular proteins and organelles such as mitochondria (a process known as mitophagy).

Lysosomal protein degradation works as follows,

1. **Protein delivery to lysosomes:**
   - Proteins targeted for degradation are typically delivered to lysosomes through various pathways, including endocytosis, autophagy and phagocytosis.
   - In endocytosis, extracellular proteins or membrane receptors are internalized into vesicles called endosomes, which mature into late endosomes or multivesicular bodies (MVBs). MVBs eventually fuse with lysosomes, delivering their cargo for degradation.
   - In autophagy, cytoplasmic components, including proteins, organelles and macromolecules are engulfed by double-membrane structures called autophagosomes. Autophagosomes then combine with lysosomes, forming autolysosomes where the engulfed material is degraded.
   - In phagocytosis, foreign particles, such as bacteria or cellular debris, are engulfed by phagosomes, which subsequently fuse with lysosomes, leading to the degradation of the phagosomal contents.
2. **Protein degradation within lysosomes:**
   - Once delivered to lysosomes, proteins are broken down into smaller peptides and amino acids by hydrolytic enzymes, including various proteases, nucleases, lipases and glycosidases.
   - Lysosomal proteases, such as cathepsins, cleave peptide bonds within proteins, resulting in the generation of short peptides and free amino acids.
   - The acidic pH environment within lysosomes (pH ~ 4.5 to 5) is optimal for the activity of lysosomal enzymes, facilitating protein degradation.
3. **Regulation of lysosomal protein degradation**:
   - Lysosomal protein degradation is tightly regulated to ensure proper protein turnover and maintain cellular homeostasis.
   - Regulation occurs at multiple levels, including transcriptional control of lysosomal enzyme genes, post-translational modifications of lysosomal proteins and trafficking of lysosomal vesicles.
   - Lysosomal function can be modulated by various cellular signaling pathways, environmental cues, and stress conditions, such as nutrient availability, oxidative stress, and lysosomal pH.

4. Role in cellular homeostasis and disease:

- Lysosomal protein degradation plays a critical role in maintaining cellular homeostasis by removing damaged or misfolded proteins, clearing protein aggregates, and recycling amino acids for protein synthesis.
- Dysfunction of lysosomal protein degradation has been implicated in various diseases, including lysosomal storage disorders, neurodegenerative diseases, cancer and metabolic disorders.
- Mutations in lysosomal enzymes or defects in lysosomal trafficking pathways can impair protein degradation, leading to the buildup of undegraded proteins and cellular dysfunction.

Understanding the mechanisms and regulation of lysosomal protein degradation is necessary for elucidating its roles in health and disease and developing therapeutic interventions for lysosomal storage disorders and other related conditions.

Proteins are essential molecules that support virtually all biological processes and are important for the structure, function and regulation of cells and organisms. A balanced and diverse diet rich in protein sources is vital for maintaining optimal health and supporting the body's physiological functions. Like protein synthesis, its degradation also plays a vital role in maintaining cellular homeostasis, regulating cellular processes and ensuring the proper functioning of cells. Dysregulation of protein degradation pathways has been implicated in various diseases, including neurodegenerative disorders, cancer and metabolic diseases. Therefore, understanding the mechanisms of protein degradation is essential for developing therapeutic interventions targeting these pathways.

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Volume: 04 Issue No: 05

PLANT GROWTH PROMOTING POTENTIAL OF KERATINOLYTIC BACTERIA

Article ID: AG-VO4-I05-13

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Introduction

Feathers are produced in large amounts as a waste by-product of poultry processing plant. A current value-added use for feathers is the conversion to feather meal, a digestible dietary protein for animal feed, using physical and chemical treatments. These methods can destroy certain amino acids and decrease protein quality and digestibility. Keratinolytic microorganisms and their enzymes may be used to enhance the digestibility of feather keratin. They may have important applications in processing keratin-containing wastes from poultry and leather industries through the development of non-polluting methods Chauhan and Devi (2020). A number of keratinolytic microorganisms have been reported, including some species of *Bacillus*, actinomycetes, and fungi. Generally, an increase in keratinolytic activity is associated with thermophilic organisms, which require high energy inputs to achieve maximum growth and the decomposition of keratin wastes (Devi et al. 2022).

Keratinolytic bacteria are a unique group of microorganisms capable of breaking down keratin, a fibrous protein found in animal tissues such as skin, hair, and feathers Sharma and Devi (2019). While their primary role is to decompose keratinaceous materials in nature, some keratinolytic bacteria (Table 1) also exhibit plant growth-promoting (PGP) potential (Tamreihao et al 2017) as depicted in Figure 1.

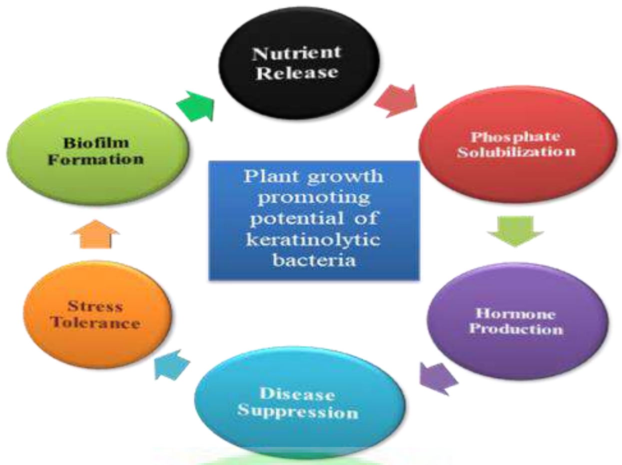

Figure 1. Plant growth promoting potential of keratinolytic bacteria

Nutrient Release: Keratinolytic bacteria degrade keratin into simpler nitrogenous compounds like amino acids and peptides, which can serve as a nitrogen source for plants. Nitrogen is a crucial nutrient for plant growth and development.

Phosphate Solubilization: Some keratinolytic bacteria can solubilize phosphate from insoluble sources in the soil, making it available for plant uptake. Phosphorus is another essential nutrient required for various plant metabolic processes.

Hormone Production: Certain keratinolytic bacteria can produce plant growth-promoting hormones like auxins, cytokinins, and gibberellins. These hormones can stimulate root growth, increase nutrient uptake, and enhance overall plant growth and development.

Disease Suppression: Some studies suggest that certain keratinolytic bacteria can suppress soil-borne plant pathogens by competing for nutrients or producing antifungal compounds, thereby indirectly promoting plant growth by reducing disease incidence.

Stress Tolerance: Keratinolytic bacteria may enhance plant tolerance to abiotic stresses such as drought, salinity, and heavy metal toxicity by various mechanisms, including the production of osmoprotectants, antioxidants, and enzymes that detoxify harmful compounds.

Biofilm Formation: Some keratinolytic bacteria can form biofilms on plant roots, providing a protective barrier against pathogens and promoting nutrient uptake by increasing the root surface area.

Table 1. Few examples of keratinolytic bacteria exhibiting PGP potential

Bacteria	PGP activities	References
Amycolatopsis sp.	IAA production, P solubilization Ammonia production	Tamreihao et al. 2017
Bacillus subtilis	IAA production P solubilization Ammonia production Antifungal	Bhange et al. 2016
Stenotrophomonas maltophilia	Antifungal IAA production Ammonia production	Jeong et al. 2010

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Volume: 04 Issue No: 05

COMAMMOX

Article ID: AG-V04-I05-14

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Introduction

Comammox (COMplete AMMonium Oxidation) bacteria are a fascinating group of microorganisms that can carry out a complete nitrification process. Nitrification is a vital part of the nitrogen cycle, where ammonia (NH_3) is converted to nitrite (NO_2^-) and then to nitrate (NO_3^-). Since the first discovery of nitrifying microorganisms by Sergei Winogradsky (Winogradsky 1891), it was believed that nitrification is a two-step process performed by two distinct functional groups, the ammonia- and nitrite-oxidizing bacteria (AOB and NOB, respectively). However, comammox possesses genes related to both ammonia oxidation and nitrite oxidation (Lawson and Lücker, 2018). This unique metabolic pathway makes comammox bacteria different from other canonical nitrifiers (Palomo et al., 2018).

Comammox bacteria belong to the phylum Nitrospirae within the domain Bacteria. The genus containing comammox bacteria is Nitrospira. Within the genus Nitrospira, there are several species, some of which include *Nitrospira inopinata*, *Nitrospira japonica*, and *Nitrospira moscoviensis*. Comammox bacteria are a relatively recently discovered group within the Nitrospira genus, characterized by their ability to perform complete nitrification, oxidizing ammonia to nitrate in a single organism. Since the identification of archaeal ammonia oxidizers, numerous studies have focused on their environmental distribution, physiology, and genomics to elucidate their ecological significance and potential factors for niche differentiation between AOA and their bacterial counterpart (Prosser and Nicol 2012).

Comammox bacteria are distinct from traditional nitrifying bacteria, such as ammonia-oxidizing bacteria (AOB) and nitrite-oxidizing bacteria (NOB), as they possess the genetic machinery to carry out both steps of nitrification within a single organism (Annavajhala et al., 2018). This unique capability has significant implications for our understanding of nitrogen cycling in various environments and has led to their classification as a separate functional group within the broader context of nitrifying microorganisms.

Comammox bacteria play a crucial role in the environment by contributing to the nitrogen cycle, specifically in the process of nitrification. Nitrification is essential for converting ammonia (NH_3), which is often a product of biological processes such as decomposition of organic matter and excretion by organisms, into nitrate (NO_3^-), a form of nitrogen that can be readily used by plants.

How comammox bacteria works in environmental nitrogen cycle:

Ammonia Oxidation: Comammox bacteria possess the enzyme ammonia monooxygenase, allowing them to oxidize ammonia to nitrite (NO_2^-). This step is typically carried out by specialized ammonia-oxidizing bacteria (AOB), but comammox bacteria can perform it as well.

Nitrite Oxidation: Following the conversion of ammonia to nitrite, comammox bacteria further oxidize nitrite to nitrate (NO_3^-). This step is traditionally performed by nitrite-oxidizing bacteria (NOB). By performing both ammonia and nitrite oxidation, comammox bacteria bypass the need for separate organisms to carry out these processes.

Complete Nitrification: The ability of comammox bacteria to perform both steps of nitrification within a single organism is a significant advancement in our understanding of nitrogen cycling in the environment. It streamlines the process and may have implications for the efficiency and stability of nitrogen cycling in various ecosystems.

Applications of comammox bacteria:

Wastewater Treatment: Comammox bacteria could play a role in improving the efficiency and effectiveness of biological nitrogen removal processes in wastewater treatment plants. By harnessing the complete nitrification capability of comammox bacteria, it may be possible to optimize nitrogen removal from wastewater, leading to better treatment outcomes and reduced environmental impact.

Agricultural Nitrogen Management: Understanding the ecology and activity of comammox bacteria in agricultural soils could aid in developing sustainable nitrogen management practices.

By promoting the activity of comammox bacteria, farmers may be able to enhance nitrogen cycling in soils, potentially reducing the need for synthetic nitrogen fertilizers and mitigating environmental pollution associated with nitrogen runoff.

Bioremediation: Comammox bacteria may have potential applications in bioremediation efforts aimed at cleaning up environments contaminated with nitrogen compounds, such as nitrate or ammonia pollution. By facilitating the conversion of these compounds to less harmful forms, comammox bacteria could contribute to environmental restoration efforts.

Microbial Ecology Research: Studying comammox bacteria and their interactions with other microorganisms in various environments can provide valuable insights into microbial community dynamics and ecosystem processes. This research could lead to a better understanding of nitrogen cycling and ecosystem functioning, with broader implications for environmental management and conservation. It's important to note that while the potential applications shown in fig-1 of comammox bacteria are promising, further research is needed to fully understand their ecology, physiology, and practical implications.

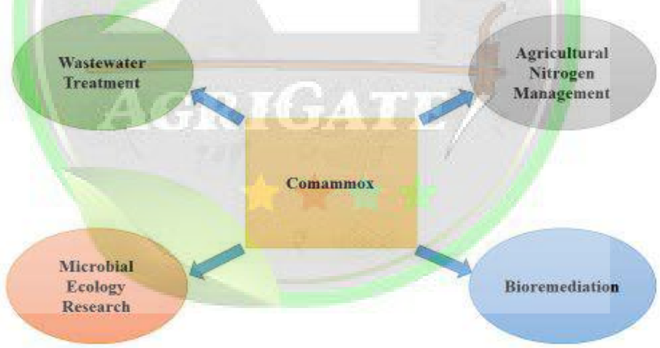

Fig 1- Applications of comammox bacteria

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Volume: 04 Issue No: 05

INDIAN CORAL AN AGROFORESTRY TREE FODDER

Article ID: AG-V04-I05-15

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Introduction

Indian Coral Tree, botanically called *Erythrina variegata* (2n: 42 & 44) belonging to legume family Fabaceae and sub family Papilionoideae is a showy, spreading tree legume with brilliant red blossoms. *Erythrina variegata* is widely cultivated throughout the tropics, but especially in India, as an ornamental tree, a living fence, hedge plant, medicinal plant, shade tree and for soil conservation. It is often a component of agroforestry systems and all over South and South East Asia and the Pacific islands is seen as a valuable multipurpose tree. *Erythrina variegata* has a very large distribution in the tropics and has been introduced into a large number of countries through cultivation. This highly valued ornamental has been described as one of the gems of the floral world. It is a picturesque, broad and spreading, deciduous tree that can get 60-80 ft tall and spread 20-40 ft. It has many stout branches that are armed with black tiger's claw spines. It is also called Flame of Forest.

BOTANICAL DESCRIPTION OF INDIAN CORAL TREE

Habitat: It is widely found on Coastal lowland bush and shrub land areas and the dry edges of mangrove forests, usually on sandy loams; at elevations up to 500 metres. Succeeds in tropical, subtropical and warm temperate areas with an elevation up to 1,200 metres. Plants grow best in areas where the annual rainfall is in the region of 800 - 1,500mm, the mean minimum temperature is around 20°C and the mean maximum temperature is 32°C. Succeeds in moderately fertile and well-drained soil. Plants are tolerant of salt-laden winds and moderate levels of salt in the soil.

Habit: *Erythrina variegata* is a much-branched deciduous tree growing from 3 - 27 metres tall. It has a fluted bole, the thick and sappy bole and branches are armed with large, scattered prickles, though cultivated forms are often unarmed.

Root: Rooting is superficial, with most roots in the upper 30 cm of the soil; older trees, however, root deeper. It forms root nodules and fixes atmospheric nitrogen with *Bradyrhizobium* bacteria.

Stem: Stem with fluted bole and much branched crown; trunk and branches thick and sappy. The smooth bark is streaked with vertical lines of green, buff, grey and white. Small black prickles cover the stem and branches. These become longer if the tree suffers moisture stress. They typically drop off as the girth of the stem expands. The prickles are large, scattered and black tiger's claw curved spines.

Leaves: Leaves alternate, trifoliolate; stipules lanceolate, 1-1.5 cm long, caducous; petiole 2-28 cm long, unarmed; rachis 10-12 cm long; petiole up to 1.5 cm long, at base with globose glandular stipels; leaflets ovate to broadly rhomboid, usually wider than long, 4-25 cm x 5-30 cm, terminal one largest, base rounded or slightly cordate, apex acuminate, entire or sometimes shallowly lobed, thinly coriaceous, green or sometimes strikingly variegated, light green and yellow, glabrescent.

Inflorescence: An axillary, dense raceme 10-40 cm long, ferruginous tomentose, lateral near the top of branchlets; peduncle 7-25 cm long, suited to birds hopping and poking into the flowers.

Flower: Flowers are bisexual in groups of three, scattered along the rachis, large, bright red, occasionally white. The flowers are upturned, which prevents nectar to be dropped.

Calyx: Eventually deeply spathaceous, oblique, recurved, split to the base on one side, five toothed at the tip; 2-4 cm long, glabrescent, red.

Corolla: Standard ovate-elliptical, 5-8 cm x 2.5-3.5 cm, more than twice as long as wide, shortly clawed, longitudinally conduplicate, recurved, bright red without white veins; wings and keel subequal, falcate, free,1.5-2.5 cm long, red.

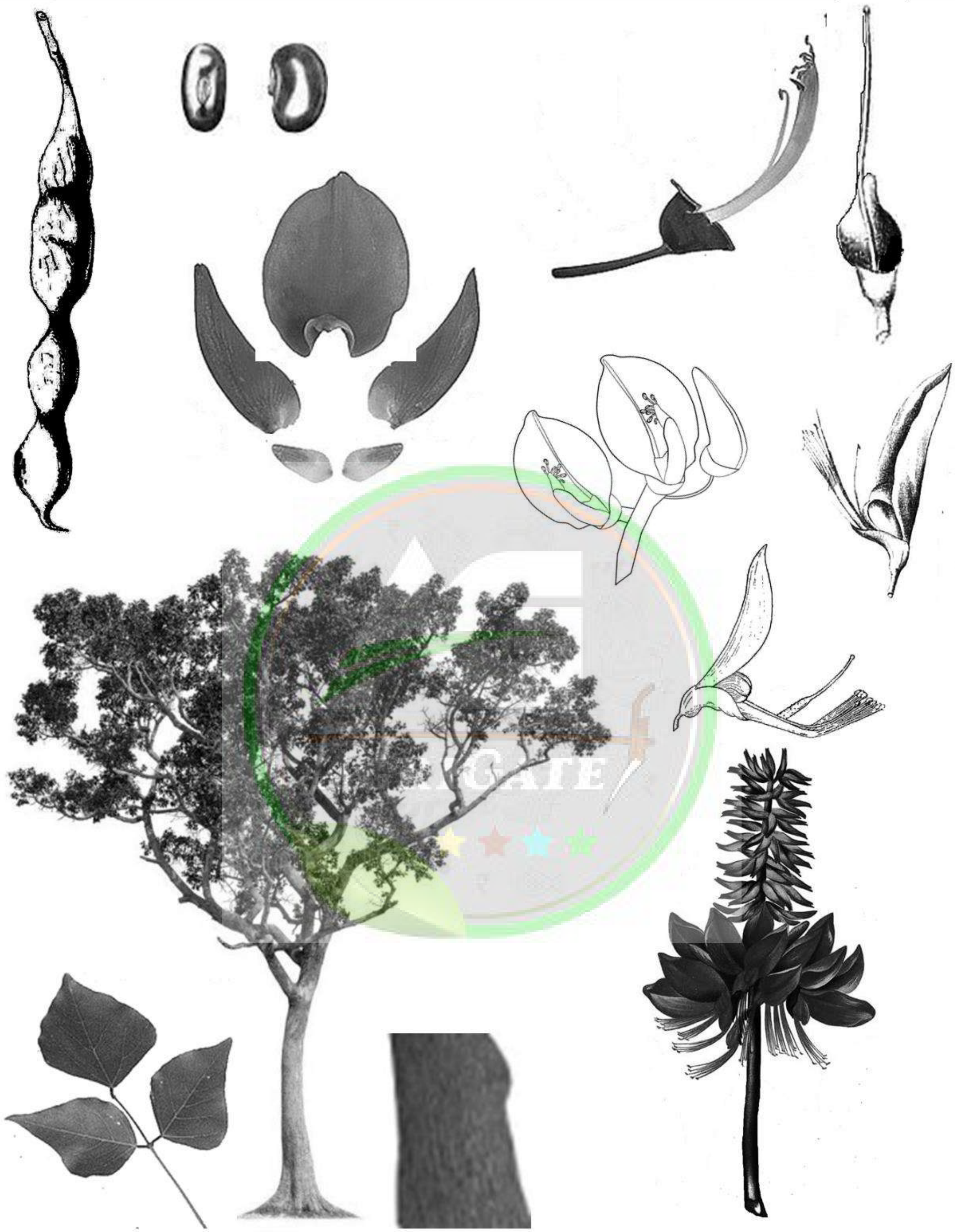

Fig. 1. Indian Coral tree (*Erythrina variegata*) botanical illustration

Androecium: Stamens 10, monadelphous, alternately longer and shorter, vexillary filament free; anthers uniform; vexillar stamen basally connate with the tube for 1 cm, red.

Gynoecium: Ovary stipitate, inferior, pubescent,1-celled, ovules many; style curved, subulate at the apex, not bearded; stigma capitate.

Fruit: Pod sausage-shaped or long cylindrical, 10-45 cm x 2-3 cm, 1-13-seeded, slightly constricted between the seeds, glabrescent, distinctly veined and exocarp bursting irregularly, indehiscent.

Seed: Seed ellipsoid to reniform, 6-20 mm x 5-12 mm, smooth, glossy black, purplish or purplish red-brown.

Pollination: *Erythrina variegata* is a cross-pollinated tree species that are commonly pollinated by perching birds (passerines) and hummingbirds. *E. variegata* has the typical 'bird flowers' scentless, strong and elastic to withstand birds hopping about and poking into the flowers. The flowers in the drooping inflorescences are upturned, which prevents the copious nectar from running out. The flowers remain open for two or three days, but stop secreting nectar after the morning of the first day.

Center of origin: *Erythrina variegata* is native of coastal forests in Southeast Asia and is widespread around the Indian Ocean from East Africa to South-East Asia and North Australia, and in the Pacific Islands to the Marquesas.

Related Species:

1. *Erythrina caffra*
2. *Erythrina fusca*
3. *Erythrina herbacea*
4. *Erythrina crista-galli*
5. *Erythrina lysistemon*
6. *Erythrina coralloides*
7. *Erythrina tajumulcesis*
8. *Erythrina poeppigiana*
9. *Erythrina vespertilio*

CULTIVATED TYPES OF INDIAN CORAL TREE

1. *Erythrina variegata* var. *variegata*: Commonly called Indian Coral Tree. It is a spreading tropical and subtropical tree legume, renowned as an ornamental for its conspicuous red blossoms. In India, it is one of the most used forage tree legume used as fodder for small ruminants.

2. ***Erythrina variegata* var. *orientalis*:** This is a wild form of coral tree commonly called Orientalis Coral tree. This fast-growing, 50 feet tall and wide deciduous tree with green and yellow-variegated, six-inch-long leaves creates a broad canopy but has spiny branches. Flowers are red in colour.

2. ***Erythrina variegata* var. *alba*:** This is also a wild form of Coral tree and commonly called Blakes Coral tree. It similar to orientalis coral tree but with scarlet or white flowers and black seeded.

USES OF INDIAN CORAL TREE

1. The young tender leaves and young sprouts are eaten as vegetable and in curries.
2. The bark is used as an astringent, anthelmintic, antipyretic to treat intermittent fever, rheumatism and asthma.
3. The decoction of leaves is used as a sedative to cure insomnia and nervous problems.
4. The crushed seeds are a remedy for snake bites.
5. It is grown as a hedgerow plant along the contour lines to prevent soil erosion.
6. It is thorny and hence grown as live fence trees to provide boundary and livestock proof hedges.
7. Coral tree is also grown as shade tree cocoa and coffee.
8. The tree is also grown as green leaf manure crop.
9. Its leaf makes excellent soil mulch and enrich the soil nutrients.
10. It is also grown as live support for betel vine, black pepper, jasmine, grapes and vanilla plantations.
11. As a columnar cultivar grown as wind breaks and protect other wind susceptible crops like banana.
12. The white wood after dying is ground into powder and used as face powder.
13. The bark yields a pale yellow fibre that is excellent for cordage.
14. The soft spongy white wood is used for making spears, shields, troughs, outriggers for canoes and as floats in fishing nets.
15. The soft wood is used for fine wood carving for making statues and toys.
16. The wood pulp is used in paper industries.

17. The wood can burn for a long time without going out and so it is traditionally used for keeping a fire in the house.
18. It is grown as an ornamental tree in botanical gardens and public places, owing to its beautiful leaves and showy flowers.
19. It is often included as a tree component in agroforestry system.
20. The blackened dried leaves are worn for their scent.
21. Coral tree when grown on heavy metal polluted soils can remove Cadmium and Zinc and thereby reclaim industrially polluted lands.
22. In Vietnam its leaves are used to wrap fermented meat.
23. The wood is also used for making packing boxes and picture frames.
24. Coral tree are moderately fire resistant and can act as fire breakers during incidence of occasional fire.

FORAGE VALUE OF INDIAN CORAL TREE

Green fodder:

Coral tree has thus great potential for goat feeding. *Erythrina variegata* foliage is a good protein source for livestock as the leaves contain high levels of protein. It shows a high intake potential for goats fed tropical forages, and could be a possible alternative protein source to soybean meal or other concentrate feed. Coral tree is one of the most widely used forage tree legume for small ruminants such as goat and rabbits. Its folliage contains relatively high protein content that makes it an excellent feed for most livestock. The tree has to be pollarded once in a year to a height of two to three meters to produce a spreading crown. The pruned leaves can be spread as mulch in the plantations. Coral tree foliage remains green even during dry season, when feed scarcity is a problem for the farmers. Coral tree can be pruned for green forage three to four times a year, producing 15-50 kg green fodder annually depending on growing conditions. Under well managed and irrigated condition an yield up to 100 kg per tree per year is also possible.

Palatability:

Coral tree foliage is highly palatable for goat and rabbits. In goat it has high intake characteristics of 550 g of organic matter per day, Protein digestibility of 73% and nitrogen retention of 24% when fed to rabbits. When fed in a ration of 25-50% of the rabbit daily requirement as a supplement to a concentrate, provided better growth and carcass performance.

Toxicity:

The leaves and bark contain erythrinine, a poison that act upon the nervous system of mammals. Its leaves, bark and seed contains Saponin, which is also poisonous, but it is poorly absorbed by the gut of ruminants. The low concentration of alkaloids has narcotic properties in ruminants when fed in higher ration. The leaves also contain condensed tannins to a concentration of 20 g per kg of leaf dry matter.

Nutritional value:

On dry weight basis coral tree leaves contain crude protein 21%, crude fibre 27%, Neutral detergent fibre 47%, Acid detergent fibre 32%, lignin 11% and mineral ash 19%. Coral leaves are rich in calcium, Zinc and Iron. The organic matter digestibility in ruminants is 625, while nitrogen digestibility 92% and dry matter degradability is 58% in ruminants. Digestible crude protein was 18% and total digestible nutrients 61% .

ADVANTAGES OF INDIAN CORAL TREE

1. Very easy to grow from cuttings with even quite large branches. Stakes thrust into the ground readily take roots.
2. Fixes atmospheric nitrogen and enriches the cultivated soil.
3. It has open crown that do not restrict light and hence it grows quickly.
4. It is quite thorny and can provide impenetrable barrier to protect from unwell come intrusions.
5. It can tolerate salt laden winds and moderate levels of salt in the soil.
6. It can tolerate acidity as well as alkalinity that is in the pH range of 4.5 to 8.
7. The tree can live up to 100 years
8. It is drought tolerant and can tolerate several months of dry season.
9. It needs almost no water when it is leafless in the winter.
10. Can come up well from light to heavy soils including sands, loams and clay soils and its intermediaries.
11. Can tolerate seasonal water logged conditions.
12. It is somewhat fire resistant and can serve as a fire breaker.
13. It can do well in windy situations
14. It is also suited for home garden.

LIMITATIONS OF INDIAN CORAL TREE

1. The leaves and seeds contain low concentration of erythrinine, and saponins and can cause neural afflictions in animals if fed in large quantities.
2. It act as host for fruit piercing moth *Orthreis fullonia* a destructive pest of orange, papaya, banana and grapes.
3. It is susceptible to powdery mildew.

Volume: 04 Issue No: 05

BABUL TREE- AN EVERGREEN DRYLAND FODDER TREE

Article ID: AG-VO4-I05-16

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Introduction

Babul, botanically called *Acacia nilotica* (2n: 26), belonging to legume family Fabaceae and sub family Mimosoideae, is a medium sized, thorny, nearly evergreen tree that can reach a height of 20-23 m, but may remain a shrub in poor growing conditions. The tree has thin light grey spines in axillary pairs, usually three to 12 pairs, five to seven cm long in young trees and mature trees commonly thorn less. It is now commonly found or cultivated within 30°N and 20°S in almost all tropical and subtropical areas of Africa, Asia, Australia and the Caribbean.

BOTANICAL DESCRIPTION OF BABUL TREE

Habitat: *Acacia nilotica* has a strong light requirement. Severe frost affects small seedlings as well as large trees. It is drought resistant and occurs in plain, flat or gently undulating ground and ravines. Trees grow best on alluvial soils in ravine areas subject to periodic inundation.

Habit: A medium sized, almost evergreen tree, straight or crooked, thorny with dark black or brown coloured irregularly, longitudinally fissured bark.

Root: The root system depends on the growing conditions and sub species: a deep taproot in dry conditions and extensive lateral roots in flooded conditions.

Stem: Woody, but upper portion herbaceous, aerial, erect, branched, solid, dark brown fissured bark, with grey to pinkish slash; exudes a reddish low quality gum from the bark.

Leaves: The leaves are bipinnate, ramal, cauline, alternate, stipulate, stipules modified into 1/2 to 2 inches long, straight, white thorns, petiolate; pinnae 5-7 pairs, pinnules 10-20 pairs, sessile or sub-sessile, minute, ovate or oblong, entire, unicostate and reticulate.

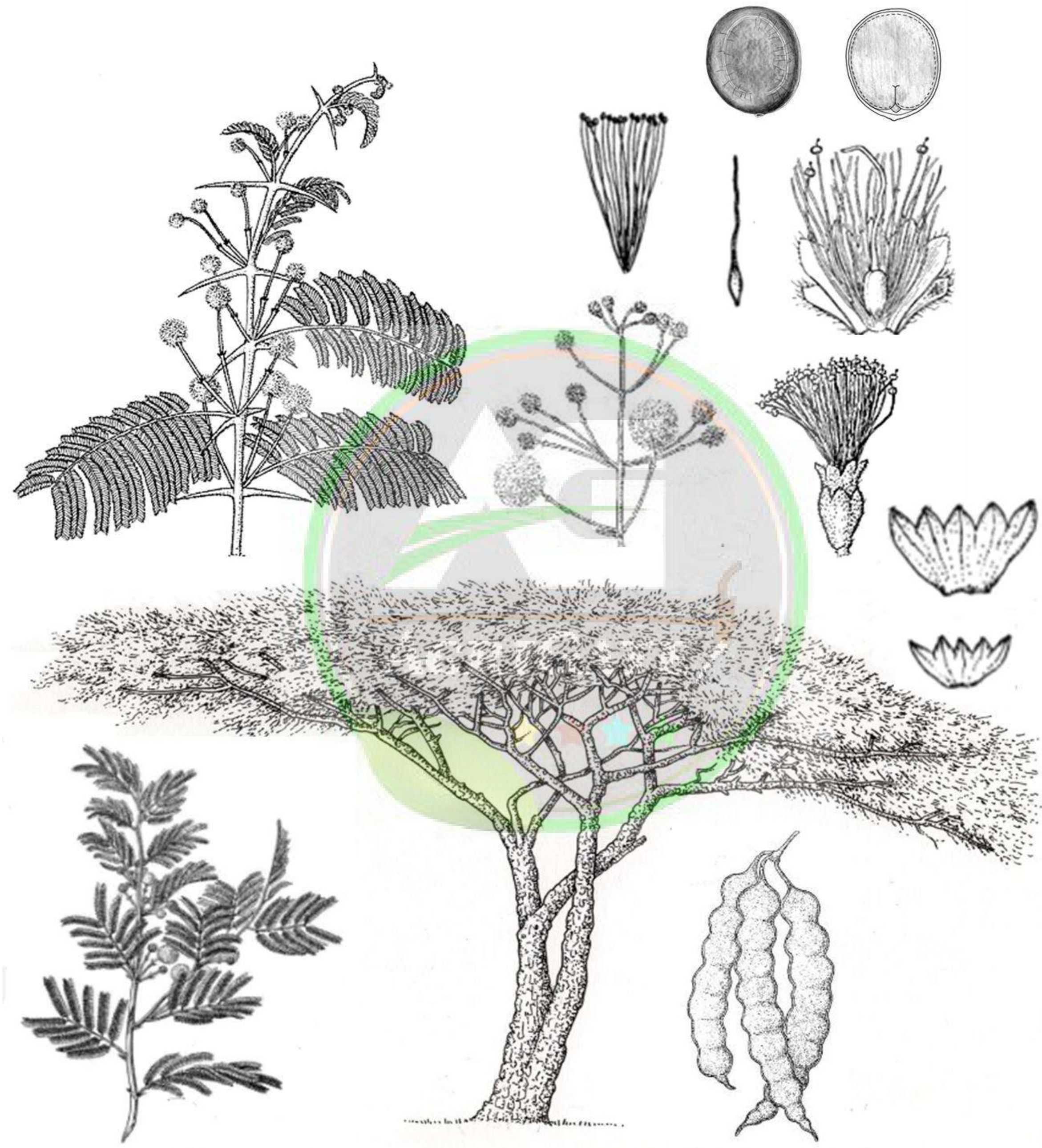

Fig. 1. Babul tree (*Acacia nilotica*) botanical illustration

Inflorescence: Globulous cymose head of 1.2 to 1.5 cm diameter, bright golden yellow colour set up on .Axillary or at the end of the branches on peduncles of 2-3 cm length.

Flower: Flowers tiny, clustered togther in bright yellow round heads. They are bracteate, ebracteolate, sessile or subsessile, complete, actinomorphic, hermaphrodite, hypohynous, pentamerous, yellow and very small.

Calyx: Gamosepalous with fouir to five sepals; campanulate, odd sepal anterior, valvate, minute in size.

Corolla: Gamopetalous with four or five petals; tubular, about double the size of calyx; valvate aestivation.

Androecium: Consisting of many stamens (Polyandrous, filaments filliform, longer than corolla; anthers dithecus, basifixed, introrse and yellow in colour.

Gynoecium: Monocarpellary, unilocular superior ovary with marginal placentation; style short; stigma flat and minute.

Fruit: A lomentum, pods are linear to oblong, glaucous green, jointed, joints nearby orbicular, compressed and minutely hairy.

Seed: Many, large, non-endospermic, brownish black in colour, oblong, compressed, smooth and glabrous.

Pollination: *Acacia nilotica* is a cross-pollinated species. Though there are one third hermaphrodite flowers, only 0.3 per cent of them set seeds. Acacia is often cross-pollinated by all types of bees including the genera *Creightonella*, *Chalicodoma*, *Megachile*, *Anthophora*, *Nomia and Xylocopa*.

Origin: Africa

Related species of Babul

1. *Acacia arabica*- Gum arabica tree
2. *Acacia dealbata* - Silver wattle tree
3. *Acacia decurrens* - Green wattle tree
4. *Acacia farnesiane* - Soapnut tree
5. *Acacia koa* - Koa tree
6. *Acacia melanoxylum* - Austrailian black wood
7. *Acacia omalophylla* - Yarran Tree
8. *Acacia pycnantha* - Golden wattle tree
9. *Acacia trachycarpa* - Curly bark wattle
10. *Acacia tortilis* - Umberlla Wattle

11. *Acacia holosericea* - Soap brush wattle
12. *Acacia mangium* - Hickory wattle

DIFFERENT SUB-SPECIES OF *ACACIA NILOTICA*

I. Evergreen or semi-evergreen tall riverine tree groups:

Grow in low to heavy clay soil and can tolerate seasonal flooding and low drainage conditions. They have ovoid crown and neclace shape pods with constrictions between the seeds. They are largely culitivated for timber, fuel and for tannins. This group includes the following three sub species *viz*., and their details as follows.

i. *Acacia nilotica* subsp. *nilotica*:

Young branches are generally glabrous to sub-glabrous or rarely pubescent. The arrangement of pods is necklace like, regularly constricted between the seeds having a smooth surface devoid of hair. Suited to riverine ecosystem. Found in Niger, Cameroon, Egypt and Sudan.

ii. *Acacia nilotica* subsp. *indica*:

Young branches sub-glabrous to thinly pubescent. Pods are arranged necklace like, narrowly clogged between the seeds and are densely white-tomentose. Suited to low altitude dry forests of India, Yamen, Omen, Pakistan and Myanmar. It can be grown in degraded saline, alkaline soils upto a pH of 9.

iii. ***Acacia nilotica* subsp. *tomentosa:***

The young branchlets are densely white tomentose. The pods are arranged in the form of a necklace, slightly constricted between the seeds. Suited to riverine ecosystem. Found in West Africa, Niger, Sudan and Ethiopia.

II. Dry deciduous spreading tree groups:

Grows in drier areas having heavy clay with light to to medium textured soils that has high drainage. These sub species have straight edge pods. These are cultivated for forage, fuel and as wind breaks. This group includes the following five sub species *viz*.,

i. *Acacia nilotica* subsp. *adstringens*: Flat spreading crown. The young branchlets are very hairy or tomentose and only rarely pubescent. Pod margins distinct and often irregularly crenate and is densely tomentose. Suited to dry Savannas of Senegal, Cameroon, Sudan and Ethiopia. Cultivated for forage and tannins.

ii. *Acacia nilotica* subsp. *subalata*:

Flat spreading crown. The branches are densely pubescent to sub tomentose. Pods are oblong with their margins flattened, straight or sometimes slightly crenate, densely and persistently subtomentose all over. Suited to dry Savannas of East Africa, Sudan, Ethiopia and Tanzania. Cultivated for forage and fuel.

iii. *Acacia nilotica* subsp. *kraussiana*:

Flat spreading crown Young branches are generally more or less densely pubescent. Pods are oblong, with margins more or less superficially crenate. The seeds of this sub-species are initially glabrescent and become hairless and shining black when dry. Suited to dry grassland of Southern Africa including Tanzania. Chiefly cultivated for forage.

iv. *Acacia nilotica* subsp. *cupressiformis:*

Narrow erect cypress like crown The branches tend to go upwards and make a narrow angle with the main stem. Suited to low altitude dry forest and saline, alkaline areas. It is found in Pakistan. Usually planted as wind breaks and preferred on agricultural crop land because of its narrow crown.

***v. Acacia nilotica* subsp. *hemispherica*:**

Hemispherical bush types suited to dry stream beds. Cheifly cultivated for forage grazing.The trunk is not clearly demarcated and the branchlets are for some time pubescent. Pod oblong with straight margins to slightly crenate, with very short simple puberulence.

vi. *Acacia nilotica* subsp. *leiocarpa*:

The young branchlets are glabrous and some times puberlous. The pods are oblong with straight margins or rarely crenate, hairless, narrow.

USES OF BABUL TREE

1. The green pods, young shoots and leaves from an excellent fodder and are especially valuable during the seasons of drought.
2. It is good fodder for sheep, goat and camel.
3. The bark is a powerful astringent and used in preparing tooth paste.
4. The young twigs are used as Datoon for cleaning teeth.
5. The timber is hard, durable, with high resins and termite resistant. Hence it is used for making boat, cabinets, wheels, tool handles and carts.

6. The tree is used very largely as high quality charcoal which are used for locomotives, river steams and in small industries.
7. The wood is durable and resistant to termites and used as railway sleepers.
8. The gum obtained from stem is used to cure dysentery and diabetes.
9. The spines are used as fishing hooks and paper pins
10. *Acacia nilotica* is planted to reclaim mined, degraded and soil eroded area.
11. Acacia nilotica is an N-fixing legume that can be grown with grass or cereal crops in order to enhance their N value.
12. The tannins from pod is used for tanning and black colour dying of leather.
13. The extract of bark, leaves and pods are used to dye cotton, silk and leather.
14. The gum tapped from the bark is used in manufacturing matches, ink, paints and confectioneries.
15. The fragrant flowers of *Acacia nilotica* are excellent bee forage for all types of bees.
16. The young bark act as a source of fibre for cordage.
17. The aqueous extract of pod is used as an algaecide
18. Used as wind breaks along the contour lines of sloppy terrains.
19. It act as a protective hedge because of its sharp thorns.
20. The wood from *Acacias* is good for paper and pulp making.
21. The decoction of the bark of the babul tree finds extensive use as soap you use for a bath.

FORAGE VALUE OF BABUL TREE

Green fodder: The trees are browsed by livestock or lopped for fodder. Pods can be eaten on the ground or browsed by livestock or collected to be fed on the farm. The forage management of *Acacia nilotica* can be quite complex as various parts of the plants are used at different periods of the year for different types of animals. For instance, an extensive survey carried out in Djibouti on *Acacia nilotica* subsp. t*ormentosa* describes how the foliage, flowers and pods are used by Afar communities to feed sheep, goats and camels. The trees begin fruiting within 5-7 years and yield about 18 kg pods/year. The trees planted along water channels yield about 1 t pods/km Dry Matter yield of tree leaves varied from 0.2 to 2.0 t/ha/year.

Palatability: The leaves and stems of *Acacia nilotica* are readily browsed by sheep, cattle, goats and camelids. Different ruminant species do not eat the same plant parts: The camels preferred the non-lignified tips of branches once the leaves had been eaten by sheep and goats. Camels ate the pods whole while goats discarded the seeds and ate only the pod husks. Young female goats exclusively eat the fallen inflorescences at the end of the flowering period. *Acacia nilotica* browse is very palatable to rabbits:

Nutritive value: The leaves contain crude protein 13.7%, crude fibre 22.7%, Neutral detergent fibre 22.7%, Acid detergent fibre 17%, lignin 6.5% and mineral ash 8.7%. It is rich in calcium, Potassium, Manganese and Zinc.

ADVANTAGES OF BABUL TREE

1. It can tolerate occasional flooding and short time water logging.
2. It can come up well along the water channels.
3. It is mostly an evergreen tree supplying forage all through the year.
4. It is propagated by seeds carried in animal droppings.
5. It is drought resistant and can tolerate fluctuating water regimes.
6. It can tolerate the temperature regime ranging from 4-47^{o}C.
7. Much suited arid and semi-arid region tree forage crop.
8. It is much suited for hedgerow planting because of its thorns.
9. It can be deployed to reclaim mined, degraded and eroded soils.
10. It improves soil nitrogen content by nitrogen fixation and soil fertility by its droppings.

LIMITATIONS OF BABUL TREE

1. It coppice very weakly. Only when young it can tolerate coppicing.
2. It can not tolerate heavy browsing and only cut-and-carry system is to be followed.
3. It is a high light demanding tree species and cannot tolerate shade.
4. It is frost tender species; small seedling as well as large tree are frost affected.
5. It acts as a host for plant parasite *Loranthus globiferous*.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

CHITHAGATHI A MEDICINALLY VALUED TREE FODDER

Article ID: AG-V04-I05-17

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Introduction

Chithagathi botanically called *Sesbania sesban* (2n: 12) otherwise known as Common Sesban or Egyptian river hemp is a nitrogen-fixing tree belonging to the legume family Fabaceae and Sub Family Papilionoideae. It is a fast growing perennial small tree. It grows up to 7 m in height with many side branches from low down on the bole. The bark, as well as the seeds, produces gum. The wood is used for making arrow, pipes, toys, and other items but more commonly used as firewood and for charcoal production.

BOTANICAL DESCRIPTION OF CHITHAGATHI

Habitat:

Sesban is widely distributed and cultivated throughout semi-arid and sub-humid tropical regions. It grows on stream banks and swamp edges, from sea level up to an altitude of 2300 m. It grows on a wide variety of soils from loose sandy soils to heavy clays. It is tolerant of saline, alkaline and acidic soils as well as of low P levels. It can withstand waterlogging, except during the first stages of seedling growth

Habit: Deep-rooted, short-lived (to 10 years) shrub or small tree 2-4 or up to 8 m tall.

Root: Deep rooted tap root with root nodules. Under intermitant water stagnation condition the lowe nodes produces adventitious roots to tide over the situation.

Stem: Main stem 6-8 or even12 cm in diameter; many side branches from low down on the bole; younger stems usually pubescent, sometimes becoming glabrous.

Leaves: Leaves paripinnate, 2-18 cm long; pinnae linear-oblong to oblong-lanceolate, opposite or nearly so in 6-27 pairs, 13-26 mm long, 3-4 mm wide, both surfaces with dark purplish glands, abaxially sparsely appressed pubescent when young but glabrescent, adaxially glabrous or glabrescent, midvein evident on both surfaces, base obliquely rounded, apex rounded to retuse and mucronate, often pilose at the margins. Stipules triangular-lanceolate, 3-4 mm, caducous and pubescent.

Inflorescence: Racemes unbranched or branched, 2-20-flowered, peduncle 2-5 or even 10 cm long, rachis 2-10 cm long, glabrous or sparsely pilose; pedicels 4-12 mm long, pubescent when young, glabrous.

Flowers: Flowers attractive, yellow, red, purplish, variegated or streaked, seldom white, large or small on slender pedicels, solitary or paired, usually unpleasantly scented.

Calyx: Calyx campanulate, green or dark purple, teeth shortly triangular

Corolla: Corolla predominantly yellow or standard adaxially dark purple or purple spotted, abaxially yellow, red and purple, and wings and keel partly purplish black or red; standard transversely elliptic. Wings oblong, 1-1.2 cm, with a curved claw, base inconspicuously auriculate, apex rounded; keel nearly semicircular, 6-8 × 5-7 mm, lamina base narrower than apex and with a triangular short auricle, claw as long as calyx.

Androecium: Nine stamens are fused into a tube by their filaments, one stamen is free. Staminal column 9-13 mm; anthers ellipsoid.

Gynoecium: Ovary glabrous; style ca. 5 mm, glabrous; stigma globose.

Fruit: A pod, subcylindrical, glabrous, straight or slightly curved, pendulous, 10-20 cm long, 2-5 mm diameter, green to straw-coloured, often with a brown or reddish-brown blotch over each septum, 10-30 seeded.

Seed: Seed sub cylindrical, ends rounded, 3-4.5 mm × 2 mm, olive-green or brown, usually mottled.

Pollination: Cross-pollinated by bees.

Origin: North East Africa

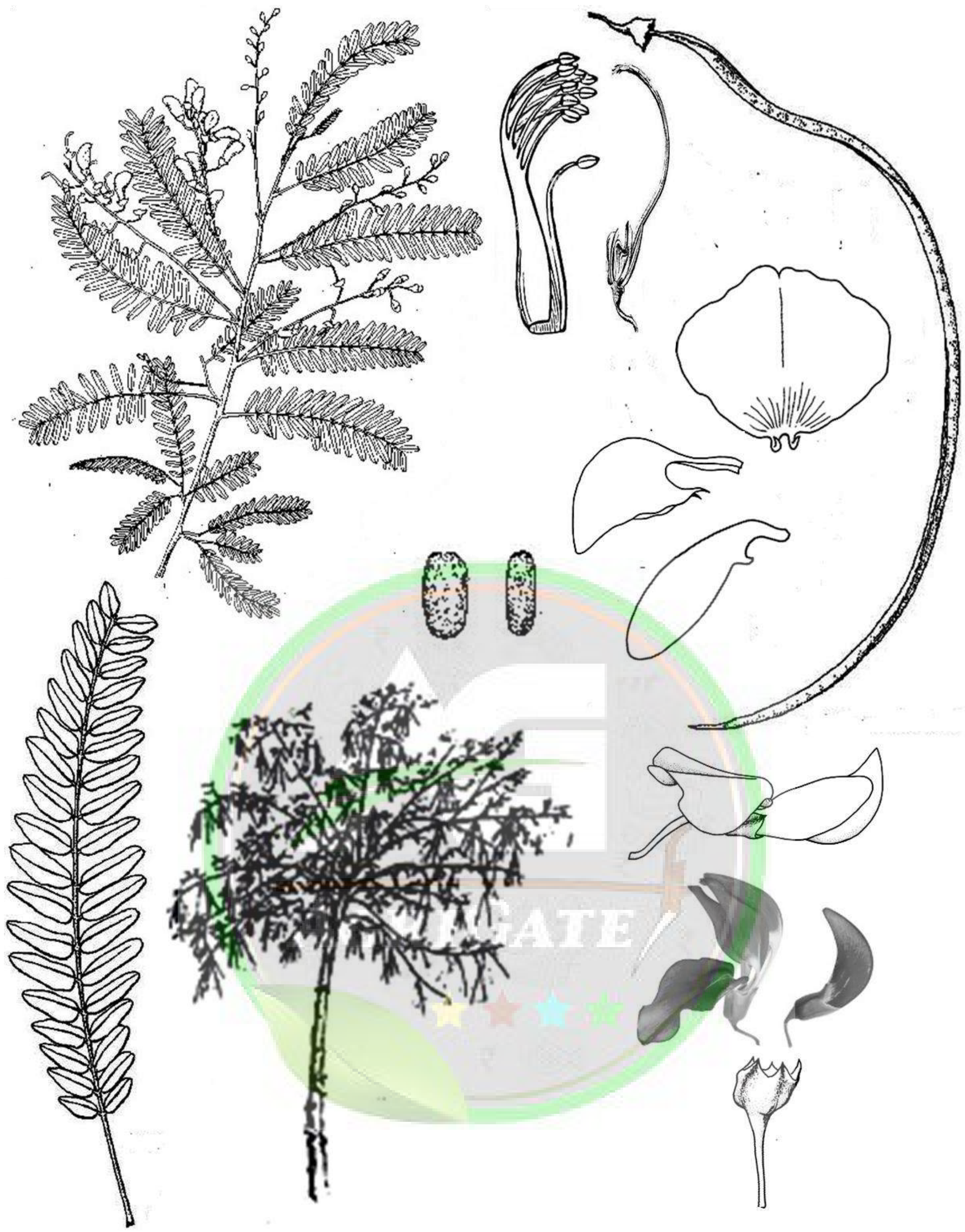

Fig. 1. Chithagathi or Sesban (Sesbania sesban) botanical illustration

Related Species:

1. *Sesbania bispinosa*
2. *Sesbania drummondii*
3. *Sesbania formosa*
4. *Sesbania herbacea*
5. *Sesbania punicea*
6. *Sesbania rostrata*

7. *Sesbania tomentosa*
8. *Sesbania versicaria*
9. *Sesbania speciosa*
10. *Sesbania virgata*
11. *Sesbania quadrata*
12. *Sesbania sericea*
13. Sesbania exasperata

BOTANICAL VARIETIES OF SESBANIA SESBAN:

1. *Sesbania sesban* spp. *sesban* *:* Pod twisted, distinctly torulose (swollen and constricted at intravals); infloresecence not branched; staminal column 9-13 mm in length.

i. *Sesbania sesban* spp. *sesban* var. *sesban:* Glabrous, flowers are yellow in colour.

ii. *Sesbania sesban* spp. *sesban* var. *bicolor:* Calyx and standard purplish black, wings and keel partly purplish black or red in colour.

iii. Sesbania sesban* spp. *sesban* var. *zambesiaca: Pubescent

2. ***Sesbania sesban* spp. *punctata:*** Pods not twisted, not torulose when mature. Inflorescence branched; staminal column 15-17 mm in length.

3. ***Sesbania sesban* spp. *muricata:*** Stem is aculeate (prickly).

USES OF CHITHAGATHI

1. Used as a source of Cut-and-carry forage for cattle and sheep.
2. It is an excellent green manure crop by virtue of high nitrogen fixation.
3. It can be grown in crop rotation with maize and thereby increase the yield of maize to 2-4 tonnes per hectare without application of nitrogen fertilizer.
4. Sesban act as a soil mulch to protect and improve soils.
5. Used to reclaim saline spoils.
6. Fresh roots and leaves are used to treat scorpion sting, boilsand abscesses.
7. Flowers are edible and used in festival dishes.
8. Sesban is used to combat parasitic weed *Striga hermonthica* by stimulating it to germinate, but being an unsuitable host to Striga, the parasite dies unless it can find another host nearby.
9. Produces light fuel wood suitable for cooking and charcoal production.

10. Used as live trellies for black pepper, grapes, cucumits and betel vine.
11. It is also grown as shape trees for coffee, tea, cocoa and turmeric.
12. Fibers obtained from the bark is useed for making ropes and net.
13. Ground preparations from the flower,leaves and seed of sesban are repoted to be an effective contraceptive for controlling rat and mice population.
14. It can be cultivated in mettalliferous soil that aree toxic in Cu, Zn and Pb.
15. The leaves are used in soap making.
16. The oil obtained from the seeds is accorded special properties in ayurvedic medicine as antibacterial, cardiac depressant and hypoglycaemic actions.

FODDER VALUE OF CHITHAGATHI

Cut-and-carry system: Sesban is used as a cut-and-carry species. It can be cut after the plant reaches 1-2 meter height in about six months. Best results are obtained when sesban is cut to 75-100 cm height and some foliage is retained for regrowth. Harvest can be done five times per year and can be grown up to 8-10 years.

Nutritional value: On dry weight basis, sesban contains crude protein 20%, crude fiber 12.9%, Neutral ditergent fiber 29%, Acid ditergent fiber 25%, lignin 5.8%, and Mineral Ash 10.6%. Sesban is an highly nutrious fodder for the ruminants.

Yield: Sesban yield to a tune of 20 t/ha/year. The yield of sesban is four times the yield of Leucaena leucocephala at three months after planting.

Palatability: Moderately well accepted by ruminants in cut-and-carry system. Novice cattle were slow to accept sesban, taking about three months to become fully acceptable and subsequent live weight gain are excellent. It is not palatable to chicken, rabbits and pigs.

Toxicity: It is low in condensed tannins, but contains phenolic compounds such as Saponins and stigmasta-galactopyranoisides that are spermicidal and haemolytic and other reproductive irregularities in ruminants if fed in higher proprtions (.30%). It is fatal to young chicks even at 10% level. It is not to be fed to birds, rabbits and pigs.

Grazing: Direct grazing by goats resulted in 80% mortality of trees due to ring-barking of trees 8-20 cm above ground level by goats. It is browsed by ruminants in its native range.

ADVANTAGES OF CHITHAGATHI

1. Sesban has a rapid establishment and early growth.
2. It can grow in a wide range of soils from loose to heavy clays.

3. It can grow in slaine, alkaline as well as in acid soils.
4. It can be grown in mettalliferous soils which are high in Cu, Zn and Pb.
5. It can tolerate periodic water logging or flooding followed by a progressive dry season.
6. It can be grown on eroded soils and vegetation can be established
7. It can tolerate light frost.
8. It has moderate shade tolerance.
9. Sesban is an highly nutritious quality forage for the ruminants.
10. It can tolerate drought after establishment.
11. It can be grown along river banks as an agroforestry species.
12. It can be grown as green manure crop.
13. It is grown for entriching the soil nitrogen through its root nodules.
14. It controls the spread of parasitic weed *Striga hermonthica*

LIMITATIONS OF CHITHAGATHI

1. Sesban seeds are water impermeable and scarification is needed to break the dormancy.
2. It is unlikely to tolerate severe fire and can not rejunivate from fire incidence.
3. It is highly competitive and can overly competitive with the companion crop.
4. It is not well suited for grazing as mortality will increase with grazing intensity.
5. Novice animals have low acceptability or late preference.

Volume: 04 Issue No: 05

GLIRICIDIA- A MULTIPURPOSE DRYLAND TREE FODDER

Article ID: AG-VO4-I05-18

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Introduction

Gliricidia, botanically called *Gliricidia sepium* (2n: 20 & 22) belonging to legume family Fabaceae and Sub family Papilionoideae is a small tree to 12 m tall with a well branched, spreading crown of broadly pinnate leaves and bright pink to lilac flowers. *Gliricidia sepium* is native to dry forests from southern Mexico to Costa Rica and is widely grown throughout the tropics as a multipurpose tree. Gliricidia has been naturalized in the tropical America, Caribbean, Africa, Asia and the Pacific Islands.

BOTANICAL DESCRIPTION OF GLIRICIDIA

Habitat: Grows best in warm, seasonally dry climate with annual rainfall ranging from 900 to 1500 mm annual rainfall. *Gliricidia sepium* is native to the lowland dry forests from sea level to 1,200 m. It is uncommon above this elevation because of its sensitivity to cold. The temperature range is 20 to 30° C. It performs poorly below this range but will tolerate temperatures as high as 42° C. It grows in sands to clays preferring freely drained soil. It can tolerate moderate acidity (pH 5.0) to alkaline pH of 8.5 and low in fertility, mainly in humid coast lowlands or lake basins. Rainfall is generally from 900 to 1,500 mm/year, but may be as low as 600 mm or as high as 3,500 mm. The dry season varies from 3 to 8 months, however *Gliricidia sepium* survives dry seasons of even nine months in Indonesia.

Habit: A small to medium-sized, deciduous, but may be evergreen, thorn less tree which usually attains a height of 10-12 m. It may be either a single or multiple stem tree with trunk diameters reaching 30 cm. Branching is frequently from the base with basal diameters reaching up to 50-70 cm.

Root: Shallow tap root development, but extensive shallow lateral root development. The fine roots are nodulated with nitrogen fixing bacterium of the family Rhizobiaceae.

Stem: The stem and branches are commonly flecked with small white lenticels. The bark colour is variable but is mainly greyish-brown, and it can be much fissured. The bark is smooth but can vary in colour from whitish grey to deep red-brown and may be deeply furrowed on old, large diameter trees.

Leaves: Leaves are alternate and pinnate with 13-25 leaflets, papery, oblong with a distinctive pointed tip. Leaflet size increases towards the distal end of the leaf. At maturity, the upper surface ranges from smooth and hairless to bristly and usually has no tanniniferous patches. The lower surface can also be smooth and hairless or bristly but commonly has purplish tanniniferous patches concentrated towards the centre of the lamina.

Inflorescence: Flower development corresponds to the beginning of the dry season when trees have lost their leaves. In its native range flowering occurs November to March. In areas without a pronounced dry season, flowering may occur throughout the year but few pods form. Inflorescence appear as clustered racemes on distal parts on new and old wood, 5-15 cm long, flowers borne singly with 20-40 per raceme.

Flowers: Flowers bright pink to lilac, tinged with white, usually pink, fading to whitish-brown or pale purple with age.

Calyx: Gamasepalous, urn shaped, glabrous, green or pinkish purple often tinged red.

Corolla: Composed of five pink coloured glabrous and clawed petals; one large erect backward curving standard, usually with a diffuse pale yellow spot at the base, two sickle shaped wings and two united incurved keel petals.

Androecium: Ten whitish stamens, nine united and one is separated (diadelphous condition).

Gynoecium: Pistil has a stalked narrow red ovary and a whitish bent style.

Fruit: Pods explosively dehiscent, strongly laterally compressed and pale green or reddish-pink when unripe, turning pale yellow-brown when fully ripe. Seeds transversely oriented, lenticular, not constricted in the middle. The pods are explosively dehiscent.

Seed: Seeds uniformly light brown, turning dark brown with age; 3-10 seeds in a single pod.

Fig. 1. Gliricidia (*Gliricidia sepium*) Botanical illustration

Pollination: Gliricidia is cross-pollinated by insects, mostly the black bee, *Xylocopa fimbriata* and *Centris* species in the tree's native range.

Center of origin*: C*entral America or Mexico.

Related species:

1. *Gliricidia brenningii*
2. *Gliricidia maculata*
3. *Gliricidia enrenbergii*
4. *Gliricidia robustum*

USES OF GLIRICIDIA

1. The flowers are fried and eaten as human food.
2. It is protein rich and highly digestible for ruminants like goat and cattle. It is able to produce profuse branching and fresh growth after every cutting.
3. Act as bee forage especially the black bee.
4. The wood is used as firewood and for charcoal production. The wood burns slowly without sparkling and with little smoke.
5. The timber is very durable, termite resistant, used for railway sleepers, farm implements, furnitures, house construction etc.,
6. Mother post are used in live-fence establishment.
7. Ground leaves, seeds and bark are used as poison to control rat and mice.
8. The tree is used to plant in hedge rows to prevent soil erosion.
9. Planted as shade trees for tea, coffee, cocoa, yarm and vanilla.
10. It is grown as nurse tree for shade loving species since it produces light shade and reduces soil temperatures.
11. It can be planted to reclaim denuded land or land infested with *Imperata cylindrica*.
12. Gliricidia is capable of fixing atmospheric nitrogen to improve soil fertility.
13. Gliricidia is also grown as green leaf manure crop. If cultivated along the border in one heactare, it will supply enough green leaf manure for 2 to 2.5 hectares of land.
14. It is grown as live support for black pepper, Cassava, vanilla, passion fruit and Yam.
15. Gliricidia when grown as an Agroforestry tree species which controls weed growth.
16. It is used as fire breaks as well as wind breaks.
17. When Gliricidia is grown as bund crops, it controls leaf spot, rust and rosette virus in groundnut, stem borer in rice.

18. It can be grown as a companion crop with paddy and upland rice, corn, cassava and coconuts.

19. Cut boles are used to propagate orchids.

20. The leaves are used to prepare bio-insecticide.

FODDER VALUE OF GLIRICIDIA

Green fodder:

Responding well to frequent cutting, Gliricidia produces abundant amounts of nutritious fodder containing 18 to 30% crude protein. Livestock respond well to the fodder. Some animals are reluctant to eat Gliricidia, but training may overcome this problem. Once Gliricidia is accepted, subsequent offspring readily consume it. The first pruning after planting is done at about 9 months. The tree tolerates lopping, coppicing and regular browsing. Gliricidia can be pruned 3-4 times per year at a height of 30-150 cm. Pruning will stimulate leaf production. It can be lopped around 7 months after establishment on plants grown from cuttings and 14 months after seedlings. Thereafter lopping can be done every 2 to 3 months during the rainy season and every 3 to 4 months during the dry season, provided regrowth reaches 1-2 m high before harvest. *Gliricidia sepium* yields 9 to 16 t/ha of DM in fodder plots, similar to *Leucaena leucocephala*, but it are less sensitive to pests and to poor growing conditions.

Palatability:

Familirization of Gliricidia is required so that cattle can eat it readily and get benefited from its high protein. Gliricidia is good forage for goats. Goat prefer the whole foliage to the leaves. It is not much palatable for rabbits, pigs and poultry. It is normally recommended, when feeding cattle, goats and sheep, to use fresh Gliricidia leaves at levels of 10-30% of the ration weight, with either grass or other roughages. Farmers sometimes complain that animals do not like Gliricidia leaves. This is because of the strong odour, which occurs when the leaves are crushed. Wilting or drying for 24 hours between cutting and feeding appears to reduce the odour of the leaves. It has been reported that animals, which first refused Gliricidia became used to it in a few days, after which it was readily consumed.

Toxicity:

Gliricidia means "mouse killer" in Latin. The leaves mixed with cooked maize are used as a rodenticide. Leaves are also reported to be toxic to horses and many animals cannot tolerate the consumption of large quantities of Gliricidia. Ruminants do not seem to be affected under normal feeding, but toxicity problems are reported with non-ruminants. Gliricidia toxicity could be due to the conversion by bacteria of coumarin to dicoumerol during fermentation. Cyanogens, HCN (up to 4 mg/kg), unidentified alkaloids and tannins may be present. Gliricidia can be a nitrate accumulator.

Nutritional value

detergent fibre 34%, lignin 13% and mineral ash 10%. It is rich in calcium, potassium and Iron.

ADVANTAGES OF GLIRICIDIA

1. Giliricidia is a self-prune tree, with short trunk usually clear of side branches below the main crown and with large spreading branches above the crown.
2. Gliricidia regenerates rapidly following cutting or other toppings.
3. It can tolerate lopping, coppicing and regular browsing.
4. Gliricidia can tolerate pollarding and forms a new crown quickly.
5. It can be managed for coppice production that is done during active growth period and if about 10% of the foliage is left on the tree.
6. Gliricidia is easily propogated by seed or large cuttings.
7. When grown as a companion crop, it prevents pest incidence like aphids, leaf spot, rust and rosette virus of groundnut and stem borer attack in rice.
8. The fine roots of Gliricidia are nodulated with nitrogen fixing Rhizobial bacteria.
9. It can be grown as a hedge row trees to prevent soil erosion and stabilization of sloppy soils.
10. Gliricidia can be used as fire breaks and as wind breaks.
11. It can tolerate salinity and mild alkalinity as well as mild acidity.

LIMITATIONS OF GLIRICIDIA

1. Should not be fed to non-ruminants and it becomes a poison.
2. It is susceptible to *Aphis cracivora*.
3. Lack of adaptation to soils that are not fertile and well-drained.
4. Lack of cool season adaptation and frost tolerance.

Volume: 04 Issue No: 05

SUPPERB SUBABUL

Article ID: AG-VO4-I05-19

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INTRODUCTION

Subabul, botanically called *Leucana leucocephala* (2n: 104), belonging to legume family Fabaceae and sub family Mimosoideae is a tree is found from lowlands up to 2100 meter. It requires an annual rainfall of 650-1500 mm, but can be found in drier and wetter regions. The species is not suited to acid soils or to waterlogged conditions. Leucaena leucocephala is a popular fodder species.

BOTANICAL DESCRIPTION OF SUBABUL TREE

Habitat: Subabul can grow often in coastal or riverine habitats, semi-natural, disturbed, degraded habitats and other ruderal sites. It tolerates a wide range of rainfall from 500 - 3500mm and withstands strongly seasonal (6-8 months of dry season) climates. However, it is not frost hardy and grows poorly, setting less seed in cooler tropical highland sites. It adapts well to a wide range of tropical and subtropical environments, especially seasonally dry tropical areas.

Habit: *Leucaena leucocephala* is a shrub or small tree usually growing 2-10 m tall, but occasionally reaching 15 m or more in height.

Root: Aggressively deep tap rooted with abundant root nodulation.

Stem: The younger stems are green and usually densely covered in fine greyish coloured hairs (finely pubescent). Older stems have a relatively smooth, greyish or greyish-brown, bark with numerous small raised spots (lenticels).

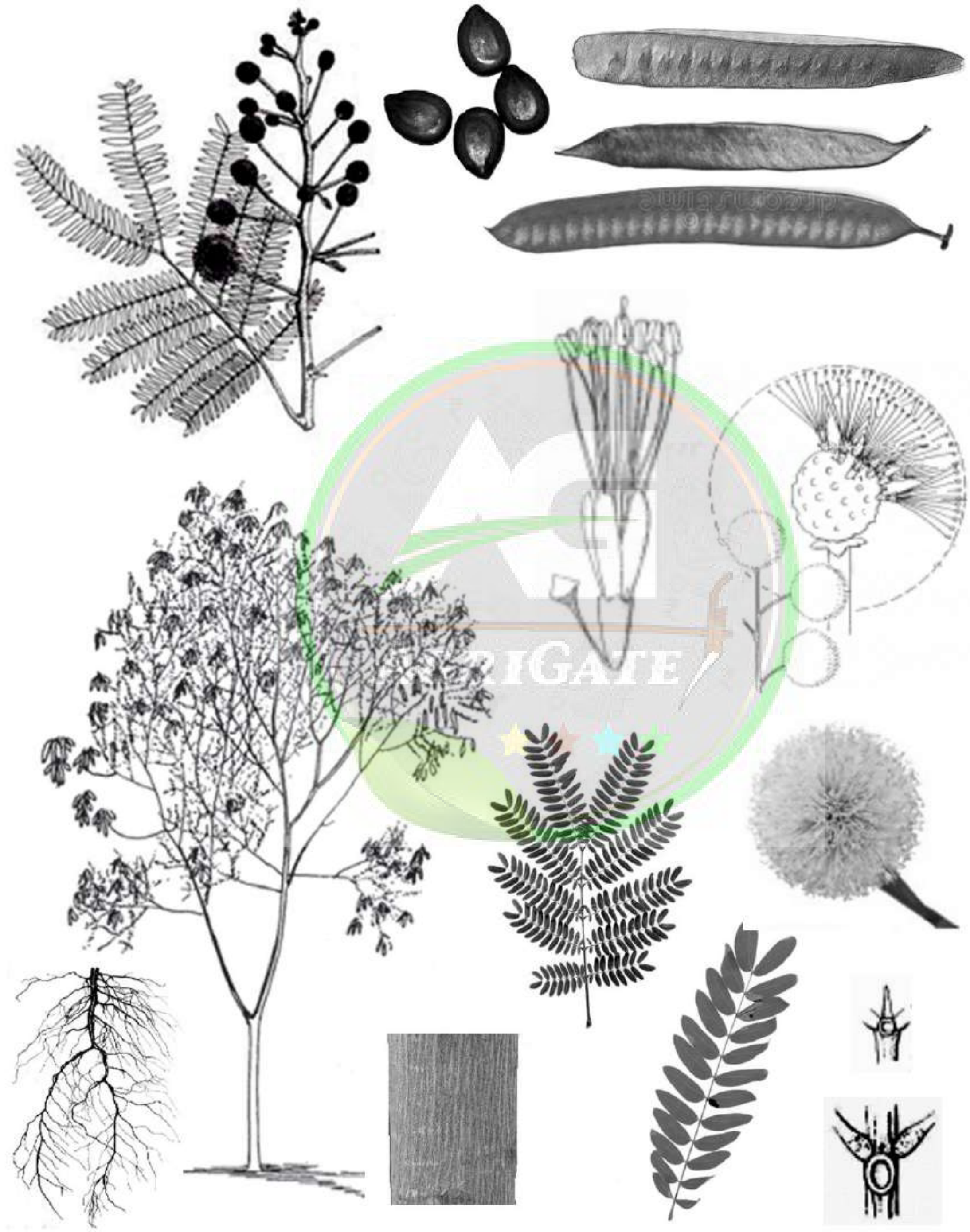

Fig. 1. Subabul (*Leucaena leucocephala*) botanical illustration

Leaves: The leaves (up to 35 cm long) are twice-compound (bipinnate) and have 3-10 pairs of branchlets (pinnae). They are alternately arranged along the stems and borne on stalks (petioles) 2-5 cm long. A small raised structure (gland) is usually present on the leaf stalk (petiole), or just below where the lowest pair of branchlets (pinnae) meet. pinnae are 2-10 cm long and each bears 5-22 pairs of leaflets (pinnules). These leaflets (7-21 mm long and 1.5-5 mm wide) are elongated (narrowly-oblong to lanceolate) in shape with pointed tips (acute apices), and are either hairless (glabrous) or have hairy (ciliate) margins.The petiole base has extrafloral nectary glands.

Inflorescence: The flowers are borne in dense globular clusters (12-30 mm across), which look like a 'pompom' when the flowers open. These clusters are borne in the leaf forks (axils) on stalks (peduncles) 2-6 cm long, with one to three clusters present in each leaf fork (axil).

Flower: Flowers white or pale cream-white.

Calyx: Five tiny sepals (2-2.5 mm long), in flared tube (campanulate) that ends with five tines

Corolla: Five free petals, small pale green or white coloured; Petals (4 to 5.5 mm long), covered with small loose hairs, pale green in color.

Androecium: Ten prominent pale yellow or whitish coloured stamens (6-10 mm long); anthers hairy.

Gynoecium: ovary glabrous, superior, shortly stipitate, puberulent; styles as long as ovary; stigma simple.

Fruit: The fruit are elongated (linear), flattened, pods with a pointed tip (beaked apex). These pods (8-22.5 cm long and 10-20 mm wide) are initially green in colour, but turn brown or reddish-brown as they mature. Several pods will usually develop from each flower cluster. Each of these pods contains 10-25 hard seeds

Seed: Seeds 6-10 mm long and 3-6 mm wide; glossy brown, flattened (compressed), and somewhat oval (elliptic-oblong) in shape.

Pollination: Self-pollination

Origin: Mexico

Related Species:

1. *Leucaena collinsii*
2. *Leucaena cuspidata*
3. *Leucaena diversifolia*
4. *Leucaena esculenta*

5. *Leucaena greggii*
6. *Leucaena lanceolata*
7. *Leucaena macrophylla,*
8. *Leucaena multicapitula*
9. *Leucaena. retusa*
10. *Leucaena pallida*
11. *Leucaena pulverulenta*
12. *Leucaena salvadorensis*

SUB-SPIECIES OF *LEUCAENA LEUCOCEPHALA*

1. *Leucaena leucocephala* subsp. l*eucocephala* - Common or Hawaiian type: It is a relatively small and much-branched tree with younger stems that are densely covered with fine greyish-coloured hairs (they are puberulous). This has been attributed to its precocious year-round flowering and fruiting, abundant seed production, self-fertility, hard seed coat, and ability to resprout after fire or cutting.

2. *Leucaena leucocephala* subsp. *glabrata* - Giant or Salvador type: It is s a relatively large and sparsely-branched tree with younger stems that are hairless (glabrous).

3. ***Leucaena leucocephala* subsp. *ixtahuacana*- Wild type:** Found in restricted areas of Northern Gautamala.

USES OF SUBABUL

1. Leaf and toppings including the pods are highly nutritious, highly palatable, highly digestible forage for cattle, goat and sheep.
2. It is suitable ornamental and roadside landscaping species.
3. It is a prime candidate for restoring forest cover, watershed and grasslands.
4. It is planted along the contour as hedgerow planting to prevent soil erosion.
5. It is used as live support for pepper, coffee, cocoa, vanilla, yam and passion fruit.
6. It is also used as shade tree for Cocoa, coffee and tea.
7. The tree are planted as wind breaks to protect cultivated crops such as banana
8. It has high nitrogen fixation of 100-300 kg N/ha /year due to its abundant root nodulation.
9. It is also used as fire breaks.
10. Subabul is also used as live fence to protect farm lands.

11. Its aggressive taproot system breaks the hard subsurface soil layer and increases the water moisture level and reduces the surface run off.
12. Tannin or dye stuff of red, brown and black obtained from pods, leaves and bark.
13. Their poles are used to prop banana crop.
14. The timber is used for furniture, small size wood works and parquet flooring.
15. The wood pulp is used in paper making, particle boards and rayon production.
16. Subabul act as high calorific fuel wood which burns steadily with little smoke,few sparks and very less ash.
17. The wood makes excellent charcoal for industrial purposes.
18. Blooms almost throughout the year, providing year around bee forage to many types of bees.
19. Dries seeds are used in ornamentation.
20. It provides green manure in alley cropping systems since its leaves decompose quickly.

FORAGE VALUE OF SUBABUL

Green fodder:

Leucaena leucocephala is a popular fodder species. It should be cut 75-100 cm above the ground every 2-4 months after the first pruning (9 months after planting). Leucaena is a vigorous coppice and responds well to pollarding. Coppiced stems sprout 5-15 branches, depending on the diameter of the cut surface, and 1-4 stems dominate after a year of regrowth. Leucaena can produce well for 10 to 20 years or even up to 35 years. Plants can be harvested in as early as 6 months after planting. However, the initial cutting should not be done until the trunk has attained at least 3 cm diameter or the plant has completed one seed production cycle. The trees can be cut at 90 to 100 cm height from ground level. As green fodder under irrigated conditions, a pure crop yields about 80 to 100 t/ha of green fodder. Under rain-fed conditions 40 t/ha of green fodder is got after 2 years of initial growth and pruning to a height of 100 cm.

Nutritive value:

On dry weight basis, subabul leaves has crude protein 23%, crude fibre 20%, Neutral detergent fibre 41%, acid detergent fibre 25%, lignin 10.8% and mineral ash 8.5%. It is also rich in Calcium, potassium, manganese and Iron.

Palatability:

It provides high quality forage during the dry season and is very palatable to cattle, sheep and goats. Moreover, it grows well in association with many subtropical and tropical grasses

Toxicity:

It contains large amounts of mimosine (up to 12% DM in young shoots), a toxic amino acid that is detrimental to non-ruminants (horses, donkeys, pigs and poultry). In ruminants, mimosine is broken down in the rumen to DHP, a goitrogen that is detoxified by rumen bacteria. However, mimosine causes Leucaena to be toxic to cattle if fed in large amounts (more than 30% of the diet) over long periods. It induces low feed intake, and reduces live-weight gain and reproductive performance. Toxicity symptoms are alopecia, excessive salivation and enlarged thyroid glands.

ADVANTAGES OF SUBABUL

1. Subabul lives up to 20 to 40 years and once established, it will supply forage on a perennial basis for long years.
2. It blooms all around the year and supply forage all the year around and especially during dry periods.
3. The seeds can remain viable for even up to 20 years in the soil.
4. It can withstand strongly seasonal dry climate for even up to six to eight months.
5. It can withstand wide range of rainfall regimes from 500 to 3500 mm annual rainfall.
6. It is highly nutricious green fodder for cattles, sheep and goat.
7. It fixes about 100 to 300 kg of N/ha/year due to its abundant root noduling.
8. Its aggressive taproot system breaks up the compact subsoil layer and increases the infiltration of water into the soil and decrease the subsurface run off.
9. It is fire resistant and can rejunuvates after fire.
10. It is used as a supplementary pasture during the dry or winter season.
11. *Leucaena leucocephala* can survive for decades under heavy cutting or grazing.
12. Its leaves decompose quickly and enrich the soil as a good green leaf manure.
13. It may withstand light frost (though with lower yields), moderate salinity and short periods of waterlogging.

14. *Leucaena* is one of the highest quality and most palatable fodder trees of the tropics.

LIMITATIONS OF SUBABUL

1. It is intolerant to low pH, low Phosphorous, low calcium, high Aluminium and high salinity as well as water logging.
2. The wood is susceptible to termite and wood borer attack.
3. It is also susceptible to Leucaena psyllid (*Hetropsylle cuban*)
4. It contains mimosine that is toxic to non-ruminants like pig, horses and birds.
5. It induces low feed intake, and reduces live-weight gain and reproductive performance in ruminants if fed in excess quantity.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

GLOBAL SCENARIO OF RICE

Article ID: AG-VO4-I05-20

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Introduction

About half of the world's population receives their sustenance from the rice harvest. Over 21% of human caloric needs are met by rice, while residents of Southeast Asia can consume up to 76% of their caloric diet from this crop. China has 148.30 million tonnes (Mt), according to the United States Department of Agriculture, which is followed by 120.00 Mt in India, 35.30 Mt in Bangladesh, 34.90 Mt in Indonesia, and 27.10 Mt in Vietnam. In addition, Thailand generated 18.6 Mt, the Philippines 12 Mt, Japan 7.62 Mt, Pakistan 7.60 Mt, Brazil 7.48 Mt, the United States 7.23 Mt, Nigeria 5.04 Mt, and the European Union 1.96 Mt Malaysia produced 1.83 Mt, and Turkey produced 0.59 Mt. Asia produces 90.6% of the global rice production, making it the world’s largest producer(APEDA-22)

Rice production by countries (Values in Metric Tons)

With 756 million tonnes produced globally in 2021-22, rice is the world’s third-most produced agricultural crop behind sugarcane and corn (maize), which both have a wide variety of non-consumption uses Just 10 countries are responsible for a bulk of global rice production:

At the top of the charts are China (#1) and India (#2), which produced 389 million tonnes combined, accounting for more than half of global production, They’re significantly ahead of #3 and #4 countries Indonesia and Bangladesh, which produced around 54.6 million tonnes each. Almost all of the top producers are located in Asia, with the exception of Brazil (#10). With in 84% of rice being harvested in just 10 countries, it's clear that many countries globally must rely on imports to meet domestic demand and rely on imports to meet their needs.

In 2019, India, Thailand, Pakistan, and Vietnam were large net exporters of rice, shipping out nearly $16 billion of rice combined. Other countries including Iran, China, Saudi Arabia, and the Philippines consume above production And not everything makes it from plant to table. In developing countries especially, estimates of 8–26% of rice are lost due to post harvest problems and poor infrastructure

Table 1. The Gross Domestic growth of top 10 countries with respect to Rice production

S. No.	Country	GDP (USD)
1	China	1,42,700
2	India	97,350
3	Indonesia	37,400
4	Bangladesh	35,200
5	Vietnam	22,100
6	Philippines	13,000
7	Thailand	11,170
8	Burma	9,900
9	Japan	8,450
10	Brazil	8,100

Top 10 rice consuming countries (in 1000 Metric Tons)

China is the world's biggest consumer and producer of rice at the same time. It has also been one of the fastest growing economies in the world over recent years with agriculture being one of the most important pillars of this economy. In effect, rice consumption is at 142,700 metric tons annually which equates to close to 30% of global rice production. Approximately 65% of the Chinese population consumes rice as a staple food, and this has been promoted by the extensive use of hybrids and suitable cultivation conditions. China frequently exports and imports rice, unlike previous years however it is currently a net exporter.

India has also experienced exponential growth just like China. The same can be said for rice consumption as India comes second at 97,350 metric tons in total consumption. India produces other grains, which include wheat, sorghum, and corn. More than half of the Indian population relies on rice as a staple food, and the government plays a pivotal role in rice production for consumption through procurement and initiating distribution programs. Farmers are supported in the different stages of production mostly through subsidies and production, which include fertilizers, seeds, electricity, and machinery.

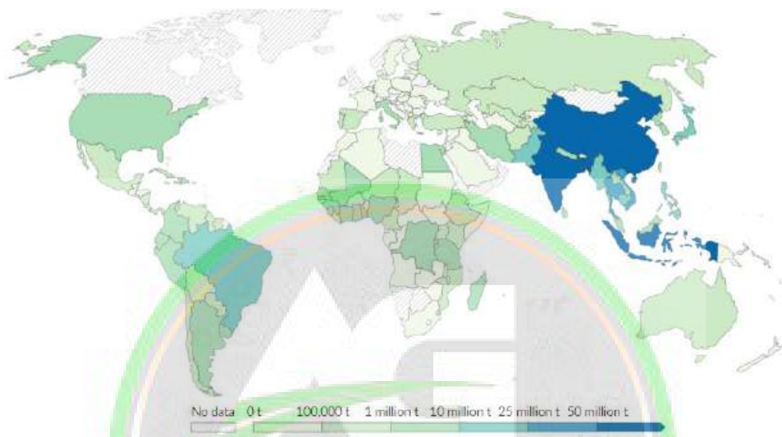

Fig. 1. Global Rice Producing countries

Indonesia third largest consumer of rice in the world is **Indonesia** which consumes 37,400 metric tons. Approximately 77% of the farmers in Indonesia grow rice, and the country is also the fourth most populous in the world where rice is its most important food crop.

Recently import of rice has declined; however, it is expected to increase in coming years because the population continues to increase. The **International Rice Research Institute** estimates that in the next 25 years or so Indonesia will require at least 38% more rice than it is currently producing. While importation is an option, over-reliance on this as a way to meet the national deficit is not advisable, and the Indonesian government is developing mechanisms of increasing domestic production to increase self-reliance.

The effect of rice in the global economy

Basic macro data for real gross domestic product (GDP) growth, exchange rates for local currency relative to the US dollar (USD), and population growth are presented in Figures for six major exporting countries that include Thailand, India, Vietnam, Pakistan, Myanmar, and Cambodia.

For the major rice exporters, GDP generally grows from 6%–7% annually over the baseline period, except for Pakistan and Thailand which have relatively low growth rates of 3%–5% (Figure 1). The exchange rates relative to U.S. dollar (USD) is relevant in rice trade because the global rice market is denominated in USD. Figure 2 shows nominal foreign exchange rate indices in terms of USD per local currency using 2010 as the base year. Currencies of Thailand and Cambodia remain on par; whereas, those of Vietnam, Pakistan, Myanmar, and India depreciate relative to the US dollar over the baseline period. Everything else equal, this implies that export competitiveness of these latter four countries is expected to improve over the baseline

Indian economy on rice

India has kept export prices low through government subsidies to farmers and exporters. Farmers receive two types of subsidies. The first is the input subsidy, which provides free or low-cost seeds and fertilizers, subsidized electricity, interest-free credit, and other inputs to farmers. The second is the food subsidy, embodied in the Public Distribution System for food grains, for which the government buys paddy (unmilled rice) from farmers at a Minimum Support Price (MSP). Between 2010 and 2015, the seed-disbursement subsidy grew 7.6 percent, from INR 693,400 to INR 746,100 per quintal (100 kilograms). In the same period, government-sponsored credit at below-market interest rates increased by 96 percent, while fertilizer subsidies increased by approximately 16 percent. In the 10 years from 2008 to 2018, the government's MSP for paddy rose by 105 percent, from INR 850 to INR 1,750 per quintal. The MSP is important, because it creates awareness and sets a benchmark price for farmers. For exporters, the government provides export subsidies. For instance, in November 2018, the government provided a subsidy of 5 per cent on the export of rice.(The Bureau of Research on Industry and Economic Fundamentals (BRIEF))

Germplasm Availability and Varietal Development

The world's rice production was transformed by the historic discovery of the semi-dwarfing gene (*sd1*) of the De-Geo-Woo-Gen variety in the district of Taichung in Taiwan ROC (province of China). Almost all of the tropical rice-growing nations now cultivate cultivars that possess this gene. In the 1980s, the grassy stunt virus posed a threat to the production of rice farmed without the use of expensive and dangerous pesticides.The necessary gene, afterwards known as *gsv*, was present in only one *Oryza nivara* accession. Since then, all of the IR variations, beginning with IR 28, have been created and distributed. In the 1980s, a single variety, IR 36, bearing the *gsv* gene, was planted in 11 million ha, according to Dr. G. S. Khush (personal communication). Another variety with the *gsv* gene, IR 64, is grown on around 8 million acres. Although there is no accurate estimate of the region affected by the *gsv* gene, it is estimated that it will cover more than 100 million ha in Asia alone.

Increasing cost of production

The unit cost of production and rice prices decreased with the use of contemporary rice varieties and technology. But from the start of the 1990s, unit production costs have started to climb, which has resulted in lower revenues for rice farmers. The main causes of the profitability reversal are a stagnating yield frontier and declining returns to further intensification. Input prices are rising as a result of recent changes to market dynamics, particularly those relating to land, labor, and water. A number of factors that have contributed to the current situation and could make it worse in the future include the quick exodus of labor from the agricultural sector, the reallocation of land for other agricultural and non-agricultural uses, the increase in competition for water, and the removal of input subsidies.

Rice Trade and Price Incentive

Even though fewer than 5% of the world's rice crop is traded there, it nonetheless affects local rice prices. Pressure from GATT has intensified for trade liberalization and market access for rice in middle- and high-income nations. Through the introduction of a market-oriented decision-making process, it also indirectly influences the determination of research priorities and rice production. Despite the fact that a slight increase in rice commerce can be anticipated as a result of the opening of Japan's and the Republic of's previously restricted markets, the Philippines and Indonesia were able to negotiate lower tariffs thanks to a specific "rice clause". Specialty rice exports may increase as a result of the EU and US lowering their tariffs, and overall global trade may expand. Individual country input subsidies may slightly lower production costs. Additional modifications may result from the transition from subsistence to market-oriented rainfed farming (Pingali et al., 1997). Given the long-term effects of GATT on the rise in ecosystem competition, irrigated ecosystems may receive 50% of the research share. To establish research priorities, it is necessary to do additional study and align viewpoints on matters such as intensification against diversity, yield enhancement versus quality improvement, knowledge-intensive technologies versus farmers' time, and private versus publicly supported research (Pingali et al., 1997).

Conclusion

More than 90% of the world's rice is produced and consumed in the Asia-Pacific region, which is home to 56 percent of the world's population. In the majority of nations, it is anticipated that rice demand will increase more quickly than supply. A major concern is how the current yearly production of 524 million tonnes could be expanded to 700 million tonnes by 2025 while utilizing less water, less land, less labor, and fewer agrochemicals. Alternative strategies for overcoming the difficulty through horizontal and vertical growth each have their own advantages and drawbacks. According to this scenario, there is hope for closing the yield gap and increasing rice production.The regional comparative advantages of producing a crop and trade globalization made possible by GATT, WTO, and COMESA can be a big motivator for farmers to work hard and close the yield difference. In order to provide answers, the Region may also concentrate on other hemispheres. Africa has the potential to be a promising "Future-Food-Basket" for Asia, but there must be added a concrete policy framework and background support under the South-South Co-operation and NAM. Asia and Africa's combined might and synergistic ties have amazing potential. This can help and give both continents a strong foundation for shared prosperity.

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AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

BIOHERBICIDE – A NEW TECHNIQUE FOR WEED CONTROL

Article ID: AG-VO4-I05-21

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Introduction

Biological control of weeds is the intentional use of living organisms (biotic agents) to reduce the vigour, reproductive capacity, density, or impact of weeds (Quimby and Birdsall, 1995). The strategies of biological control can be classified in two broad categories: (i) classical or inoculative, and (ii) inundative or mass exposure. The classical strategy is based on introduction of host-specific organisms from the weed's native range into regions where the weed has established and become a widespread problem. The biotic agents, after quarantine to assure host specificity, are released into weed-infested sites and are allowed to adapt and flourish in their new habitat over time to eventually establish a self-perpetuating regulation of the weed infestation at acceptable levels. Thus, classical biological control requires a time period of one to several years to achieve adequate control while the agent population builds up to levels to impact the weed population. (Charudattan R. 2005)

The inundative strategy attempts to overwhelm a weed infestation with massive numbers of a biotic agent in order to attain weed control in the year of release. In contrast to classical biological control, inundation involves timing of agent release to coincide with weed susceptibility to the agent and formulation of the agent to provide rapid attack of the weed host. A development of the inundative strategy is the bioherbicide approach, which involves application of weed pathogens in a manner similar to herbicide applications. Since most bioherbicides have been developed using selected plant pathogenic fungi that cause such diseases on weeds as anthracnose and rust, the term mycoherbicide is often used in reference to these fungal preparations. The objectives of this review are to identify the place for bioherbicides in weed management including their integration into current systems, to develop an understanding of factors affecting their successful use in both conventional and alternative management systems, and to assess the prospects of developing strategies for using bioherbicides in biologically-based weed management.

Important mycoherbicides being produced and used commercially viz, Devine, Collego, Bipolaris, Biomal, Dr. Biosedge, ABG-5003, Welco, Luboa, and CASST that controlled specific weed in a different region. (www.apsnet.org)

Objectives

Use of Biological Agents to control agricultural weeds.

To minimize the use of chemicals.

To maintain the ecological balance.

Why Bioherbicides

1. Yield losses still occur despite of available herbicides
2. Herbicide resistant weed populations have developed
3. Herbicides may have detrimental effects on non target plants
4. Large areas where herbicide application not possible or not effective
5. Damage to the environment
6. Ground water contamination

The Bioherbicide Advantage

1. Bioherbicide can be readily integrated into weed management systems
2. Bioherbicides are often compatible with synthetic herbicides
3. Organically acceptable
4. Low maintenance and management.
5. Effective area not limited

Ideal Characteristics of a Bioherbicide

1. Produce abundant and durable inoculum in culture
2. Target specific
3. Genetically stable
4. Capable of killing a significant portion of the weed population under a variety of environmental conditions (weed densities

Approaches for Microbial Weed Control

a. Classical Approach

The classical or inoculative approach involves the import and release of one or more natural enemies that attack the target weed in its native range, in to areas where its natural enemies are absent.The classical approach has been used almost exclusively for the control for the extensive infestation of perennial weeds in relatively undisturbed environments such as aquatic and range land.The objective of classical approach is generally not eradication of the weed species, but self- perpetuating regulation of the weed population at acceptable low levels.

b. Inundative or Bioherbicidal Approach

The bioherbicide approach in which a natural enemy is used within its native range to control a native or naturalized weed. Bioherbicide have been targeted towards a wide range of weed problems, including weeds of cropping systems. Consequently, bioherbicides often must be effective in disturbed environments, delivering economically valuable weed control within specific, short time frame

c. Augumentative Approach

This approach falls into the category of periodic release and can be regarded as midway between the classical and the inundative approach.The pathogen may be native or naturalized in their respective region causing endemic disease.They can be self-disseminate causing certain level of self-sustaining epidemics after inoculation. The amount of inoculum is required larger than for inoculative approach and less than the inundative strategy

Important Bioherbicides being produced and used commercially

Trade name	Mycoherbicide	Country	Weed controlled
DEVINE	*Phytophthora palmivora*: it is a liquid suspension & cause root rot in the weed.	-	Strangle vine (*Morrenia odorata*) in citrus orchard
COLLEGO	*Collectotrichum gloesporiodes* f.sp. *Aeschynomene.*: it is a wettable powder and causes stem and leaf blight in the weed.	USA	Northern join vetch (*Aeschynomone spp*.)
BIPOLARIS	*Bipolalaris sorghicola:* it is a liquid suspension	-	Johnson grass (*sorghum halepense*)

BIOLOPHOS	A microbial toxin produced as fermentation product of *streptomyces hygroscopicus*	-	Non specific general vegetation
BIOMAL	Wettable powder of *Collectotrichum gloesporiodes* f.sp. *Malvae*	USA	*Malvapusilla*
Dr. BIOSEDGE	*Puccinia canooliculata*	-	*Cyperus esculentus*
ABG-5003	Wettable powder *cercospora rodmanii*	USA	Water hyacinth (*Eichornia crassipes*)
WELCO	*Collectrichum coccodes*	USA	*Abutilon theophrasti*
LUBOA	*Collectotrichum* f.sp. *cuscutae*	CHINA	*Cuscuta* spp.
CASST	*Alternaria cassiae*	USA	*Cassia obtusifolia*

www.apsnet.org

Steps in Bioherbicide development

The development of bioherbicide involves three major phases:

Discovery

The discovery phase involves Collection of diseased plant material:

I. Isolation of the causal organism
II. Identification of the pathogen, culture of the pathogen on artificial media
III. Maintenance of the pathogen cultures in short-term and long-term storage

Development

The development phase involves:

I. Determination of optimum conditions for spore production
II. Determination of optimum conditions for infection and disease development
III. Determination of host range and explanation of mechanism of action of the pathogen

Deployment

Involves close collaboration between non industrial and industrial sectors through

1. Formulation
2. Scale-up
3. Field evaluation

4. Marketing stages of commercialization of new bioherbicide product

Bioherbicide Production Methods

In general, three methods have been evaluated for the production of bioherbicides

a. The use of living host plants
b. Solid substrate fermentation
c. Liquid culture fermentation

Adequate production of many potential bioherbicides can be achieved only by using living plants (rust fungi) or solid substrate fermentations (Alternaria spp.) these methods are to costly for commercial use. At present, liquid culture fermentation is the most economical method for producing microbial biocontrol agents.

Microorganisms for bioherbicide

Fungi

Most fungi produce spores and thus a high inoculum level can be readily produced on infected grain or by mixing fungal propagules in inert carriers

Bacteria

Very few bacteria produce endospores and thus, bacterial formulations are problematic

Viruses

Some are quite amenable to drying and hence, would be easy to formulate

Some Commercial Mycoherbicides in Use Abroad

Product	Content	Weed controlled
De-vine	A liquid suspension of fungal spores of *Phytophthora palmivora* Butler. It causes root rot in the weed	Strangle vine (*Morrenia odorata*) in citrus orchards
Collego	Wettable powder containing fungal spores of *Colletotrichum gloesporiodes* Penzig & Sacc. Sp. *Aeschynomene*	Northern joint vetch (*Aeschynomone sp*) in rice fields. The bioherbicide causes stem and leaf blight in the weed
Bipolaris	A suspension of fungal spores of *Bipolaris sorghicola*	Johnson grass (*Sorghum halepense*)
Biolophos	A microbial toxin produced as fermentation product of *Streptomyces hygroscopicus*	Non-specific, general vegetation

Volume: 04 Issue No: 05

APPLICATIONS OF PRE-BREEDING IN CROP IMPROVEMENT

Article ID: AG-V04-I05-22

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Introduction

Using crop wild relatives (CWR) in crop improvement is much more difficult than breeding with domesticated varieties. Pre-breeding aims to isolate desired genetic traits (e.g., disease resistance) from unadapted material like CWR and introduce them into breeding lines that are more readily crossable with modern, elite varieties-breeding broadens the elite gene pool by re-capturing lost beneficial genetic diversity. Pre-breeding involves all the activities associated with identification of desirable traits and/or genes from unadapted germplasm (donor) that cannot be used directly in breeding populations (exotic/wild species), and to transfer these traits into well-adapted genetic backgrounds (recipients) resulting in the development of an intermediate set of material which can be used readily by the plant breeders in specific breeding programmes to develop new varieties with a broad genetic base

Pre breeding in major crops

(a).Grain Zn in Rice

Exploitable genetic variability for any trait, its systematic characterization, and effcient use are essential for a successful breeding program. Most elite modern rice varieties and their closest elite genetic pool have low grain-Zn content. *Oryza nivara, O. rufpogon, O. longistaminata, and O. barthii* accessions, landraces, colored rice, and aus and aromatic accessions were found to have rich grain-Zn content.But these accessions may not be agronomically desirable because of their poor phenotype and lower yield. Therefore, a systematic pre-breeding for grain Zn is essential to develop high-Zn rice varieties. The advanced backcross method for genetic dissection of wild rice, and for developing high-Zn introgression lines, is an attractive approach for effcient use of wild rice accessions . Several wild rice-derived introgression lines with high grain Zn and yield have already been developed by several groups . Multi-parent-derived populations to select transgressive variants with a combination of desirable traits have yielded many desirable transgressive variants for grain Zn. Marker-assisted QTL deployment, QTL pyramiding, and marker-assisted recurrent selection are helpful in germplasm enhancement for grain Zn with other traits.

(b).Simple Traits in Wheat

Trait- and marker-based incorporation of simple traits is possible if based on the availability of robust linked markers. Simple traits or major gene-based traits are relatively easier to incorporate since their selection in subsequent generations can be done phenotypically or through marker assisted selection approaches. For example, reduced plant height, controlled by the famous green revolution alleles Rht-B1b and Rht-D1b is relatively easy to select visually. In addition, the identifcation of molecular markers with technologies such as Kompetitive allele specifc PCR (KASP) and gene cloning is possible with relatively fewer generations and less time compared to complex traits. Another example of a trait that is easy to screen and incorporate is developmental traits. Although multiple genes related to fowering time have been identifed in wheat, the different genes determining spring to winter growth habit remains a major screen in every pre-breeding activity. Other examples include genes for traits such as vernalization (Vrn), photoperiod (Ppd), plant height (Rht), earliness per se (Eps), thousand grain weight (TaGW2) and rust genes for leaf rust (Lr), stripe rust (Sr), and yellow rust (Yr) (For details on rusts refer to Chap. 8). Marker-assisted selection and marker-assisted backcrossing are normally used in selection for simple traits

(c). Bean

Scientists at the International Center for Tropical Agriculture (CIAT) have identified two wild *Phaseolus acutifolius* accessions which can tolerate high night temperatures. They have been used as parents in breeding programs for improving heat tolerance. Our partners have also found that bean wild relatives have traits for tolerance to waterlogging and root rot pathogen.

(d).Pigeonpea

Pre-breeders at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) have selected a high-yielding line (ICPL 15028) which has resistance to multiple diseases (wilt, sterility mosaic disease and phytophthora). The line has been included in the national crossing program of India.

(e).Pearl millet

Blast is a newly emerging disease that is devastating the production of pearl millet in India and Africa. Researchers at ICRISAT discovered that some populations of a pearl millet subspecies found in Mali and Chad has resistance to multiple forms of blast. They crossed them with the domesticated pearl millet and developed four pre-breeding populations for further testing.

(f).Finger millet

Progress has been made in Kenya to identify crop wild relatives tolerant to the parasitic plant Striga (witchweed), which can cause crop losses of up to 100%.

(g).Eggplant

Project partners generated promising materials and lines with drought tolerance. In the second phase of the project, partners will evaluate the new pre-breeding materials in different environments. The Crop Trust is collaborating with the World Vegetable Center as well as five breeding companies in this work.

Applications of pre-breeding in crop improvement:

There are major four applications of pre-breeding:

1. Broadening the genetic base, to reduce vulnerability
2. Identifying traits in exotic materials and moving those genes into material more readily accessed by breeders
3. Moving genes from wild species into breeding populations when this appears to be the most effective strategy and
4. Identification and transfer of novel genes from unrelated species using genetic transformation techniques.

The adoption of pre-breeding facilitates the efficiency and effectiveness of crop improvement programmes by enabling increased access to, and use of, genetic variations conserved in gene bank.

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Volume: 04 Issue No: 05

HOUSE CENTIPEDE - *SCUTIGERA COLEOPTRATA*

Article ID: AG-VO4-I05-23

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Introduction

Scutigera coleoptrata, also known as the house centipede, is a species of centipede that is typically yellowish-grey and has up to 15 pairs of long legs. Originating in the Mediterranean region, it has spread to other parts of the world, where it can live in human homes and termite mound also. It is an insectivore; it kills and eats other arthropods, such as insects and arachnids.

Morphology

The body of an adult *Scutigera coleoptrata* is typically 25 to 35 mm (1.0 to 1.4 in) in length, although larger specimens are sometimes encountered. Together with the antennae they give the centipede an appearance of being 75 to 100 mm (3 to 4 in) in length. The delicate legs enable it to reach surprising speeds of up to 0.4 meters per second (1.3 ft/s) running across floors, up walls and along ceilings. Its body is yellowish-grey and has three dark dorsal stripes running down its length; the legs also have dark stripes. S. *coleoptrata* has developed automimicry in that its tail-like hind legs present the appearance of antennae. When the centipede is at rest, it is not easy to tell its cranial end from its caudal end.

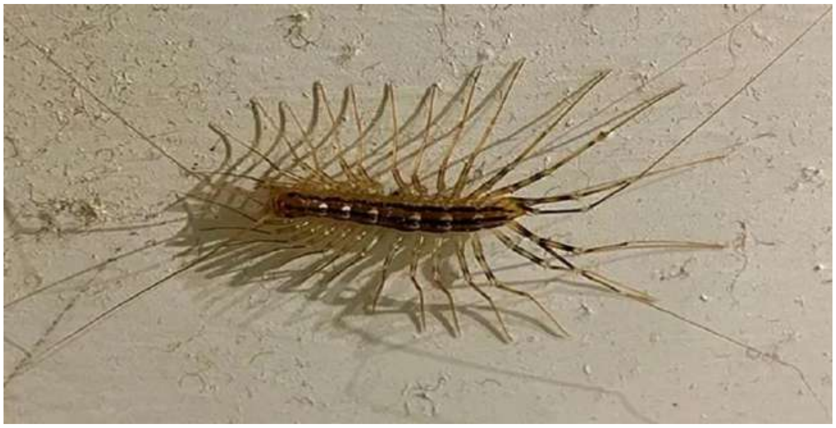
Reproduction and development

House centipedes lay their eggs in spring. In a laboratory observation of 37 house centipedes, an average of 93 and a maximum of 187 eggs were laid. Young centipedes have four pairs of legs when they are hatched. They gain a new pair with the first moulting and two pairs with each of their five subsequent moulting. Adults with 15 pairs of legs retain that number through three more moulting stages. House centipedes live anywhere from three to seven years, depending on the environment. They can start breeding in their third year. To begin mating, the male and female circle around each other. They initiate contact with their antennae. The male deposits his sperm on the ground and the female then uses it to fertilize her eggs.

Behavior and ecology

House centipedes feed on spiders, bed bugs, termites, cockroaches, silverfish, ants and other household arthropods. They administer venom through forcipules. These are not part of their mandibles, so strictly speaking they sting rather than bite. They are mostly nocturnal hunters. Despite their developed eyes, they seem to rely mostly on their antennae when hunting. Their antennae are sensitive to both smells and tactile information. They use both their mandibles and their legs for holding prey. This way they can deal with several small insects at the same time. To capture prey they either jump onto it or use their legs in a technique described as "lassoing". *S. coleoptrata* ability to distinguish between possible prey, avoiding dangerous insects.

They also adapted their feeding pattern to the type of hazard the prey might pose to them. For wasps, they retreat after applying the venom to give it time to take effect. When the centipede is in danger of becoming prey itself, it can detach any legs that have become trapped. House centipedes have been observed to groom their legs by curling around and grooming them with their forcipules. It may often be seen darting across floors with very great speed, occasionally stopping suddenly and remaining absolutely motionless, presently to resume its rapid movements, often darting directly at inmates of the house, particularly women, evidently with a desire to conceal itself beneath their dresses, and thus creating much consternation.



Scutigera coleoptrata

Habitat

House centipedes prefer to live in cool, damp places. Centipede respiratory systems do not provide any mechanism for shutting the spiracles, and that is why they need an environment that protects them from dehydration and excessive cold. Most live outside, primarily under large rocks, piles of wood or leaves, in bark dust and especially in compost piles. They often emerge from hiding during the watering of gardens or flowerbeds. These centipedes can be found in almost any part of the house, although they are usually encountered in dark or dimly lit areas such as basements and garages. Inside the home, they can be found in bathrooms and lavatories, which tend to be humid, but they can also be found in drier places like offices, bedrooms and dining rooms. They are usually seen crawling along the ground or floor, but they are capable of climbing walls. The greatest likelihood of encountering them is in spring, when they emerge due to warmer weather and in autumn/fall, when the cooling weather forces them to seek shelter in human habitats.

Distribution

S. coleoptrata is indigenous to the Mediterranean region, but it has spread through much of Europe, Asia, North America and South America It has also been introduced to Australia, also found in all over the India and Tamil Nadu.

Biological details

The faceted eyes of *S. coleoptrata* are sensitive to daylight and very sensitive to ultraviolet light. They were shown to be able to visually distinguish between different mutations of Drosophila melanogaster. How this ability fits with its nocturnal lifestyle and underground natural habitat is still under study. They do not instantly change direction when light is suddenly shone at them, but will retreat to a darker hiding spot.

Interaction with humans

Unlike its shorter-legged but larger tropical cousins, *S. coleoptrata* can live its entire life inside a building, usually on the ground levels of homes. Many homeowners may be unsettled by house centipedes due to their speed and appearance. However, they pose little to no threat towards humans, and are often beneficial as they catch other, more harmful pests, such as cockroaches. They are not aggressive and usually flee when disturbed or revealed from cover. Sting attempts are therefore rare unless the centipede is cornered or aggressively handled. Its small forcipules have difficulty penetrating skin, and even successful stings produce only mild, localized pain and swelling, similar to a bee sting. Allergic reactions to centipede stings have been reported, but these are rare; most stings heal quickly and without complication.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

UNRAVELLING NATURE'S CODE: EXPLORING WEATHER PATTERNS WITH ALMANACS, ITK AND ASTROLOGICAL INSIGHTS

Article ID: AG-VO4-I05-24

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Introduction

Weather forecasting has long been a pursuit that marries both science and intuition. From ancient almanacs to modern technological advancements, humanity has sought to decode the mysteries of nature's patterns. In this article, we delve into the intricate tapestry of weather prediction, combining the wisdom of almanacs, the innovation of Indigenous Traditional Knowledge (ITK), and the celestial guidance of astrological insights.

Harnessing Indigenous Traditional Knowledge (ITK):

The ethnic people, especially farmers, and fishers, are very incisive weather watchers and are quick to recognize weather conditions and whether or not they are favorable to their production systems *(Ravi Shankar et.al., 2008).* Indigenous civilizations have developed substantial archives of traditional knowledge that have been passed down over the years in tandem with almanacs. ITK is a comprehensive awareness of the natural world shaped by close relationships with the land and the sky. Indigenous peoples have evolved complex systems for predicting the weather, based on hints from the natural world, animal behavior, and astronomical occurrences. The vulnerability caused by the vagaries of the weather creates a knowledge base among the ethnic people/farmers in the form of Indigenous Technical Knowledge (ITK) that helps people overcome uncertainty and prepare for possible adverse or favorable events *(Roncoli et al.,2002).* By respecting multiple ways of knowing and promoting cross-cultural interchange, we can better understand weather dynamics by acknowledging the ITK alongside contemporary scientific methods.

These ITKs consist only of folktales. The Intergovernmental Panel on Climate Change recognized traditional pieces of knowledge as ITK in 2007. It was grouped according to multiple criteria. Factors include means of observation that include biological indicators, chemical and physical changes, and visible changes in the atmosphere. Additional variables include astrological techniques that deal with calculating planetary placements and star conjunctions, studying solar ingress, identifying certain dates for each month, and studying nakshatra and nadi chakras of the respective events.

ITK BASED ON OBSERVATION METHODS:

Local indicators and local knowledge systems cannot be replaced with scientific knowledge, because they are holistic and specific to local situations, providing farmers and others with the ability to make decisions and prepare for the coming agricultural year *(Bharara LP et.al., 1994; Mahima Shakrawar, 2018)*

Weather forecast using airspace elements such as clouds, sky, and rainbows: Farmers in the northwest corner of India have an indigenous idea that architectural works should be done when it rains after a hot summer and the sky should appear to be the color of a crow's egg.

- Rainfall is also possible if we can visually identify a dense, black cloud that is perpendicular to the sun's orbit.
- According to farmers' legend, if the sky becomes crimson after a prolonged period of rain, there is no possibility for the occurrence of rainfall in the region.

Weather forecast using birds and animals:

- If swallowtail butterflies and sparrows are seen flying in a lower area, a large rainfall total is predicted, while their absence from the surrounding area indicates an imminent drought.
- Crows cawing at night and owls shrieking during the day are signs of an impending drought; signals of rainfall arriving in a few days include sparrows bathing in dust and bees fleeing into their colonies.
- A peacock lying in the ground spreading feathers under the sun can also be used to estimate the likelihood of rain.



Sparrows' dust bath and peacocks' dancing indicates the arrival of rainfall

The position of a weaver bird's nest also records long-range rain forecasts; that is when the bird builds its nest close to the base of a well, it signals less recharging of well water owing to a weak monsoon, and vice versa.

The following table represents the list of birds and their significant behavior in the prediction of weather conditions:

Common name	Local name	Scientific name	Behaviour	Prediction
Cuckoo	Khashopapu	Cuculidae	Singing	Sowing of seeds
Sparrow	Shoqheti/ Tughashoqhe	Passeridae	Appearance/ Abundance	Warm season
Domesticated Chickens	Awudu/ Awuli	Gallus gallus	Pick food during rain Rests during rain	Rain will continue Rain will stop
Amur falcon	Inami laqu	Falco amurensis	Migration	Cold season
Partridge	Agili	Perdix perdix	Singing	Rainfall
Long-tailed Wren babbler Rusty-capped fulvetta	Ashomi kushowu ghau Marutsa kutsuqho ghau	Spelaeornis chocolatinus Alcippe dubia	Height of their nests	Flooding
Yellow-throated laughing thrust	Akunu ghau	Garrulax galbanus	Flight	Fair or adverse weather
Grey-crowned warbler Bamboo partridge	Kutsuqho ghau Akhawu agili	Seicercus tephrocephalus Bambusicola	Perching behaviour	Strong winds/ storm
Sparrow	Shoqheti/ Tughashoqhe	Passeridae	Dipping in water and chirping	Rainfall is imminent

(Alino Sumi, 2018

Weather forecast using insects

There is some evidence that insects adjust their behaviors associated with flight, mating, and foraging in response to changes in barometric pressure. *(Ana Cristina Pellegrino et.al, 2013)*

- The antennae of insects can accurately detect an increase in humidity.
- The presence of white worms crawling on cow dung suggests significant rainfall.
- Dragonflies indicate evening rain when they are observed flying between three and four meters above the ground.

- Ants' nest building style helps in weather forecast. Building it with one side higher than the other will cause rain to fall from that direction; building the walls high all the way around will cause storms to arrive.
- Dry weather will arrive when cicadas are heard, and frost will arrive in six weeks.
- Rain will leak from the skies if ants continue to build their barriers regularly.
- Days are warm and skies are beautiful when bees are far enough away to fly; yet, inclement weather is certain to arrive when their flight concludes close to home.
- In houses, flies congregate immediately before it rains.
- The earlier the crickets arrive on the hearth, the earlier winter will arrive.
- The more quickly crickets chirp, the warmer will be the temperature. By Counting the number of chirps in 15 seconds, and by adding 40 to the counted value, the temperature in Fahrenheit can be roughly estimated. This is called Dolbear's Law.
- A cold winter is expected if spiders weave larger webs than normal.
- The spell will soon get quite dry when spiders begin to fly with their webs.
- Before it rains, spiders descend from their webs.

- The height at which the bald-faced hornets make nests in trees helps in the prediction of snow.

Weather forecast by reptiles and amphibians: *(Catherine Boeckmann,2023)*

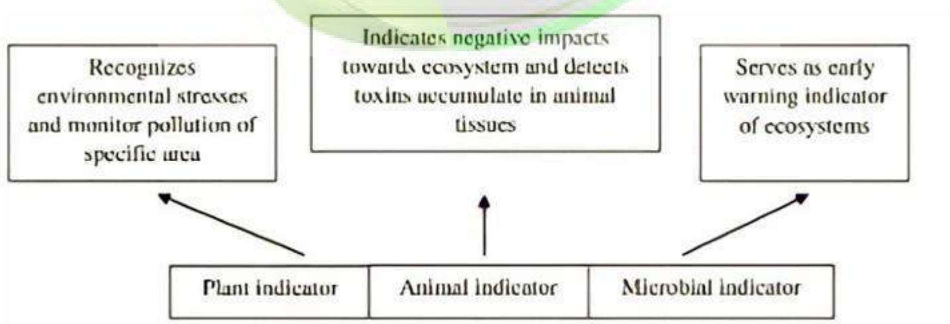
- More rain is expected if the frog croaks louder.
- Hanging of snakeskin also indicates the arrival of rainfall.

Weather forecast using plants and trees:

Long-term forecasts are typically made using plants and the phenomena that are related to them, whereas predicting short-term natural occurrences is based on observations of changes in animal behavior. Although they are not visible to the human eye, plants' physiological reactions to changes in their external environment are reflected in their phenology.

There is a belief that ash (Fraxinus excelsior L.) and sycamore (Acer pseudoplatanus L.) trees have apotropaic power [having the power to prevent evil or bad luck] to thunder and other natural disasters and therefore are honored *(Sharlanova V, 1999).*

- When neem blooms fully in the summer, it's too hot outside. Low pressure is consequently produced in the inland area. It was anticipated that wet clouds would arrive to fill this low-pressure vacuum. By this, long-range weather forecasting is possible.
- The so-called state flower of Kerala, Cassia fistula, or the "Golden Shower Tree," proved helpful in predicting the advent of the monsoon in India. It was thought that the coming of the monsoon is anticipated when the blossom opens in roughly 45 days.



SEASONAL SOOTHSAYER: THE ULTIMATE WEATHER ALMANAC:

Although the development of contemporary meteorological techniques and technology has diminished their significance, almanacs have historically played a vital part in weather forecasting.

Historical Weather Data:

Almanacs usually contain historical weather information for different areas. Meteorologists can forecast future weather conditions with a degree of accuracy by studying historical weather patterns. To comprehend climate trends and forecasting patterns, this historical data provides a baseline.

Astronomical Information:

Astronomical details like moon phases, dawn and sunset timings, and celestial events are customarily included in almanacs. Indirect effects of these data on weather patterns include how the sun's location influences temperatures and how lunar phases affect tides, which in turn affect weather conditions.

Almanacs are frequently important in terms of culture, especially in rural or agricultural societies. They might know planting and harvesting schedules, which are affected by weather patterns, that are pertinent to farmers and gardeners. They might also include holidays and seasonal events that are dependent on the weather.

- Kautilya's manuscript known as Arthasashtra contains records of rainfall measurements made by astrologers. The support of the nation's revenue and relief efforts in 3B.C. was provided by this data.
- The full moon's occurrence was a criterion for the seasonal rainfall forecast in the Brihatsamhita manuscript.
- Farmers in Maharashtra employed the Nakshatra Varsha Almanac Calendar, which was created to forecast rainfall patterns six months ahead of time, to plan their crops.

INFLUENCE OF STARS ON WEATHER PREDICTION:

Some people think that celestial bodies, especially stars, may affect weather patterns through astrological or astrometeorological means, while orthodox meteorology relies on atmospheric and oceanic elements to anticipate weather. It is noteworthy, therefore, that the consensus in science does not endorse the notion that stars have a direct impact on weather.

- In Saurashtra, farmers predict drought when there is low wind velocity during the Mirghirsh (Orion) constellation and no excessive heat during the Rohini season. This is based on old wisdom for weather forecasting for agro-consultants. The prediction accuracy was around 60 to 70%.
- In 2005, Anand Agricultural University, a state agricultural university, completed a Nakshatram forecast. The weather prediction was found to be 42–73% accurate. It included Gujarat's eight agroclimatic zones for forecasting. *(M.C.Varshneya et.al, 2005).*

Conclusion

As a result, even if different approaches like astrometerology, indigenous traditional knowledge systems (ITKs), and almanac predictions may present different viewpoints on weather forecasting, it's important to examine them critically. Even though they could be historically and culturally significant, they frequently lack scientific validity and actual data. For accurate and trustworthy forecasts, it is vital to give priority to scientific rigor and evidence-based techniques when incorporating these methods into weather forecasting practices. For the benefit of all, we can work to improve our understanding of weather patterns and forecast accuracy by adopting a multidisciplinary approach that incorporates cutting-edge scientific discoveries with conventional wisdom.

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Volume: 04 Issue No: 05

UNVEILING SEMI-HYDROPONICS: REVOLUTIONIZING HOME GARDENING

Article ID: AG-VO4-I05-25

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Abstract

The global demand for sustainable living and locally sourced food fuels interest in home gardening. Traditional soil-based methods face space limitations, soil depletion and high maintenance. Semi-hydroponics offers a practical solution, using inert media and nutrient solutions, especially in urban areas. This article explores how semi-hydroponics conserves water, prevents soil degradation, and enhances self-sufficiency in produce. By merging traditional gardening with hydroponic techniques, it optimizes root growth and yields through nutrient solution reservoirs. Various inert mediums adapt semi-hydroponics to urban and indoor settings, enabling year-round cultivation. Constraints like root rot nutrient balance and prevention are documented, refining system performance and promoting sustainable gardening practices.

Keywords: Semi-hydroponics, urban gardening, soil-borne diseases and resource efficiency

Introduction

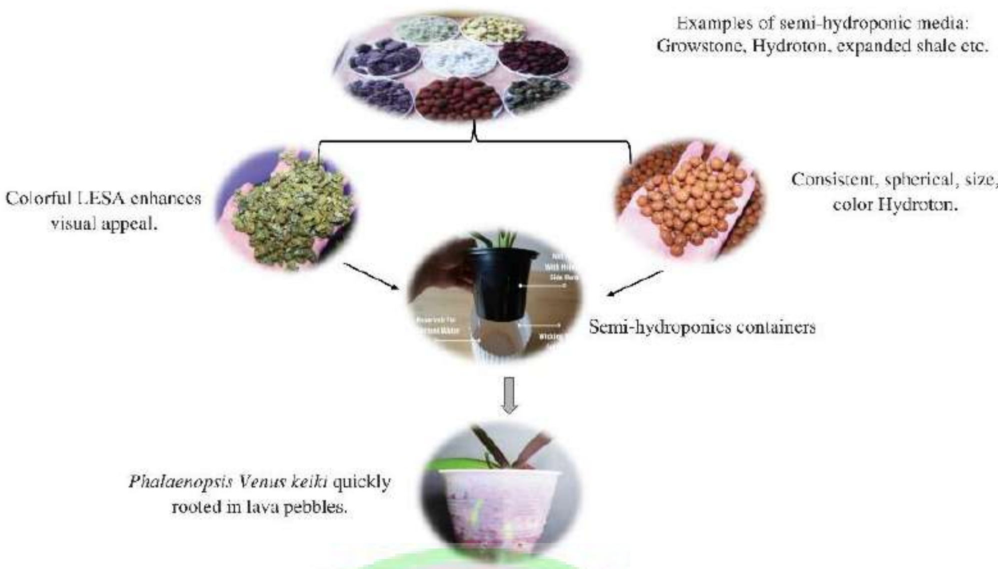
The rising popularity of home gardening signifies a world shifting towards sustainable living and the desire for fresh, healthy and locally grown produce. Despite the limitations of traditional soil-based methods due to space constraints, soil depletion, and high maintenance requirements, semi-hydroponics emerges as a practical solution of problems. This method integrates inert media and nutrient solutions, simplifying the gardening process. Particularly in urban environments where space is scarce, semi-hydroponics addresses these challenges effectively. By reducing loss of water, preventing soil degradation, and fostering self-sufficiency in produce, semi-hydroponics aligns with the principles of sustainability and food security.

Semi-hydroponics, also called to as passive sub-irrigation or passive hydroponics presents itself as a self-contained iteration of contemporary hydroponic methods (Hankins, 2017). Diverging from traditional hydroponic systems that primarily cater to a single species within a shared basin with ongoing or intermittent nutrient supply, semi-hydroponics amalgamates elements of conventional soil-based gardening and hydroponic methodologies (Green, 2019). Originally developed in the early 1990s, primarily targeting orchids, this technique employs Lightweight Expanded Clay Aggregate (LECA) as a medium enclosed within solid-bottomed containers (Williams, 2020). These containers incorporate small-diameter holes in their sidewalls, regulating the internal reservoir's depth (Johnson *et al.,* 2018). Alternatively, standard pots with bottom drainage can be arranged within a tray to establish an external reservoir (Smith & Brown, 2021). Reducing the necessity for continue watering and augmenting sustainability and pest, disease management measures these are the advantages of semi-hydroponics over the traditional gardening practices.

This amalgamation of traditional and hydroponic methods simplifies plant care as well as offers additional benefits such as sustainability and pest prevention. By employing inorganic potting materials, semi-hydroponics ultimately reducing the frequency of watering while promoting healthier plant growth. Moreover, this approach decreasing the risk of soil-borne pests and diseases, contributing to increasing overall plant vigor, health and yield.

How Semi Hydroponics Works

Semi-hydroponics represents a passive growing technique enabling the transformation of conventional household plants into more manageable specimens devoid of soil reliance (Smith, 2019). Often referred to as semi-hydroponic plants, these specimens are situated within "double" containers. The first container contains inorganic materials (media) serving the dual purpose of water absorption and plant anchorage (Jones *et al.*, 2020). Meanwhile, the second container functions akin to a reservoir commonly observed in hydroponic systems. The seamless integration of these containers is facilitated by small drain holes at the bottom of the upper container (Brown & Johnson, 2018). Upon watering, plants selectively absorb the requisite amount of water, with excess water draining into the secondary container. Roots may serve as natural wicks, facilitating water uptake from the reservoir when needed (Taylor, 2021).



Semi Hydroponic Pots and Containers:

Self-watering pots and containers are ideal for semi-hydroponic gardening. A wonderful semi-hydroponic container has enough room for the plant of your choice and, at the very least, permits the creation of a shallow reservoir in a second lower area of the container. For a less expensive option, you can even put the nursery pots you bring home with your plants inside a cache pot that has been filled with nutrient water.

Semi Hydroponic Mediums:

Numerous growing mediums are working well for semi-hydroponics. Inorganic, absorbent and typically reserved for hydroponics are some features of media. A few popular choices are LECA / Clay balls, pumice, loose gravel, river rock, sand, foam, rockwool, vermiculite, perlite and other soilless mixes. Many media are available for passive hydroponics, but the most common are expanded clay pellets, coconut husk chips, perlite, vermiculite, diatomite and rock wool.

Watering Semi Hydroponic Plants:

Most plants require watering not more than once every 2 to 3 weeks once converted to semi hydroponics. There are always exceptions of course, as there are with any growing methods. Some plants will always need watering more than others, regardless of their growing medium. Generally speaking, plants that are grown with semi hydroponics can go as much as 2 to 3 times as long between watering as the same plants that are grown in soil.

Semi Hydroponic Fertilizer and Nutrients:

In semi-hydroponic gardening, nutrients and fertilizers play an important role in sustaining plant growth and development. Unlike traditional soil-based cultivation, where nutrients are obtained from the soil, semi-hydroponic plants rely on a nutrient solution. This solution typically contains essential micronutrients like sulfur, iron, and manganese along with macronutrients such as nitrogen, potassium, and phosphorus. These nutrients are dissolved in water and supplied to the plants through the reservoir system, ensuring optimal growth and development. Monitoring and adjusting nutrient levels regularly are essential to maintain plant health and productivity in semi-hydroponic setups.

Kratky method:

The Kratky method is a passive hydroponic technique where plants are grown suspended on a reservoir of nutrient-rich water. Non-circulating, no extra water or nutrients are necessary post-initial application and no electricity, pumps, or water and oxygen circulation systems are needed. This method finds use in both commercial food production and as a simple, low-maintenance option for home growers. It's often termed as "**the simplest hydroponic system."**

The various hydroponic media available contain more air space than more traditional potting mixes, delivering increased oxygen to the roots. Allowing air to reach the roots is particularly important in preventing root rot in epiphytic plants i.e. orchids and bromeliads, whose roots are exposed to the air in nature. Passive hydroponics also may add additional ambient humidity through evaporation. It is important in passive subirrigation to wash out the system from time to time to remove salt accumulation. Some feel that plants that require drying between waterings or a dry dormant period may fail to thrive under the constant moisture of passive hydroponics, while others have found that - once a plant has replaced its existing root system with one that has grown optimized for the environment, their care is greatly simplified (Ernie 2011).

Three lettuce plants cultivated in Mason jars.

Comparison between Semi Hydroponics and Soil:

The contract character between utilizing semi-hydroponics and cultivating plants in soil are substantial. Soil harbors, diseases, pests, bacteria and necessitates more frequent watering compared to semi-hydroponics. Additionally, soil has a limited lifespan and requires fertilization, recycling, or complete replacement, weeding and some intercultural operations. Conversely, semi-hydroponics sustains its inorganic medium for longer periods and simply necessitates periodic cleaning. Overall, semi-hydroponics provides a simpler method for growing plants than soil cultivation, encompassing planting, propagation, maintenance and watering.

Benefits of semi-hydroponics:

- The wicking action makes sure that plants get the water they require, so there's less chance of over- or underwatering.
- The absence of soil allows for better aeration around the roots, which can promote healthier root growth and ultimately reduces the risk of root rot and nematode attack.
- Minimize the risk of soil-borne pests and diseases because of soilless growing mediums.
- They require less frequent watering and feeding hence, relatively low-maintenance compared to traditional soil gardening.
- In semi hydroponics the roots of the plant should always sit above the water level. The LECA will wick the moisture and nutrients up to the roots as the plant needs it, keeping the moisture level consistency.

Problems:

- One common constrains in semi-hydroponics is maintaining the correct balance of nutrients in the water solution. Imbalances can lead to nutrient deficiencies or toxicities, affecting plant growth and development.
- Despite efforts to promote aeration, root rot can still occur in semi-hydroponic systems if moisture levels are too high or if there's inadequate drainage.
- Highly exposure to light or organic matter in the nutrient solution can promote algae growth, which can compete with plants for nutrients and other things potentially harming plant health.
- pH levels in the nutrient solution can fluctuate over the time, affecting nutrient availability to plants. Monitoring and adjusting pH levels regularly is necessary for maintain optimal growing conditions.
- Over time, inert growing mediums like perlite or vermiculite can degrade, losing their structure and affecting their ability to support plant roots adequately (Resh 2013).

Conclusion

Semi-hydroponics transform home gardening by seamlessly integrating the benefits of hydroponics with the familiarity of soil-based methods. Its simplified maintenance, reduced water usage, and adaptable nature make it accessible to all levels of gardeners while encouraging experimentation and innovation. With its high potential to optimize plant growth and sustainability, semi-hydroponics being a changing step towards greener, healthier and more resilient home gardening practices, poised to shape the future of how we cultivate our green spaces.

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Volume: 04 Issue No: 05

SOIL DEGRADATION- CAUSES, TYPES, IMPACT AND RESTORATION

Article ID: AG-VO4-I05-26

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Abstract

Soil is an important natural resource which sustains life on earth. It is necessary to protect it from any kind of and degradation. Due to the population growth, intensive agriculture, over grazing, industrialization and urbanization led to the release of toxic pollutants and heavy metals leading to the contamination. This makes the soil unhealthy over the time and becomes incapable to support life on earth. In order to restore the soil degradation the sustainable soil management practices like conservation agriculture, reduced tillage, adoption of crop rotation, protecting the soil by growing cover crops and afforestation can be initiated. It is our sole responsibility that we protect and maintain the balance of our ecosystem to pass on to our future generations.

Keywords: Soil degradation, Soil productivity, Restoration

Introduction

Soil degradation is a global issue and is increasing at an alarming rate. The soil degradation can either be a natural process or man-made[1]. The increase in population has led to over exploitation of natural resources and is a main reason behind soil degradation. The natural calamities like floods, cyclones, earthquakes and forest fires cause soil degradation. The manmade activities like deforestation, shifting cultivation, overgrazing, improper agricultural practices, urbanization, mining and industrial activities result in degradation of soil. The soil degradation initially starts with the removal of vegetative cover protecting the top fertile soil.

This leads to soil erosion converting the fertile soil to barren lands causing desertification. It is necessary to restore the degraded soils by adopting some soil conservation practices to ensure the long term agricultural production to feed the increasing population and to protect the earth's natural resources.

The different types of soil degradation are caused by chemical, physical and biological processes. The chemical processes change the chemical property of soil which determine the nutrient availability like soil salinization, acidification, loss of nutrients and organic matter, pollution and eutrophication. The physical processes influence the natural composition and structure of the soil like soil compaction, soil crusting, soil erosion, water logging and lowering of water table. The biological processes like reduced microbial activity and loss of flora and fauna caused by human interference results in soil degradation.

TYPES OF SOIL DEGRADATION

Chemical degradation

- Soil salinization
- Soil acidification
- Loss of nutrients and organic matter
- Pollution
- Eutrophication

Physical degradation

- Soil compaction
- Soil crusting
- Soil erosion
- Water logging
- Lowering of water table
- Mining & Urbanization

Biological degradation

- Loss of flora & fauna
- Reduced microbial activity

Causes of Soil Degradation

1. Deforestation:

The reduction or clearing of the forest area is one of the greatest issues on a global scale. The deforestation may be either caused by natural factors or human activities. The natural factors that cause deforestation are natural forest fires and diseases caused by various pathogens or parasites. Human activities like increased population, urbanization, expansion of land for agriculture, construction of roads and dams, industrialization and mining activities contribute significantly to soil degradation. Deforestation is the removal of trees and vegetative covers by exposing the soil. Plants, trees and vegetative covers will help in binding the soil particles together. On removal of these protective covers it affects the water holding capacity, aeration, structure and biological activities of the soil leading to degradation.

2. Overgrazing:

The practice of grazing the livestock for a longer period of time on land without allowing the vegetation to recover is called as overgrazing. It alters the vegetation cover on the pasture lands causing nutrient loss and soil erosion. The soil erosion increases the bulk density, reduces the water holding capacity and infiltration rates of the soil[2]. The loss of fertile top layer due to erosion will make the soil infertile and creates barren land.

3. Improper agricultural practices:

The intensive agricultural practices like increased use of chemical fertilizers, pesticides and fungicides will affect the soil quality. The excess amount of nutrients when washed away with the irrigation water to the water bodies will result in eutrophication. The long term application of chemical fertilizers is known to increase the heavy metal contamination in soils. The adoption of mono cropping and improper surface irrigation systems will also add to the soil degradation. The increased mechanization in agriculture involves deep ploughing, heavy tillage and removal of crop cover. The usage of heavy machinery will lead to the formation of soil compaction and hardpan affecting the growth of plants.

4. Increased population and Urbanization:

The increasing population has led to the expansion of urban areas. The transformation of agricultural and forest lands for residential, commercial, transportation and industrial purposes is noticed with the growing population. Therefore the ever rising population and urbanization has triggered the land degradation faster.

5. Industrial and mining activities:

The industrial and mining activities also degrade the fertile soils. These activities will result in the accumulation of heavy metals and toxic pollutants in the soil making it unfit for various agricultural and ecological purposes.

Impact of Soil Degradation

- **Soil salinization:** The increase in salt concentration in plant root zone due to increased evaporation and improper drainage causes salinization. The accumulation of salts will make it difficult for plant growth and makes soil unsuitable for cultivation.
- **Soil acidification:** The decrease in pH of the soil causes acidification. It is usually caused due to improper fertilizer application. It reduces the microbial growth and activity affecting the nutrient cycles.
- **Soil erosion:** The loss of fertile top layer of soil by wind and water results in soil erosion leading to degradation.
- **Soil compaction:** The movement of heavy agricultural machines continuously results in soil compaction hindering the plant growth and development.
- **Soil quality and productivity:** The removal of protective vegetative cover on soil due will lead to the removal of fertile top soil and resulting in soil erosion. The reduction in soil quality and productivity is found with severe soil erosion and degradation.
- **Food security:** The loss of arable land due to various degradation activities like depletion of organic matter, erosion, acidification and salinization has reduced the soil fertility and food production. It can be a major threat to global food security.
- **Loss of biodiversity:** With the rapid deforestation and urbanization the loss of biodiversity is observed. The loss of native flora and fauna is a serious problem caused by soil degradation.
- **Desertification:** Soil degradation will reduce the fertility of the soil and makes it unsuitable for plant growth. Removal of vegetative cover, soil erosion, over grazing, deforestation and mining will result in barren land causing desertification.

Restoration of degraded soils

- **Adoption of conservation tillage practices:** The conservation tillage involves reduced tillage or no till practices which controls the heavy tillage practices and minimizes the soil disturbance. It improves the soil organic matter, soil structure and water holding capacity of water and controls soil degradation.

- **Afforestation:** The planting of trees and establishing new forest areas in deserted areas or in areas where agriculture is abandoned will help restore degraded soils.
- **Practice of crop rotation:** The practice of growing different crops on a piece of land is crop rotation. The incorporation of legumes is beneficial in crop rotation as it helps fix atmospheric nitrogen in soil. Crop rotation increases soil fertility, controls weeds and breaks the pest and diseases cycles.
- **Adoption of effective irrigation practices:** The irrigation practices like drip and sprinkler can be adopted to conserve water and reduce soil degradation[3].
- **Judicious use of chemical fertilizers:** The application of chemical fertilizers judiciously as per the soil test recommendation will reduce the hazards caused by them.
- **Restoration of plant cover:** The growing of cover crops like grasses and legume without leaving the land barren will protect the soil from erosion and degradation.
- **Contour and terrace farming:** The adoption of contour and terrace farming will help reduce soil erosion and water runoff thereby preventing soil degradation.

Conclusion

Soil degradation is an important issue to be addressed. It is going to be major concern and threat if proper action is not taken up. The restoration measures should start with soil conservation measures to keep the soil fertile and productive to feed the increasing population. The fertile and healthy soils will sequester carbon dioxide, act as a carbon sink and mitigates the climate change. It is necessary to restore the degraded soils and pass on the healthy ecosystems to the future generations.

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Volume: 04 Issue No: 05

IMMUNOCHEMICAL TECHNIQUES FOR ASSESSING FOOD QUALITY

Article ID: AG-VO4-I05-27

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Introduction

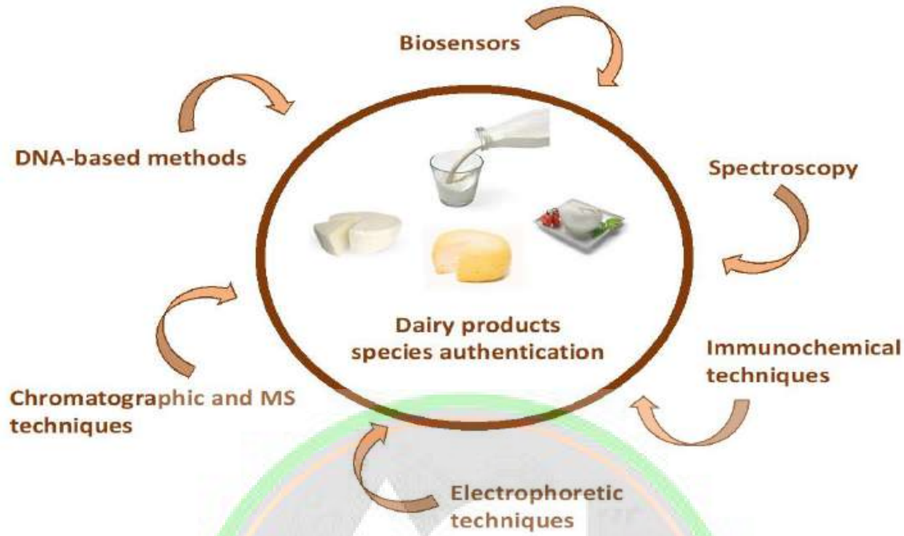
The quality of food is a paramount concern for consumers, regulatory bodies, and food producers alike. Ensuring that food products are safe, nutritious, and free from contaminants is essential for public health and consumer satisfaction. Immunochemical techniques have emerged as powerful tools in the assessment of food quality due to their specificity, sensitivity, and ability to detect a wide range of analytes.

Principles of Immunochemical Techniques:

Immunochemical techniques are based on the specific interaction between an antigen and an antibody. Antigens are molecules that can induce an immune response, while antibodies are proteins produced by the immune system in response to the presence of antigens. The binding affinity between an antigen and its corresponding antibody forms the basis of immunochemical assays.

There are several immunochemical techniques commonly used in food quality assessment, including enzyme-linked immunosorbent assay (ELISA), lateral flow assays (LFAs), immunoblotting, and immunofluorescence. These techniques utilize antibodies labeled with enzymes, fluorescent markers, or gold nanoparticles to detect and quantify target analytes in food samples.

Applications of Immunochemical Techniques in Food Quality Assessment:



1. **Allergen Detection:** Immunochemical techniques play a crucial role in detecting allergenic proteins in food products. ELISA-based assays are commonly used to quantify allergens such as peanuts, tree nuts, soy, milk, eggs, and gluten. Accurate allergen detection is essential for food labeling and ensuring the safety of consumers with food allergies.
2. **Pathogen Detection:** Rapid and sensitive detection of foodborne pathogens is vital for preventing foodborne illnesses and outbreaks. Immunochemical techniques, such as LFAs and ELISA, enable the detection of pathogenic bacteria (e.g., Salmonella, Escherichia coli) and toxins (e.g., aflatoxins, mycotoxins) in food samples. These assays provide valuable information for food safety management and regulatory compliance.
3. **Antibiotic Residue Analysis:** The presence of antibiotic residues in food products poses a significant public health concern due to the potential for antimicrobial resistance. Immunochemical assays offer a reliable method for screening antibiotic residues in meat, milk, and other animal-derived products. By detecting trace levels of antibiotics, these techniques help ensure compliance with regulatory limits and safeguard consumer health.
4. **Quality Control in Food Processing**: Immunochemical techniques are integral to quality control measures during food processing. By monitoring key parameters such as protein content, lipid oxidation, and microbial contamination, these assays enable producers to

maintain consistent product quality and safety standards. Rapid, on-site immunoassays provide real-time feedback, facilitating timely interventions to prevent product spoilage or contamination.

Advancements in Immunochemical Techniques:

Recent advancements in immunochemical techniques have enhanced their sensitivity, specificity, and versatility for food quality assessment. Nanotechnology has revolutionized immunoassay development, enabling the use of nanoparticles for signal amplification and multiplexed detection. Furthermore, the integration of microfluidic devices with immunoassays has enabled automated sample processing and high-throughput analysis.

Another notable advancement is the development of biosensors based on immunochemical principles. Biosensors offer portable, rapid, and cost-effective solutions for on-site detection of contaminants in food samples. By combining immobilized antibodies with transducers, biosensors can detect target analytes with high sensitivity and selectivity, making them valuable tools for food safety monitoring in resource-limited settings.

Additionally, advancements in data analysis techniques, such as machine learning and artificial intelligence, have improved the accuracy and efficiency of immunochemical assays. These computational approaches enable pattern recognition, classification, and predictive modeling based on complex immunoassay data, enhancing the interpretation and diagnostic capabilities of these techniques.

Conclusion

Immunochemical techniques have revolutionized the assessment of food quality by providing sensitive, specific, and reliable methods for detecting contaminants, allergens, and quality parameters in food products. From allergen detection to pathogen screening and quality control, immunoassays play a critical role in ensuring the safety and integrity of the food supply chain. With ongoing advancements in technology and methodology, immunochemical techniques continue to evolve, offering innovative solutions for addressing emerging challenges in food quality assessment. As we strive for safer and more sustainable food systems, immunochemical techniques will remain indispensable tools for ensuring food safety, quality, and consumer confidence.

Volume: 04 Issue No: 05

FARMING 2.0: THE INTEGRATION OF ARTIFICIAL INTELLIGENCE IN MODERN AGRICULTURE

Article ID: AG-VO4-I05-28

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Abstract

The United Nations World Population Forecast-2022 predicts that by 2050, India's population could reach 166.8 crores. Additionally, this is leading to a rise in the need for both jobs and food. Farmers' customary methods were insufficient to achieve these goals. New automated procedures were created as a result. Artificial intelligence has transformed the agricultural industry. Farming-related problems including weed and pest infestations that lower yields and climate change may be resolved by artificial intelligence. With the use of this technology, crop production will be shielded from a number of threats, including population expansion, climate change, labor disputes, and worries about food security. Applications for AI include autonomous machine adjustment for disease or pest diagnosis and weather forecasting.

Introduction

Artificial intelligence has brought about changes in the agricultural sector. Climate change, pest infestations, and weed infestations that lower yields are just a few of the problems that farmers may find solutions for via artificial intelligence. With the use of this technology, crop production will be shielded from a number of threats, including population expansion, climate change, labor disputes, and worries about food security. These innovations will help with effective farming by lowering the need for pesticides, precisely applying herbicides, maintaining soil fertility, and using less irrigation water. Applications for Al include automatic machine adjustment for disease or pest diagnosis and weather forecasting. Using sensors and robots to monitor crops, watering, and controlling pests can help conserve resources, boost effectiveness, and enhance quality and output.

2. Classification of Artificial Intelligence

- ✓ **Artificial Narrow Intelligence (ANI)**, also referred to as weak AI, is the use of AI exclusively for particular activities. For example, self-driving cars, Alexa, Siri, and Sofia.
- ✓ **Artificial General Intelligence (AGI)**, sometimes referred to as strong AI, refers to robots that are capable of carrying out any intellectual work that a human being is capable of. For instance, Agriculture Robots.
- ✓ The phrase **"Artificial Super Intelligence" (ASI)** describes the moment when computers will be more intelligent than people.

3. Application of AI in Agriculture

Artificial intelligence has numerous applications in agriculture, including weather forecasting, water resource management, weed control, crop growth enhancement, insect and disease detection, nutrient provision, and fertilizer spraying. AL robots, sometimes known as Agri-bots, are designed to operate more quickly than human labour, enhance crop yields, and function similarly to contemporary combine harvesters. In India, the use of artificial intelligence is growing in popularity. This approach has been implemented in many areas, drawing young people and promoting an interest in farming and agriculture.

3.1. Sensors

Sensors are devices that monitor or detect physical attributes like motion, pressure, light, or temperature. They then translate these measurements into signals that other devices or systems can understand. They are crucial to a wide range of applications, such as industrial automation, consumer electronics, automobile systems, healthcare, and environmental monitoring. In this sense, sensors are applied to agriculture to improve tractor and other equipment performance.

They are also employed at the climatological level, where soil sensors that display indications of soil fertility like wetness and weather stations situated at agricultural areas are used.

3.2. Satellite and Aerial Pictures

Satellite images provide a bird's-eye perspective of enormous areas through cameras installed on orbiting satellites. On the other hand, aerial photographs provide a more in-depth view of smaller regions and are captured from balloons, drones, or airplanes. Numerous applications exist for both kinds of photos, such as surveillance, urban planning, agriculture, environmental monitoring, mapping, and disaster response.

3.3. Agricultural Robots

Agribots, sometimes referred to as agrobots, are automated devices made to carry out different agricultural chores. Planting, watering, weeding, harvesting, and keeping an eye on the health of the crop are among these duties. Their objectives are to improve resource utilization, lower labour costs, and boost efficiency in farming operations. Autonomous tractors, drones for crop surveillance, robotic harvesters, and robotic weed eaters are a few examples.

3.4. Soil Management

Soil management and AI can intersect in various ways, primarily through data analysis and precision agriculture. AI can help analyze soil data to optimize nutrient management, predict crop yields, detect soil erosion, and recommend personalized treatments for specific soil conditions. AI-powered drones or sensors can collect real-time data to monitor soil health, moisture levels, and nutrient content, allowing farmers to make informed decisions and minimize environmental impact. Using a colorimetric testing technique, IBM built a tiny soil testing system in 2018 that is capable of evaluating five indicators. On the card's microfluidic chip, chemical analysis is performed, and artificial neural networks (ANN) can forecast the moisture content of soil. Support vector machines are supervised Al-based machine learning algorithms

(SVM). It was able to anticipate the soil's mean weight diameter. AI is able to identify the sources and sinks of carbon in different places. ANN proposes the carbon flow model, sink model for possibly stored carbon release, source model for carbon sequestration, and emission model for greenhouse gases. Management-oriented modelling, or MOM, is an AI-powered method of managing soil. It is an effective tool to stop nitrogen leaching. Another essential soil management strategy is the use of decision support systems (SRC-DSS).AI neural networks are capable of evaluating the soil's hydraulic conductivity. AI is able to forecast both physical and biological factors, such as soil enzyme activity.

3.5. Weather Forecasting

Artificial intelligence (AI) weather forecasting makes use of machine learning algorithms to evaluate enormous volumes of meteorological data and produce precise forecasts. In order to identify trends and correlations in weather patterns, artificial intelligence (AI) models can interpret data from radar systems, weather stations, satellites, and other sources. To forecast future weather conditions, these models can take into account a number of variables, including temperature, humidity, wind speed, atmospheric pressure, and historical meteorological data. Artificial intelligence (AI)-powered weather forecasting systems can increase accuracy over time by continuously learning from fresh data and improving their predictions.

3.6. Weed Management

The term "weed management" mainly refers to the methods and techniques used in agricultural areas to suppress the growth and negative effects of weeds, which are undesired plants. Cultural practices like crop rotation and mulching, mechanical techniques like tillage and mowing, chemical techniques like herbicide application, and increasingly integrated approaches that blend various techniques for efficient weed control while minimizing environmental impact are some examples of these practices. One of the biggest factors lowering a farmer's projected profit is weeds. In order to minimize costs and the possibility of crop damage, laboratory-tested AI weedicides are used to identify the appropriate spray dosage and spray precisely in the intended region. Systems for identification have been created.

3.7. Pest and Disease Management

Agriculture uses a variety of ways to manage pests and diseases, including integrated pest management (IPM) techniques, chemical control, biological control, and cultural practices. With the least amount of damage to the environment and public health possible, these techniques seek to lessen the effects of pests and diseases on crops. Artificial intelligence is therefore utilized to diagnose agricultural ailments and provide treatments. To handle pests and plant diseases, traditional farmers have depended on their knowledge and experience. Companies increasingly employ IT systems for everything from disease analysis and control to pest control. Early detection and management of pests and diseases can reduce damage to agricultural plants and increase yields.

Conclusion

In summary, artificial intelligence (AI) has the potential to completely transform the agricultural sector by increasing productivity, sustainability, and efficiency. Aspects of farming, such as crop monitoring, disease detection, precision farming, and yield prediction, can be optimized by AI-powered technologies including machine learning, computer vision, and predictive analytics. But for implementation to be successful, issues like access to technology, data privacy, and making sure AI solutions are appropriate for local settings must be addressed. In general, AI has the potential to change agriculture and solve issues related to global food security in the future.

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Volume: 04 Issue No: 05

USE OF BIO FLOC PRODUCTS AS AN ALTERNATIVE INGREDIENT IN AQUAFEED FOR SUSTAINABLE AQUACULTURE

Article ID: AG-VO4-I05-29

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Introduction

The rapid growth of global human population has direct relation with the food production. Aquaculture is one of the most promising food production sectors and it has huge potential but at the same time growth of the aquaculture industry must take environmental, economic and social contexts into account as well as the factors of sustainable development in the expansion of this industry. Intensification raises the amount of organic matter in the water, particularly in coastal areas, and poses long-term environmental problems (Sharifinia et al., 2018). Recirculating aquaculture systems (RAS), which take an appropriate approach to wastewater control and move toward sustainable aquaculture development, have been created in the last several decades. In this system, 10% of the total volume of water is replaced daily, but due to the high operating and maintenance costs, adoption of the RAS among farmers, especially in developing countries, is low. Therefore, the need for a low-cost, sustainable and eco-friendly technology that is acceptable to farmers and can be used on a large scale is evident and noteworthy.

Biofloc system

Biofloc system, also known as biofloc technology (BFT), has garnered significant interest as a low-cost, environmentally friendly, and sustainable method of producing microbial protein for aquatic species while also improving water quality. This is because it essentially eliminates water exchange and artificial feeding ratios. In recent decades, there has been a lot of attention paid to the Biofloc system because it maintains water quality, improves feed conversion ratio (FCR), applies low-protein diets, lowers production costs, and substitutes alternative protein sources for conventional high-cost feeds. Large-scale aquaculture that uses biofloc systems can benefit marine and coastal ecosystems through improved production. Aquaculture wastewater's impact on the environment can be reduced by substituting floc compounds for fish or soybean meal in aquatic nutrition. According to Ekasari (2017), culturing in a biofloc system can help remove nitrite and total ammonia nitrogen (TAN), as well as reduce water usage and waste production, decrease Vibrio density, boost body-bound crude protein, and improve feed utilization efficiency. More significantly, the biofloc nutrient-rich waste can be used as a feed in BFT to reduce environmental problems in the aquaculture business.

Principle of biofloc system

In essence, it's one of the waste treatment techniques used to get rid of garbage and preserve water quality. To treat waste, an active microbial suspension is kept in water and vigorously mixed and aerated to prevent anoxic conditions. The system will contain an aggregate of fecal particles, feed, and bacteria. The waste that is present in the system is used by the heterotrophic bacteria. It is important to maintain a thick microbial floc volume (20–50 mg/L operational). Finally, fish can eat microbial biomass as a natural food source or as a component in feed. The key component of biofloc is the recycling of lost nutrients for the production process.

How does biofloc works

Heterotrophic bacteria feed on organic matter

⬇

They use the Chemical energy in organic substrates

⬇

Need C:N Ratio = 15:1 for its best activity

⬇

Organic load, carbon level and oxygen is ensured to let bacteria multiply

⬇

number of bacteria in such tanks is 10 million up to 10 billion Bacteria /ml

⬇

Utilizes the organic load and nitrogen waste

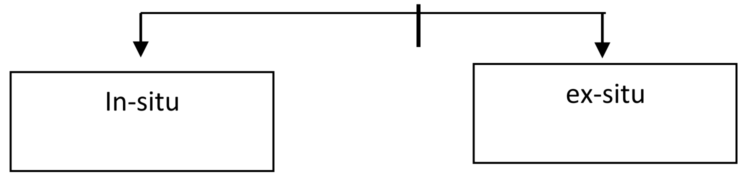
⬇

Get utilized as food by fish

⬇

feed C:N ratio = 10 to 7 :1 Hence it is added with molasses to raise C:N ratio = 15:1

Culture of biofloc



In-situ and ex-situ are two major types of BFT depending on how wastes are treated. While in the ex-situ BFT effluent flows into a suspended-growth biological reactor where biofloc are made and subsequently used as feed, the in-situ system bioflocs formed alongside the cultured animal in a culture pond (Walker et al., 2020). Each approach—in-situ and ex-situ—has specific benefits and drawbacks. For example, in in-situ BFT, ammonia can either directly absorb into microbial proteins or be converted by chemoautotrophic bacteria into nitrite and nitrate (a process known as nitrification), which can cause an accumulation in the system under conditions of limited water exchange (Walker et al., 2020). Aquatic animals raised for food, including tilapia and shrimp, gain from the in-situ floc's direct supply of nutrients. Furthermore, in-situ biofloc is probably less complicated and low cost than ex-situ; yet, because of the oxygen consumed by the produced organics and microbial biomass, the nutritional profile of floc cannot be regulated with a high biological oxygen demand (BOD). BOD management in separate tanks and improved floc nutritional profile control are achievable with an ex-situ biofloc system.

Nutritional profile of Biofloc :

Bioflocs have been found to provide a wide range of nutrients including protein, lipids, vitamins, and micronutrients. Various factors such as type of culture species, stage of species, stocking density, bioflocs' particle size, type of carbon source used, C:N ratio, light and aeration intensity, water quality parameters (e.g. DO, temperature, salinity), and selection/grazing habits of the cultivated animals have been found to affect the bioflocs' biochemical composition.

- Crude protein ;28- 42 %
- Lipid; 2-9%
- Ash: 7%
- Energy: 22kj/g dry matter

Biofloc meal as fish feed

Biofloc meal at various inclusion level in the feed has been studied in different species. 10% inclusion in shrimp feed revealed the potential of ex-situ biofloc to manage water quality, improve shrimp growth performance and enhance shrimp nutritional value under intensive culture at low salinity conditions.Emerenciano *et al.* (2023) stated that the presence of biofloc in the brood-stock diet of *P. vannamei* and *P. stylirostris* improved reproductive performance and egg quality.

Labeo rohita's growth rate, immunological response, and metabolic and digestive enzyme activity all increased after biofloc meal was added to its diet (Kheti et al., 2017). The greatest growth performance and digestibility of rohu fingerlings were obtained when 20% biofloc food was included. Apart from proteins and fats, the biofloc meal also includes bioactive substances such as vitamins, amino sugars, free amino acids, phytosterols, carotenoids, and chlorophyll. The research below demonstrates the advantageous effect that biofloc plays in fish diets. Growth, digestibility, immune system, reproductive function, and even water quality—one of the most important requirements for aquaculture—were all enhanced by biofloc meal.

Economics

It is important to consider various factors including initial setup costs, operational costs, yield, and profitability. BFT is an innovative and sustainable aquaculture system that promotes high productivity in a small footprint by converting waste into usable feed through microbial flocs. This not only improves water quality and reduces the need for water exchange but also lowers feed costs by allowing aquatic animals like fish and shrimp to consume the biofloc as an additional nutrient source.

Calculating Return on Investment (ROI)

A biofloc meal operation's economic viability would normally be evaluated by calculating the ROI, which is the net profit divided by the original and ongoing costs over a predetermined time frame. In order to prepare feed, this calculation entails predicting the total revenue from substituting other products rich in protein for biofloc meal.Thorough financial planning and market research are essential given the complexity and unpredictability of the expenses and income related to biofloc systems. It's also important to remember that a biofloc system's economics can be greatly impacted by variables like the species being raised, the location of the system, and its size.

Example of biofloc meal production (Ex-situ):

- Let us assume that biofloc is cultured in ex situ system having the capacity of 15000L.The floc available from ex situ culture system is 130g/ L.

- Total floc available in the system will be 1950kg
- But since floc contain only 1% dry matter, final available dry meal will be 19.5 kg. So through waste produced from the culture system, meal can be produced at the following rate.
- Similarly, 20% inclusion in the diet means that 6% contribution to the total protein of feed. Ultimately it reduces 6% protein from other protein rich ingredients like fish meal or soyabean meal.

Conclusion

Adopting BFT necessitates cautious management, which includes keeping an eye on water quality indicators and regulating the system's microbial balance. Nonetheless, biofloc can greatly improve aquaculture operations' sustainability and productivity if it is handled correctly. BFT and the use of biofloc meal as fish feed offer great promise as the aquaculture industry continues to search for more sustainable and effective methods. To go beyond current obstacles and streamline the procedure, more investigation and advancement are required. However, biofloc meal presents a strong case for the future of aquaculture feed due to its potential advantages in terms of cost savings, environmental sustainability, and enhanced fish health and growth rates.

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Volume: 04 Issue No: 05

CLIMATE CHANGE AND ITS IMPACT ON SERICULTURE INDUSTRY

Article ID: AG-VO4-I05-30

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Abstract

Climate change poses significant challenges to the sericulture industry, impacting various aspects of silk production from silkworm rearing to mulberry cultivation. This paper examines the effects of climate change on sericulture, including its influence on silkworm behaviour, cocoon production, mulberry growth, and the prevalence of diseases and pests. The economical hazards of climate change, such as decreased revenue due to crop failure is also discussed. Despite these challenges, there are opportunities for adaptation and mitigation, including indoor rearing of silkworms and implementing temperature control systems for mulberry cultivation. Collaboration among stakeholders is essential to develop and implement strategies that promote resilience and sustainability within the sericulture industry. By addressing the impacts of climate change now, the future of sericulture and its vital role in livelihoods and economies can be secured globally.

Keywords: Climate change, sericulture, Muga silkworm, Mulberry

Introduction

The long-term statistical representation of the short-term weather is called the climate. The climate on Earth is far more variable and highly unstable than that of any other planet. The expected rise in the global mean surface temperature is a crucial indicator of climate change. Prominently, the primary cause of the increase in global atmospheric temperature is the accumulation of greenhouse gases (GHGs), such as nitrous oxide (NO_2), carbon dioxide (CO_2), and methane (CH_4). The combustion of fossil fuels, industrialization, deforestation, agricultural practices, space explosion, grazing, degradation of wetlands, and changes in land use are all linked to rising GHG emissions. However, climate models estimate that between 1990 and 2100, global warming will average between 1.4^0 C and 5.8^0 C due to the increase in greenhouse gases (Karl and Trenberth, 2003). This will likely to result in a faster rise in surface temperatures and more intense local variations. With this sharp hike in temperature, Assam, the state in northeastern India that holds the title of being the world's greatest producer of golden silk, faces losing of its silk production monopoly (Bora and Saikia, 2022). The loss is not confined within the Muga silkworm (*Antheraea assamensis*) production, but also other silkworms as a result of the recent changes in global climatological aspect.

Impact of climate change on Sericulture

Major portion of population in our nation make their living mostly from agriculture and agro-based sectors like livestock, poultry, sericulture etc. The science that studies the rearing of silkworms to produce silk is known as sericulture. Dating back hundreds of years, India has a long history of using silk and sericulture as a traditional trading resource (Bhattarcharjya et al., 2020). Since India is the second-largest producer of silk, with 35,468 MT production (Parrey, 2018), the country has a major power over the silk industry. Silkworm production is greatly influenced by the weather and climatological factors because silkworms are cold-blooded creatures with body temperatures that are roughly equal to their surroundings, even a slight change in air temperature have an impact on their behaviour, growth, survival, and reproduction. A temperature range of 22^0 C to 27^0 C is ideal for producing high-quality cocoons and any temperature over this range will result in lower-quality cocoon formation (Ganie et al., 2012). High temperatures during the rearing of silkworms, especially in the later instars, shorten the larval period and increase larval growth. However, the low temperature leads to increase in larval period pertaining to poor production of silk (Hulmi, 2005).

Effect of climate change on silkworm hostplant

Qualitative and quantitative growth of the silkworm and their ability to produce silk is highly dependent on the quality of food, which is influenced by the host plant. Notably, the activity and population of various beneficial microorganisms are significantly impacted by the climate change. It has an indirect impact on the quality of the soil which eventually hampers the growth of the host plants. Similarly, plant-pest population ratio yields undesirable value due to the frequent occurrence of extreme weather events due to climate change. A rise in temperature can cause changes in these aspects namely, shift in the geographical distribution of the silkworm species and host plant, increase in the number of generations, extension of the developmental seasons, adjustments to the crop-pest phenological synchrony and increase in the risk of migrant pests.

Effect of climate change on physiological growth of Mulberry

Plant growth and development are influenced by various environmental factors, including temperature, moisture content, rainfall and soil fertility. Since Mulberries are C3 plants so they differ greatly from C4 plants in terms of physiology. Therefore, cooler and wetter conditions with higher CO_2 concentrations are more conducive to the growth of these plants (Datta, 1992). The ideal seasons for Muga raising to get maximum yield are thought to be autumn and spring. However, in recent years, since the fall season has become warmer, producers have been extending the rearing season for the commercial crop Katia (October) by ten to fifteen days. Since, the Eri silkworm (*Samia ricini*), is fully domesticated, variations in these variables are rather controllable.

Effect of climate change on cocoon production

The amount and quality of cocoon and silk are crucial for the sericulture industry's economic growth. In addition to genetics, environmental factors such as temperature, humidity, and airflow can also affect the distinct characteristics of silkworms and cocoons. Seasons, ambient temperature and other environmental factors all have a significant impact on the quality of the cocoon and silk. According to Srivastava *et al*. (1998), variations occur in cocoon weight, shell weight, filament length, silk yield, denier and sericin percentage due to change in environmental conditions.

Effect of climate change on Mulberry diseases and pests

The combined impacts of the climate, such as temperature, precipitation, humidity along with additional elements like soil moisture, atmospheric CO_2, and tropospheric ozone (O_3), determine the potential influence of global climate change on plant-pest populations. Due to intensive farming methods and the careless application of nitrogenous fertilizers and pesticides, numerous pests and diseases have been identified as the main problems restricting mulberry leaf productivity and production in recent years. The problem of emerging pests is especially concerning on all continents in light of rising trade and climate change. Changes in the agro-ecosystem and climate have also resulted changes in the insect pest situation in mulberry. The major pests and diseases in the mulberry are Bihar hairy caterpillar (*Diacrisia oblique*), Pink mealybug (*Maconellicoccus hirsutus*), Root-knot nematode (*Meloidogyne incognita*), Powdery mildew (*Phyllactinia corylea*), Leaf rust (*Peridiospora mori*), and Leaf spot (*Cercospora moricola*) respectively (Rajadurai et al., 2000).

Effect of climate change on economy of Sericulture industry

If the average global temperature rises by 2^0 C, it is predicted that climate variability will cause crop losses of between 10 to 40 percent with a substantial downfall in the agricultural revenue (Gowda and Reddy, 2007). Global warming is predicted to cause mulberry leaf yields, raw silk output, silk content, silk thread quality during, water stress, soil acidification and salinization risk, organic matter decomposition, crop-weed competition, longer growing seasons for insect pests & shorter growth periods for silkworms, soil erosion, runoff and increased likelihood of bacterial, fungal, and viral infections. Additionally, it is predicted that a rise in the mean annual temperature of 2^0 C or more will have a significant impact on sericulture in tropical regions like Karnataka, Tamil Nadu, Andhra Pradesh, West Bengal, Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Bihar, Jharkhand, and Assam. However, Jammu Kashmir and the Sub-Himalayan region of North-Eastern India are expected to experience a minor to marginal loss.

Conclusion

The impacts of climate change on the sericulture industry are significant and multifaceted. From influencing the growth and behaviour of silkworms to affecting the quality and availability of mulberry plants, climate change poses challenges at every stage of silk production. The economic ramifications, including crop losses and decreased revenue, are substantial and could have far-reaching consequences for communities reliant on sericulture for their livelihoods. However, amidst these challenges, there are opportunities for adaptation and mitigation. Concerns are developing that the new species may threaten ecosystems and be the cause of biodiversity loss. Therefore, indoor rearing of early stage Muga silkworm worms can be done to prevent crop loss and also to prevent excessive rain and insect infestation, rearing can be done inside nylon nets. A temperature control system can be constructed for mulberry silkworm rearing in order to prevent crop loss and regular maintenance is necessary. Moreover, continued research and investment in sustainable practices are crucial for building resilience within the sericulture industry. It's imperative that stakeholders, including policymakers, researchers, and industry players, collaborate to develop and implement strategies that not only address the immediate impacts of climate change but also promote long-term sustainability and resilience.

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AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

LOW COST AND WATER SAVING IRRIGATION SYSTEM IN AGRICULTURE

Article ID: AG-VO4-I05-31

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Abstract

Water supports for growth and development of plants and plays major role of seed germination to maturity and contributing expected yield. Source of water for irrigation is declining in quantity as well as quality and diversion for other utilization is increasing every year. Advanced irrigation systems needs government support for implementation at farmers fields, in addition to knowledge and skills required on establishment, installation and maintenance in major crops. The level of adoption and sustainability of advanced irrigation system is depends on the knowledge and skill level on operations and continuous maintenance of irrigation systems. The system supports for achieving higher water use efficiency with higher water productivity and having the speciality of need of less knowledge and skill and maintenance results in higher level of adoption and sustainability. Rain hose irrigation systems is growing as alternated advanced irrigation system in closed spaced crops with less maintenance and higher water use efficiency and water productivity.

Iintroduction

Water is a vital component crucial for survival. Human bodies are comprised of approximately seventy percent water, while plants contain nearly ninety percent water. Similarly, the growth and development of crops heavily rely on water. It plays a pivotal role in seed germination and facilitates the proper maturation of flowers, fruits, seeds, and overall plant health. Consequently, ample water supply is imperative for plants. The process of providing water to crops is termed irrigation.

Historically, irrigated agriculture has contributed to 40% of global food and fiber production, utilizing merely 18% of arable land. However, irrigation demands have led to about 70% of worldwide freshwater withdrawals, profoundly altering hydrological and environmental conditions in surface and subsurface water resources. This has sparked debates regarding the sustainability of irrigated agriculture. Irrigation managers frequently find themselves having to justify water usage, efficiency, and productivity compared to other users.

Currently, irrigation systems waste approximately 50% of applied water. Drip irrigation stands out as the most efficient method, wasting only around 10% of water. Spray irrigation, on the other hand, squanders roughly 35% of applied water, but this can be reduced to about 10% through the adoption of overhead pipes. There is a pressing need for irrigation systems with higher water use efficiency that are farmer-friendly, ensuring ease of operation and maintenance while maximizing water productivity.

Irrigated Area in India and Tamil Nadu

According to DE&S, in 2023, India's total irrigated area stands at 112,229,000 hectares, with a net irrigated area of 754,560,000 hectares. This signifies that 55% of India's agricultural land now has access to irrigation, marking an increase from 47.8% in 2013-14. In the fiscal year 2022-2023, 73 million hectares, equivalent to 52% of India's cultivated land, had access to irrigation. In Tamil Nadu, the irrigated area spans 2.15 million hectares, constituting 54% of the state's total cropped area. This area includes 26% (7.53 lakh hectares) is under canal irrigation, 18% (5.06 lakh hectares) is under tank irrigation, and 56% (16.04 lakh hectares) is under well irrigation. Tamil Nadu's irrigation infrastructure includes a total of 2,239 canals, 41,260 tanks, 1,832,154 wells, and 78 dams.

Need of Water For 2025

As per the findings of the National Commission on Integrated Water Resources Development, India's irrigation requirements are projected to reach 611 billion cubic meters (BCM) by 2025. This estimate is derived from an average weighted value of 0.73 meters for surface water and 0.51 meters for groundwater. The irrigation sector in India is anticipated to continue being the largest consumer of water, with usage expected to increase from 688 BCM in 2010 to 910 BCM in 2025 and further to 1,072 BCM by 2050.

Importance of Irrigation

The significance of irrigation lies in mitigating the adverse effects of insufficient and unpredictable rainfall on agriculture, which often supports to droughts and famines. By providing water even during periods of low rainfall, irrigation contributes to increased productivity compared to rain-fed agriculture. In regions where the rainy season is limited, irrigation enables year-round cultivation and facilitates multiple cropping, which would otherwise be constrained by seasonal rainfall patterns. Additionally, irrigation infrastructure has facilitated the cultivation of previously fallow lands, stabilizing output and yield levels. Moreover, by enhancing water availability, irrigation contributes to increased farmer income. However, it's crucial to ensure optimal irrigation practices, as excessive watering can have detrimental effects such as water logging, hindered germination, elevated salt concentrations, and root damage. Hence, selecting the appropriate irrigation methods is essential for achieving optimal cultivation outcomes.

Irrigations Systems

Crops necessitate consistent water provision for optimal development. The provision of water to plants is termed irrigation, which can be sourced from wells, rivers, lakes, and tube-wells. Traditional agricultural methods involve manual labor and animal assistance, employing techniques such as moats, chain-pumps, dhekli, and rahat. In contrast, modern irrigation methods encompass technologies like sprinkler systems and drip irrigation.

TYPES OF IRRIGATION SYSTEM AND THEIR EFFICIENCY

The primary categories of irrigation systems encompass surface irrigation, localized irrigation, sprinkler irrigation, drip irrigation, centre pivot irrigation, sub-irrigation, manual irrigation, and both traditional and modern methods.

Surface Irrigation: This method involves the distribution of water across the land via gravity, without the need for irrigation pumps. Water efficiency at the field level typically ranges between 50–60%, with flood and furrow techniques achieving 60–70% efficiency.

Localized Irrigation: Water is applied to individual plants through a network of low-pressure pipes in this system.

Centre Pivot Irrigation: Water distribution occurs through a sprinkler system that moves in a circular pattern.

Spray Irrigation: This method wastes approximately 35% of applied water, but the introduction of overhead pipes can reduce wastage to around 10%.

Sub Irrigation: Water is distributed through a system of pumping stations, gates, ditches, and canals to raise the water table.

Manual Irrigation: This labor-intensive and time-consuming system involves distributing water through watering cans by manual labor.

MODERN METHODS OF IRRIGATION

Modern irrigation methods offer solutions to the shortcomings of traditional techniques, promoting efficient water usage. These methods primarily include the sprinkler and drip irrigation systems.

Sprinkler System: Water is dispersed over the crops either from a central location via high-pressure overhead sprinklers or from moving platforms equipped with sprinklers. This method ensures uniform water distribution and is particularly beneficial in areas experiencing water scarcity. A pump connected to pipes generates pressure, leading to water being sprinkled through pipe nozzles. Sprinkler systems typically exhibit a water use efficiency of 80–85%, although actual efficiency may range between 60–90%, averaging at around 75%. Center-pivot systems typically achieve an efficiency of approximately 85%.

Drip System: The drip irrigation system delivers water directly to the roots of plants, drop by drop, via hoses or pipes. It is suitable for regions with limited water availability. This method minimizes water wastage and runoff. While drip irrigation demands more maintenance, it boasts impressive water use efficiency, ranging between 95–100%. Additionally, it facilitates efficient plant water utilization, with an efficiency rate of around 90%. By delivering water precisely to the plant root zone, drip irrigation reduces evaporation and runoff.

Constraints and Limitations in Modern Irrigation Systems

Drip irrigation stands out as the most water-efficient method for irrigating various types of plantings. Particularly well-suited for clay soils, this method applies water slowly, allowing the soil to absorb it effectively and prevent runoff. Compared to overhead spray devices, drip devices utilize only a fraction of the water. However, despite its numerous advantages, drip irrigation systems come with several drawbacks to consider:

High Initial Cost: The upfront investment for installing a drip irrigation system can be relatively steep compared to traditional methods. This includes expenses for materials like emitters, filters, valves, and the installation of system components.

System Complexity: Designing and installing drip irrigation systems can be complex and require technical expertise. Proper planning and layout are crucial to ensure uniform water distribution and prevent issues like clogging or emitter malfunction.

Maintenance Requirements: Regular maintenance is necessary to keep drip irrigation systems functioning optimally. Emitters may become clogged with debris or mineral deposits, necessitating frequent cleaning or replacement. Filters may also require periodic cleaning or replacement.

Susceptibility to Damage: Drip irrigation components, such as tubes and emitters, are vulnerable to damage from rodents, insects, or accidental human interference. Physical damage can lead to leaks or disrupt water flow, impacting system performance.

System Design Challenges: Designing a drip irrigation system requires careful consideration of factors such as soil type, topography, plant spacing, and water pressure. Inadequate design or layout may result in uneven water distribution or insufficient coverage.

Limited Water Flow: Drip systems operate at relatively low pressure, which may restrict water flow compared to other methods. This limitation could affect the system's ability to provide adequate water during peak demand periods or for water-intensive crops.

Susceptibility to Clogging: Drip irrigation systems are prone to clogging, especially if the water source contains sediments, debris, or high mineral levels. Clogged emitters can disrupt water flow, reduce uniformity, and require regular maintenance.

Dependency on Water Quality: The quality of water used in a drip irrigation system is critical. High salinity or chemical content in water can lead to salt buildup in the soil, affecting plant health and system performance. Water quality testing and appropriate treatment may be necessary.

Alternate Method with High Use Efficiency and Low Cost Irrigation System:

Rain hose irrigation systems, alternatively referred to as rain pipes, rain tape, or micro irrigation spray tubes, offer numerous advantages for farmers. These systems utilize perforated tubes with spaced holes to deliver water to plants efficiently. The holes are meticulously created using laser punching technology to ensure a consistent water flow, which is then sprayed either by gravity or with the assistance of a water pump.

Advantages of Low-Cost Irrigation Systems:

Affordability: Rain hose irrigation is a cost-effective option compared to sprinkler or drip irrigation methods.

Water Conservation: Rain hose irrigation has the potential to save over 60% of water usage.

Uniform Water Distribution: These systems evenly distribute water across the field, fostering consistent crop growth.

Precise Water Delivery: Rain hose irrigation targets water directly at plant roots, reducing evaporation and water wastage.

Soil Erosion Prevention: By minimizing surface runoff, rain hose irrigation helps mitigate soil erosion.

Enhanced Crop Quality: The consistent moisture provided by rain hose irrigation often results in higher yields and improved crop quality.

Versatility: Rain hose irrigation is adaptable for various crops, including row crops, field crops, and terrain with uneven or sloping land.

Environmental Sustainability: Rain hose irrigation aligns with environmentally conscious farming practices by conserving water and minimizing runoff.

Portability and Ease of Installation: These systems are portable, lightweight, and flexible, facilitating straightforward installation and maintenance.

In summary, rain hose irrigation systems offer farmers an economical, efficient, and environmentally sustainable solution for irrigating a wide range of crops.

Suitability of Low Cost Irrigation For Agricultural Crops

Rain hose irrigation systems are well-suited for densely planted crops such as onions, various vegetables, leafy greens, pulses and groundnuts. These systems, also known as rain pipe irrigation, employ a flexible hose featuring a series of drip holes designed to spray water up to 10–15 feet on either side. Utilizing nano punching technology, these drip holes ensure a consistent water flow. • Rain hose irrigation boasts the capability to conserve over 60% of water while irrigating crops at an accelerated pace, leading to savings in electricity and labor. The utilization of nano punching technology ensures uniform water distribution, with the laser-punched holes less prone to clogging.

Research and investment efforts have been directed towards implementing cost-effective technology, precision agriculture, and environmentally friendly practices to promote sustainable water usage in agricultural development. Rain Hose technology exemplifies an affordable spray irrigation solution, serving as a substitute for traditional sprinkler systems. It offers easy installation and maintenance, featuring a flexible hose with a series of drip holes crafted using nano punching technology to ensure consistent water distribution. It represents an emerging irrigation technique widely adopted for densely planted crops, functioning on a spraying mechanism akin to sprinkler irrigation. The spraying pattern of rain hose irrigation typically extends linearly on both sides along the full length of the hose(up to 50 m). Studies have investigated variations in spray width and water discharge from nozzles across different flow rates and rain hose diameters. However, there is currently no standardized recommendation regarding the optimal combination of rain hose length and diameter. Field tests employing the Catch-can method have been conducted to evaluate the influence of rain hose length and diameter across various flow rates and pressure values within the main pipe.

Rain pipe irrigation has emerged as a promising solution for maximizing water utilization and enhancing crop yields at a reduced cost compared to traditional irrigation systems. An experiment was conducted to assess the hydraulic performance of rain pipes of varying lengths. The findings revealed that the optimal performance of the rain pipe system was achieved when operated at a pressure of 1.50 kg/cm², with a rain pipe length of 30 meters and a spacing of 4 meters. This configuration resulted in the highest uniformity coefficient (87.83%), distribution uniformity (76.29%), and mean application rate (6.81 cm/h). Moreover, utilizing a 30-meter length at 1.5 kg/cm² led to the maximum discharge per meter length of rain pipe and the widest coverage width. These results underscore the effectiveness of rain pipe irrigation, particularly when employing an operating pressure of 1.5 kg/cm², a rain pipe length of 30 meters, and a spacing of 4 meters. The study underscores the suitability of rain pipe irrigation as a cost-effective and efficient alternative for water management in Indian agriculture. By optimizing factors such as operating pressure, rain pipe length, and spacing, farmers can enhance water use efficiency and bolster crop productivity, thereby contributing to sustainable agricultural practices amidst resource constraints.

Research in Groundnut:

The current irrigation systems, such as drip and sprinkler systems, incur additional production costs. Consequently, an alternative low-cost irrigation system, namely rain hose irrigation, was compared with existing methods. The study aimed to determine the optimal soil moisture levels by selecting an appropriate irrigation system that promotes effective soil moisture management, increased productivity, high water use efficiency, and lower production costs. Various irrigation methods (drip, sprinkler, rain hose, and BBF) and deficit irrigation levels (100%, 125%, and 75% of PET) were evaluated as treatments. The findings revealed that the highest pod yield (3086 kg/ha) and water use efficiency (11.2 kg/ha.mm) were achieved with drip irrigation at 100% and 75% of PET. Moreover, rain hose irrigation at 100% of PET demonstrated a high benefit-to-cost ratio, making it an economically favorable irrigation technology for maximizing profits (Harishma et al., 2022).

Research in Black gram:

The rain hose irrigation method exhibited superior results compared to the check basin method across various parameters. Notably, it resulted in a higher plant population (31.12 nos/m²), increased plant height (44.70 cm), greater dry matter production (2.96 t/ha), a higher number of pods per plant (47.06), and a seed yield of 1032 kg/ha, with a benefit-to-cost ratio (BCR) of 2.46. Additionally, the rain hose system demonstrated enhanced water use efficiency, with a value of 33.4 kg/ha/mm, and water productivity amounting to Rs. 262.33/ha/mm. Comparatively, the rain hose irrigation method recorded a 23.64% increase in seed yield, resulting in a net income of Rs. 14,339/ha-1, along with water savings of 16.62%. Furthermore, the rain hose system exhibited improvements in water use efficiency (37.61%) and benefit-to-cost ratio (14.63%) when contrasted with the check basin irrigation method.

Conclusion

The promotion of low cost irrigation system supports for the achieving the yield potential of major agricultural closed spaced crops. The system components are easy to install, maintain and operate with less knowledge and skill to achieve higher performance. Government supports to alternate low cost irrigation system for certain crops reduce the water requirement and reduce the water demand of nation in irrigated agriculture.

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AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

THE CARBON HARVEST: AGRONOMIC APPROACHES TO SEQUESTERING CO_2

Article ID: AG-VO4-I05-32

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Abstract

Soil carbon sequestration occurs through the fixation of atmospheric CO_2 by plants via photosynthesis, followed by the transfer of carbon compounds into the soil through root exudates, litterfall, and decomposition. Various biotic and abiotic processes regulate the stabilization and turnover of soil organic matter, determining the net carbon storage capacity of soils. Factors such as land use management practices, soil type, vegetation cover, and climate significantly influence soil carbon dynamics. Conservation tillage, agroforestry, cover cropping, and organic amendments are among the sustainable land management strategies that enhance carbon sequestration in soils while promoting soil health and fertility. Carbon sequestration in soils not only helps mitigate climate change by reducing atmospheric CO_2 concentrations but also contributes to soil ecosystem services such as improved water retention, nutrient cycling, and biodiversity conservation. However, challenges such as land degradation, deforestation, and unsustainable agricultural practices threaten the potential of soils as carbon sinks. In conclusion, understanding the processes and factors influencing soil carbon sequestration is essential for developing effective climate change mitigation strategies and sustainable land management practices to enhance carbon storage in terrestrial ecosystems.

Introduction

Soil carbon sequestration is a CDR option that is dependent on intentional land management targeted at enhancing the storage of carbon as soil organic matter and in labile, inorganic form. Occurrence of soil carbon sequestration takes place in the wake of alteration land management practices increasing the carbon content of soil thereby ensuing in a net subtraction of carbon dioxide from the atmosphere. In view of the fact that carbon in the soil is a semblance of equilibrium of carbon inputs absorbed from litter, residues, roots, or manure and carbon losses, accruing largely from reparation that is increased by soil disturbance, practices that either augment inputs or decrease losses, can lead to soil carbon sequestration. Some scholars (Lal *et al.*, 2015) have cited several land management's practices that can produce soil carbon sequestration, and some of that also entail the potential of generating soil carbon sequestration in the above-ground biomass. Significant variations characterize rates for soil carbon sequestration and these rely upon land management approaches, soil type and climate region (Smith, 2016). At the global scale, the technical probability for soil carbon sequestration is estimated at 4.8 $GtCO_2eq$/year. The worldwide carbon emissions mitigation probability of soil carbon sequestration is likely to vary between 1.5 and 2.6 $GtCO_2eq$/year, if unit costs are assumed between US$20 and US$100/ton of carbon (Smith, 2016). Nevertheless, for some systems like croplands and grazing lands, soil carbon sequestration costs can vary from minus US$45 to plus US$10/ton of carbon (Zomer *et al.*, 2017). Estimates worked out by Smith (2016) demonstrate that subtraction of carbon dioxide via soil carbon sequestration at a rate of 2.6 $GtCO_2eq$/year would save US$7.7 billion, comprising US$16.9 billion of savings and US$9.2 billion of costs.

Need for carbon sequestration

Carbon capture, utilization and storage (CCUS) is acknowledged as a critical element of climate action, helping to offset hard-to-abate emissions from heavy industry, aviation and other sectors. But the world's current CCUS capacity is a fraction of what it needs to be to fulfil its potential. Here's the scale of that challenge.

The Paris Agreement of 2015 aims to keep global average temperature rises to 2°C and ideally to within 1.5°C, a target that requires the world to reach net-zero greenhouse gas emissions by 2050. According to the IEA, meeting this net-zero 2050 target means reaching 1.7Gt CO_2 capture capacity by 2030, including 1,150Mt CO_2 per year in industry and power transformation alone: 370 Mt CO_2 in industrial applications and 775Mt CO_2 in fuel transformation. At present, the annual CO2 capture capacity from industrial and power facilities is just 40Mt CO_2.

Although the consensus around the importance of CCUS in climate action has spurred its expansion - with momentum behind incorporating it into industrial 'hubs' like the Alberta Carbon

Trunk Line - the current pipeline of projects falls far short of what is needed to meet climate goals.

Carbon sequestration versus utilization

CO_2 sequestration and utilization are different functions with a common aim of reducing or avoiding greenhouse gas (GHG) emissions (Bai *et al.*, 2019).

• *Sequestration* as a function seeks to reduce net GHG emissions through the long-term storage of CO_2, achieving carbon neutrality in the case of fossil carbon storage (i.e., CCS) or negative emissions in the case of biogenic carbon (as in BECCS) or DAC

• *Utilization* as a function seeks to (re)use CO_2 as a carbon feedstock, achieving negative emissions relative to a counterfactual case in which the product or service is delivered using virgin fossil carbon.

Impacts of Carbon Sequestration

- About 25% of our carbon emissions have historically been captured by Earth's forests, farms and grasslands. Scientists and land managers are working to keep landscapes vegetated and soil hydrated for plants to grow and sequester carbon.
- As much as 30% of the carbon dioxide we emit from burning fossils fuels is absorbed by the upper layer of the ocean. But this raises the water's acidity, and ocean acidification makes it harder for marine animals to build their shells. Scientists and the fishing industry are taking proactive steps to monitor the changes from carbon sequestration and adapt fishing practices.

Sequestration Facts

- **45%** of co_2 stays in the atmosphere, the rest is sequestrated naturally by the environment
- **25%** of our carbon emissions have historically been captured by earth's forests, farms and grasslands.
- **30%** of the carbon dioxide we emit from burning fossil fuels is absorbed by the upper layer of the ocean.

Types of carbon sequestration

1. **Biological carbon sequestration**

Biological carbon sequestration is the storage of carbon dioxide in vegetation such as grasslands or forests, as well as in soils and oceans (Valkama *et al.*, 2020).

Biological Carbon Found in the Oceans

Oceans absorb roughly 25 percent of carbon dioxide emitted from human activities annually. Carbon goes in both directions in the ocean. When carbon dioxide releases into the atmosphere from the ocean, it creates what is called a positive atmospheric flux. A negative flux refers to the ocean absorbing carbon dioxide. Think of these fluxes as an inhale and an exhale, where the net effect of these opposing directions determines the overall effect. Colder and nutrient rich parts of the ocean are able to absorb more carbon dioxide than warmer parts. Therefore, the polar regions typically serve as carbon sinks. By 2100, most of the global ocean is expected to be made up of carbon dioxide, potentially altering the ocean chemistry and lowering the pH of the water, making it more acidic.

Biological Carbon Found in Soil

Carbon is sequestered in soil by plants through photosynthesis and can be stored as soil organic carbon (SOC). Agroecosystems can degrade and deplete the SOC levels but this carbon deficit opens up the opportunity to store carbon through new land management practices. Soil can also store carbon as carbonates. Such carbonates are created over thousands of years when carbon dioxide dissolves in water and percolates the soil, combining with calcium and magnesium minerals, forming "caliche" in desert and arid soil. Carbonates are inorganic and have the ability to store carbon for more than 70,000 years, while soil organic matter typically stores carbon for several decades. Scientists are working on ways to accelerate the carbonate forming process by adding finely crushed silicates to the soil in order to store carbon for longer periods of time.

Biological Carbon Found in Forests

About 25 percent of global carbon emissions are captured by plant-rich landscapes such as forests, grasslands and rangelands. When leaves and branches fall off plants or when plants die, the carbon stored either releases into the atmosphere or is transferred into the soil. Wildfires and human activities like deforestation can contribute to the diminishment of forests as a carbon sink.

Biological Carbon Found in Grasslands

While forests are commonly credited as important carbon sinks, California's majestic green giants are serving more as carbon sources due to rising temperatures and impact of drought and wildfires in recent years. Grasslands and rangelands are more reliable than forests in modern-day

California mainly because they don't get hit as hard as forests by droughts and wildfires, according to research from the University of California, Davis. Unlike trees, grasslands sequester most of their carbon underground. When they burn, the carbon stays fixed in the roots and soil instead of in leaves and woody biomass. Forests have the ability to store more carbon, but in unstable conditions due to climate change, grasslands stand more resilient (Smith .,2016).

2. **Geological carbon sequestration**

Geological carbon sequestration is the process of storing carbon dioxide in underground geologic formations, or rocks. Typically, carbon dioxide is captured from an industrial source, such as steel or cement production, or an energy-related source, such as a power plant or natural gas processing facility and injected into porous rocks for long-term storage. Carbon capture and storage can allow the use of fossil fuels until another energy source is introduced on a large scale.

3. **Technological carbon sequestration**

Scientists are exploring new ways to remove and store carbon from the atmosphere using innovative technologies. Researchers are also starting to look beyond removal of carbon dioxide and are now looking at more ways it can be used as a resource.

Graphene production: The use of carbon dioxide as a raw material to produce graphene, a technological material. Graphene is used to create screens for smart phones and other tech devices. Graphene production is limited to specific industries but is an example of how carbon dioxide can be used as a resource and a solution in reducing emissions from the atmosphere.

Direct air capture (DAC): A means by which to capture carbon directly from the air using advanced technology plants. However, this process is energy intensive and expensive, ranging from $500-$800 per ton of carbon removed. While the techniques such as direct air capture can be effective, they are still too costly to implement on a mass scale.

Engineered molecules: Scientists are engineering molecules that can change shape by creating new kinds of compounds capable of singling out and capturing carbon dioxide from the air. The engineered molecules act as a filter, only attracting the element it was engineered to seek.

Pros

- **Reduced Carbon Dioxide Emissions**

The primary benefit of CCS is that it reduces carbon dioxide emissions. These emissions are responsible for a significant portion of global warming and climate change. By capturing and storing carbon dioxide, we can reduce the amount of greenhouse gases in the atmosphere, thereby mitigating the impacts of climate change (Henderson *et al.*, 2022).

- **Energy Security**

CCS can also help to improve our energy security. As we transition away from fossil fuels, we need to find new sources of energy that are reliable and affordable. CCS can help to make renewable energy sources, such as wind and solar, more reliable by providing a backup source of energy when these sources are not available.

- **Job Creation**

The deployment of CCS technologies can lead to job creation in areas such as construction, engineering, and maintenance. This can benefit local communities and help to revitalize local economies.

Cons

- **High Costs**

One of the major drawbacks of CCS is that is still has a relatively high cost. The technology requires significant investments in research, development, and infrastructure, which can be prohibitively expensive. Thus, research needs to be further developed to help reduce such costs.

- **Energy Intensive**

Some CCS technologies can also be an energy-intensive process. It requires a significant amount of energy to capture carbon dioxide and transport it to storage facilities. For that reason, there has to be a thorough planning and selection of the adequate technology to mitigate this con.

- **Environmental Risks**

Carbon capture and storage involves the injection of carbon dioxide into geological formations. While this can be an effective method for storing carbon dioxide, it also poses environmental risks, such as leakage or seepage into groundwater or the atmosphere. For this reason, technologies like Enhanced Rock Weathering (ERW) can be applied to reduce these risks, as they are safer and with less damage likelihood.

- **Limited Scale**

CCS is currently only being used on a limited scale. This is due to the high costs, technical challenges, and regulatory hurdles associated with the technology. As a result, CCS may not be a silver bullet solution for addressing climate change. Nevertheless, with further improvements brought by new developments in research, this challenge can be overcome.

Conclusions

Carbon capture and storage has the potential to be a key tool in mitigating climate change and for this is imperative to overcome its challenges In conclusion, carbon capture and storage is a promising technology for mitigating greenhouse gas emissions and climate change. However, it also has its drawbacks, including high costs, energy intensity, environmental risks, and limited scale. While policymakers and industry leaders continue to explore the potential of CCS, it is important to consider these pros and cons and weigh the benefits against the costs. Ultimately, the success of CCS will depend not only on its technical feasibility but also its economic viability and social acceptance.

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AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

Article ID: AG-VO4-I05-33

ORNAMENTAL BREEDING IN CHANGING CLIMATE

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Abstract

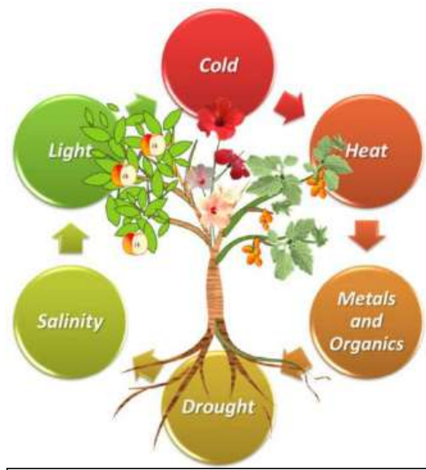
The development of cultivars with enhanced aesthetic qualities (floral characteristics, leaf traits, and overall plant structure) have been prioritized by traditional ornamental breeding programs, recent years have witnessed a concerning and critical emerging challenge a climate change. Rising temperatures, altered precipitation patterns, and increased frequency of extreme weather events translate to a multitude of abiotic stressors, including temperature fluctuations, drought, and salinity, poses a significantly impeded the optimal crop growth and productivity. In response to these challenges, Stress breeding initiatives are becoming more and more effective as a means of addressing climate change in response to these issues. Breeding techniques, including hybridization, mutagenesis, and even genetic engineering, to enhance the abiotic stress tolerance of ornamental varieties.

Key words: Stress breeding, Abiotic tolerance, ornamentals, climate change

Introduction

Many of today's favorite ornamental plants in Europe have roots in the 17th and 18th centuries. Back then, explorers and botanists introduced new species from Asia and the Americas, which Europeans cultivated and bred to create even more varieties. 1717 is the earliest known year that a synthetic hybrid carnation was created (Leapman, 2001)

However, the initial advancements in ornamental breeding primarily relied on the selection of natural mutations or choices made from spontaneously occurring seedling populations. In recent decades, the primary objective of numerous commercial ornamental breeding initiatives has remained consistent even in the changing climate, the creation of novel cultivars boasting enhanced floral features (such as color, shape, fragrance, and extended vase life), leaf qualities, or overall plant structure. However, Climate change poses significant challenges to plant growth and development adversely affecting the ornamental plants. Rising temperatures, altered precipitation patterns, increased frequency of extreme weather events, and changing pest and disease pressures all contribute to environmental stresses. These stresses not only reduce plant health and vigor but also compromise the aesthetic appeal of ornamental landscapes.

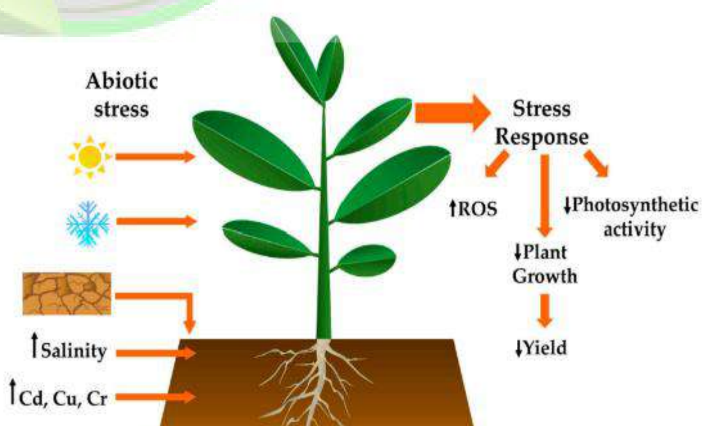


Source :Francini and Sebastiani (2019)

In response to these challenges, stress breeding programs are emerging as a powerful tool to combat climate change. This innovative technique offers a strategic approach to cultivate ornamental varieties with the resilience to thrive in evolving climatic reality. Stress breeding programs systematically expose ornamental plants to controlled levels of environmental stress, mimicking the challenges they are likely to face in a changing climate. By selecting and breeding from the plants that exhibit tolerance or even thrive under these controlled stresses, breeders can develop new generations of ornamentals better equipped to withstand the rigors of a warming world.

Stress Breeding

Stress breeding is the practice of subjecting plants to severe situations which includes exposing plants to various stressors, such as drought, high temperature, or salinity, and choosing plants that thrive under those conditions for improved survival and growth.. Stress breeding plants are bred over multiple generations to develop genetic characteristics that enhance their resistance to stress. Stress breeding can be achieved using classic approaches like cross-breeding and selection, as well as



(Source: Godoy et al.,2021)

genetic engineering for more precise manipulation of plants' genomes. The goal is to create crops that can sustain high yields despite adverse environmental circumstances. In stress breeding, scientists employ traditional and modern approaches to enhance a plant's resilience, allowing it to thrive despite challenging circumstances. By understanding the genetic mechanisms involved, researchers can create crops that better withstand stress, ultimately contributing to food security and sustainable agriculture. Stress can be biotic (produced by living organisms) or abiotic (due to environmental conditions). Biotic stress is caused by biological forces as insects, diseases, and pathogens. Abiotic stress is caused by environmental variables such as drought, high temperatures, salinity, and nutritional deficits.

Some of the Commonly Used Breeding Methods for Abiotic Stress Include

a) Conventional breeding involves crossing plants with desired qualities to create offspring with those traits.

b) Marker-assisted selection: This method selects plants based on genetic markers linked to the desired attribute.

c) Genomic selection uses genomic data to predict progeny performance and choose plants with certain features. This strategy is effective for selecting plants with complex features.

d) Mutagenesis is the process of introducing mutations in a plant's genome by various techniques such as chemicals or radiation. Mutagenesis can generate new genetic variations and improve plant resistance to abiotic stresses.

e) Genetic engineering involves adding genes from other organisms into a plant's genome to achieve desired features. Genetic engineering can add genes that enhance abiotic stress resistance, including drought and salt tolerance.

f) Recombinant DNA technique combines fragments of DNA from many sources to create novel gene combinations. Recombinant DNA technology can develop novel genetic variations that enhance abiotic stress tolerance.

g) Polyploidy breeding includes increasing the number of chromosomes in a plant's genome to generate genetic diversity. Polyploidy breeding can improve abiotic stress tolerance by selecting plants with more genetic variety and resistance to stress.

Breeding for Abiotic Stress

Abiotic stress is the most detrimental non-living element affecting crop development and productivity worldwide. Abiotic elements include strong winds, harsh temperatures, droughts, floods, and natural disasters. Additional factors include rock content, pH, high radiation, pollution, and quick dehydration. Stress response typically involves the creation of antioxidants, phytoalexins, protein protectants, cryoprotectants, defence proteins, and protein chaperones.

Traditional breeding methods have limitations due to the complexity of stress-tolerant characteristics, low genetic diversity in yield components, and inefficient selection under stress conditions. The commercialization of Bt plants, combined with advanced molecular approaches like genomics and proteomics, has led to greater plant stress. Research suggests that molecules like glycine betaine can prevent stressed cells from harm. Genes cloned from plants or other organisms are overexpressed in plants to improve resistance to abiotic stresses. Strong constitutive promoters control the transfer of these genes, resulting in the accumulation of LEA (Late Embryogenesis Abundant) during seed germination. Somaclonal diversity has led to the development of abiotic stress resistance in important crops.

Interspecific and intergeneric hybridization can improve abiotic stress tolerance in crops by importing stress-tolerant characteristics from wild relatives. Interspecific hybridization has led to the development of drought-tolerant chrysanthemum cultivars. Developing interspecific hybrids between Dendranthema morifolium and Dendranthema nankingense using ovary rescue can enhance cold tolerance in farmed species.

Crop	Stress	Variety	Breeding method	Parents
Lilium	Cold	East red	Hybridization	Co Amore x Acapulco
Lilium	Cold	Water lily dew	Hybridaztion	Golden Horn x Brunello
Marigold	Heat	Zenith	Polyploidy (triploid)	
Lisianthus	Heat	UF99-49	F6 Selection	UF94-404 X UF94-46

(source : Kumar Tarun et al., 2023)

Mutation approaches, such as transposon mutagenesis, have helped researchers understand the molecular basis of plant stress response using Arabidopsis and other models. In vitro mutagenesis combines tissue culture with induce mutation strategies. One remarkable use of this method was the establishment of a NaCl-tolerant Chrysanthemum (Chrysanthemum morifolium Ramat.) cultivar through the use of ethyl methane sulfonate (EMS) as a chemical mutagenic factor. Through employing this strategy, stable mutations were created in the plant, increasing its resistance to salt stress. The E2 variety exhibits higher tolerance due to increased activities of SOD, APX, and DHAR, as well as less membrane damage compared to NaCl-treated control plants.

Genetic engineering allows for faster molecular changes than traditional plant breeding methods. To generate tolerant crops by genetic engineering, it's necessary to identify the essential genetic determinants that contribute to plant stress tolerance and incorporate these genes into crops. This method allows for just desired genes to be transferred, as opposed to conventional breeding, which involves transferring unwanted genes simultaneously. Advances in cellular and molecular biology enable the cloning and mobilisation of key genes in any organism, allowing for stable expression and transmission across sexual hybridization barriers. Living organisms have evolved to avoid or tolerate abiotic stressors. Plants produce essential enzymes or proteins from species affected by abiotic stress.

Transgenic plant	Abiotic stress	Gene	Origin	References
Petunia	Cold	CBF-3 (C-repeat binding factor)	Arabidopsis	Warner,
Petunia	Salt and drought	ATNHX1(Na+/N+ exchanger1)	Arabidopsis	Xu et al.,
Orchid	Cold	LTP	Rice	Quin et al.,
China rose	Freezing and drought	RcXET and DREBIC (dehydration responsive element binding)	*Medicago truncatula*	Chen et al., 8
Chrysanthemum grandiflorum	Salt, cold and drought	ICE1	*Chrysanthemum dichrum*	Chen et al., 11
Rose	Sal and drought	RhEXPA4 (A rose expansingene)	Arabidopsis	Jiang et al.,

(Source: Sunita Dhakar et al.)

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Volume: 04 Issue No: 05

HIGH-THROUGHPUT DIGITAL PHENOTYPING PLATFORMS : TRANSFORMING AGRICULTURE FOR A SUSTAINABLE FUTURE WITH IMAGE-BASED TECHNOLOGY

Article ID: AG-VO4-I05-34

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Abstract

High-throughput phenotyping platforms, utilizing advanced optical sensors, automate the evaluation of plant traits with non-destructive imaging techniques. These platforms assess morphological, physiological, biochemical, and performance aspects, crucial for understanding plant health and development. Market trends indicate a rising demand for plant phenotyping products, driven by the need to increase agricultural yield to feed a growing global population. Despite challenges such as high costs, technological advancements like AI and remote sensing are enhancing plant phenotyping efficiency. Image-based phenotyping, utilizing various optical sensors, offers detailed insights into plant characteristics. Different imaging platforms, including indoor, ground-based, and aerial systems, provide unique advantages for plant research. Various imaging techniques, such as RGB, thermal, hyperspectral, and LiDAR imaging, contribute to the comprehensive assessment of plant traits. Plant phenotyping finds applications in plant breeding, precision agriculture, and postharvest management, aiding in crop improvement and sustainable agriculture. Continued innovation in digital phenotyping is crucial for addressing food security and sustainability challenges in agriculture.

Keywords: High-throughput phenotyping, Plant traits, Agricultural technology, Imaging techniques, Sustainable agriculture

Introduction

Using a variety of optical sensors, high-throughput phenotyping platforms are able to take pictures of hundreds of plants every day. The non-destructive evaluation of morphological, physiological, biochemical, and performance aspects is made possible by these systems. They usually consist of a control terminal, a platform for data analysis, and data gathering equipment. These platforms primarily use spectroscopic and non-invasive imaging methods to gather phenotypic data. Additionally, they immediately monitor plant development and physiological status using high-performance computing technology.

Market Trends of High-Throughput Phenotyping Platforms

Agribusiness is the major occupation of almost 40% of the world's population. Farmers are using new technologies more and more in an effort to increase agricultural yield. It is anticipated that this tendency will fuel demand in the plant phenotyping industry. The global population is expected to increase from 7.8 billion in 2021 to 9.5 billion by 2050. The need for agricultural products will rise as a result of this expansion, making the application of plant phenotyping to create high-yielding crops necessary and driving up demand for plant phenotyping products. However, one of the factors impeding the growth of the plant phenotyping market is the high cost of the services.

On the other hand, technical advancements in plant phenotyping products and services, like the use of artificial intelligence (AI), the newest HD cameras and other sensors, remote sensing, and others, can increase the equipment's efficiency. Over the course of the forecast period, this is anticipated to generate profitable chances for the plant phenotyping market's expansion. Furthermore, significant businesses in the agricultural industry constantly innovate their products, greatly depending on plant research. The market for plant phenotyping is anticipated to have demand driven by this aspect as well.

Image-Based Phenotyping

The basis of the image-based phenotyping idea is the interaction of electromagnetic radiation with the plant surface, including absorption, reflection, emission, transmission, and fluorescence, which differs between genotypes or between stressed and healthy plants. Through the use of optical sensors, these interactions will aid in the estimation of many plant phenotypic features. Image-based high-throughput phenotyping necessitates the employment of different kinds of optical sensors in order to assess multiple features. Among the sensors that are currently available for plant phenotyping are thermal, fluorescence, hyperspectral, multispectral, magnetic resonance imaging (MRI), X-ray computed tomography (X-ray CT), positron emission tomography (PET), and visible light (Red-Green-Blue).

Applications of High-Throughput Phenotyping

High-throughput phenotyping is used in postharvest, breeding, and even agricultural production, depending on the purpose of the phenotyping process. In plant breeding, phenotyping a large number of samples (population) aims to increase the selection intensity and accuracy and characterize various crop traits to select the best genotypes, whereas in crop cultivation, phenotyping a large number of samples (population) is used to monitor the occurrence of any plant stresses such as disease, pests, nutrient stress, weeds, or abiotic stress at an early stage. Obtaining and analyzing real-time phenotypic data will facilitate the making of prompt crop management decisions.

Imaging Techniques in Plant Phenotyping

The types of plant phenotyping imaging platforms can be broadly categorized into indoor-based, ground-based, and aerial-based platforms, each offering unique advantages for plant research and monitoring.

Indoor-based plant phenotyping platforms are designed for controlled environments and include conveyor belt type systems, which automate the movement of plants for imaging, and benchtop type systems, which provide a stationary setup for high-resolution imaging and analysis.

Ground-based plant phenotyping platforms offer versatility in capturing plant data in field conditions. These include pole-based platforms, which use extendable poles for imaging taller plants, cable-suspended platforms for capturing data from multiple angles, gantry-based systems for large-scale phenotyping, and mobile platforms for flexibility in data collection across different locations. An aerial perspective of crops is made possible by aerial-based platforms, such as manned aerial platforms (MAPs) and unmanned aerial platforms (UAPs), enabling effective crop monitoring. Satellite-based platforms use remote sensing technologies to gather data over large agricultural areas, offering a broad perspective on crop health and growth. Each type of plant phenotyping platform has its strengths and applications, contributing to advancements in agricultural research and crop improvement strategies.

Imaging Techniques in Plant Phenotyping

Plant phenotyping relies on various imaging techniques that cover different parts of the electromagnetic spectrum. Here are some common imaging techniques used in plant phenotyping along with their corresponding electromagnetic spectrum ranges:

1. **RGB Imaging:** This technique uses wavelengths in the range of approximately 400 to 700 nanometers, covering the visible light spectrum, to capture images of plants and assess their morphology and color.
2. **Thermal Imaging:** Thermal cameras detect infrared radiation, which has wavelengths longer than visible light (around 700 nanometers). Thermal imaging typically covers the range of about 8 to 14 micrometers (mid-infrared spectrum), allowing for the detection of variations in plant temperature.
3. **Hyperspectral Imaging:** Hyperspectral cameras capture a wide range of wavelengths, typically from around 400 to 2500 nanometers or even beyond (covering visible to near-infrared and shortwave infrared ranges). This allows for detailed analysis of plant biochemical and physiological properties.
4. **Fluorescence Imaging:** This technique measures the fluorescence emitted by plants, typically in the range of 400 to 800 nanometers (visible to near-infrared spectrum), which can indicate photosynthetic activity and stress responses.
5. **Multispectral Imaging:** Multispectral imaging uses specific wavelengths within the range of about 400 to 2500 nanometers, similar to hyperspectral imaging but with fewer bands. This is useful for studying specific plant characteristics such as chlorophyll content or water stress.
6. **LiDAR Imaging:** LiDAR uses laser pulses, typically in the near-infrared spectrum around 800 to 900 nanometers, to create 3D models of plants. This is useful for measuring plant height and structure.
7. **X-Ray CT Imaging:** X-ray CT scans use X-rays, which have wavelengths in the range of about 0.01 to 10 nanometers, to provide detailed internal images of plants, allowing researchers to study root growth and development.

8. **MRI Imaging:** Magnetic Resonance Imaging (MRI) can be used to study plant water content and distribution non-invasively. It operates in the radio frequency range, typically below 1000 megahertz.

Types of Phenotypic Traits

In plant phenotyping, researchers often focus on several key phenotypic traits to understand the characteristics and responses of plants. These traits can be broadly categorized into morphological, physiological, biochemical, and responses to biotic or abiotic stress.

1. **Morphological Traits:** These traits refer to the physical characteristics of plants, including traits such as plant height, leaf area, stem diameter, branching patterns, and overall plant architecture. These traits can provide insights into plant growth and development.
2. **Physiological Traits:** Physiological traits relate to the internal functioning of plants, including processes such as photosynthesis, transpiration, nutrient uptake, and water use efficiency. Measuring these traits can help researchers understand how efficiently plants are converting resources into growth.
3. **Biochemical Content:** Biochemical traits involve the analysis of plant compounds such as sugars, starches, proteins, and secondary metabolites. These traits can provide information about the nutritional content and stress responses of plants.
4. **Biotic/Abiotic Stress Responses:** Plants respond to various stresses, both biotic (from living organisms such as pests and pathogens) and abiotic (from environmental factors such as drought, salinity, and extreme temperatures). Monitoring how plants respond to these stresses can help researchers develop more resilient crop varieties.

By measuring and analyzing these phenotypic traits, researchers can gain a comprehensive understanding of plant performance, health, and responses to environmental conditions. This information is valuable for improving crop yields, resilience, and sustainability in agriculture.

Applications of Plant Phenotyping

Plant phenotyping has a wide range of applications across various fields in agriculture. Some of the key applications include:

1. **Plant Breeding:** Plant phenotyping plays a crucial role in plant breeding programs by enabling the identification and selection of plants with desirable traits. This includes the

discovery of quantitative trait loci (QTL), genes, and molecular markers associated with traits such as yield, quality, stress resistance, and climate resilience.

2. **Precision Agriculture:** In precision agriculture, plant phenotyping is used to optimize crop management practices. This includes precise irrigation scheduling based on plant water status, efficient fertilization strategies based on nutrient requirements, targeted fungicide spray based on disease symptoms, and optimal harvesting time based on crop maturity.
3. **Postharvest Phenotyping:** After harvesting, plant phenotyping is used for grading and sorting produce based on quality parameters such as size, color, and ripeness. It is also used to estimate the shelf life of produce, helping in better storage and distribution practices.

These applications of plant phenotyping are essential for enhancing crop productivity, improving crop quality, and ensuring food security in a sustainable manner.

Computing Infrastructure of Plant Phenotyping

Data analysis software, a control terminal, and data gathering hardware are all integrated into high-throughput phenotyping platforms. In order to quickly assess plant development activities and physiological status, they mostly use non-invasive imaging and spectroscopy techniques to gather phenotypic data. They also employ high-performance computing equipment.

Plant phenotyping has seen significant advancements with the integration of various imaging techniques and algorithms, enabling researchers to delve deeper into plant characteristics and responses. In the realm of classification, algorithms like Faster R-CNN are utilized with RGB imaging to predict strawberry yields, while convolution networks paired with X-ray CT imaging are employed for assessing watermelon seed quality. For grapevine health, a combination of linear discriminant models, partially least squares, multi-layer perceptrons, and radial-basis function networks, coupled with hyperspectral imaging, aids in identifying grape yellows.

Detection algorithms play a crucial role in agriculture, with 3D point clouds, convolutional neural networks, and other techniques in visible light imaging facilitating apple fruit detection and counting. In thermal imaging, algorithms like convolutional neural networks and template matching are applied to count banana plants efficiently.

Identification of plant issues is another critical area. Neural networks, radial basis functions, and k-nearest neighbor algorithms, paired with hyperspectral imaging, help identify bacterial spot in tomatoes. PCA algorithms with fluorescence imaging are used to assess salt stress in lettuce, while EVI2 threshold algorithms with multispectral imaging aid in understanding banana plant growth. Lastly, logistic regression with LiDAR imaging helps identify drought stress in potatoes.

These applications demonstrate the diverse range of algorithms and imaging techniques that are driving advancements in plant phenotyping, ultimately leading to more sustainable agricultural practices.

Conclusion

In conclusion, digital phenotyping has emerged as a transformative tool in agriculture, offering innovative solutions for sustainable crop production and management. High-throughput phenotyping platforms, equipped with advanced imaging techniques and algorithms, are revolutionizing how we study and understand plant traits. These platforms allow phenotypic properties, ranging from morphological and physiological features to reactions to biotic and abiotic challenges, to be measured non-destructively by researchers and farmers.

The need for more effective farming methods and the rising demand for agricultural products brought on by population increase are the main factors driving the growing usage of digital phenotyping. While the high cost of services remains a challenge, technological advancements, including the use of AI, remote sensing, and high-resolution cameras, are enhancing the efficiency and effectiveness of plant phenotyping equipment.

Moreover, the integration of various imaging techniques, such as RGB, thermal, hyperspectral, and LiDAR imaging, is providing researchers with unprecedented insights into plant health and performance. These advancements are crucial for breeding programs, precision agriculture, and postharvest management, ultimately leading to improved crop yields, quality, and resilience.

Looking ahead, tackling the issues of food security and sustainable agriculture will require ongoing study and innovation in digital phenotyping. With the use of technology, a more productive and robust agricultural system that feeds the world's growing population while safeguarding the environment might be created.

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Volume: 04 Issue No: 05

BASIC CONCEPT & APPLICATION OF BIOFLOC TECHNOLOGY- SHAPING AQUACULTURE TOWARDS SUSTAINABILITY

Article ID: AG-VO4-I05-35

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Abstract

Biofloc system is an eco-friendly production system where dense microbial communities are allowed to grow by adding extra carbonaceous materials to reduce the inorganic nitrogenous waste levels of the pond through microbial assimilation. Adding external carbon sources into the culture water with proper mixing and aeration produces a suspended growth of heterotrophic bacteria, algae, protozoa, rotifers, nematodes, and living and dead particulate organic matter aggregates. The heterotrophic microbial biomass assimilates the nitrogenous waste and checks the water quality. Such *in situ* bioremediation requires zero or minimal water exchange of the culture system to achieve maximal biosecurity and minimize the external environmental effects. This helps to increase the fish stocking density with subsequent increases in the yields. Additionally, microbial proteins, suspended in the pond as microbial flocs, are utilized as food by the cultivable species. In addition to the advantages of BFT, as discussed above, the technology is also expected to act as an alternative measure to fight pathogenic microorganisms in aquaculture. BFT ponds are successfully applied in shrimp ponds and fish ponds (mostly tilapia) in several parts of the world.

Introduction

Aquaculture is currently the most rapidly growing animal food-producing sector globally. India is one of the largest fish producing countries in the world and shares 7.58% to the global production. Contributing 1.24% to India‘s Gross Value Added (GVA) and 7.28% (2018-19) to the agricultural GVA, fisheries and aquaculture continue to be an important source of food, nutrition, income and livelihood to millions of people. Fisheries sector in India has shown impressive growth with an average annual growth rate of 10.88% during the year from 2014-15 to 2018-19. The fish production in India has registered an average annual growth of 7.53% from 2014-15 to 2018-19 and stood at an all-time high of 137.58 lakh metric tons during 2018-19. The export of marine products stood at 13.93 lakh metric tons and valued at Rs 46,589 crores (USD 6.73 billion) during 2018-19 with an impressive average annual growth rate of about 10% in recent years (NFDB, 2023). The aquaculture industry aims to produce healthy fish with minimum water and land usage and minimum environmental impact. Maintenance of water and soil quality in culture systems, disposal of aquaculture effluent to the environment, and maintenance of sound fish health are challenging issues for sustainable aquaculture. The application of advanced technologies is the need of the hour. Biofloc technology (BFT) can be one such advanced technology for the sustainable development of aquaculture.

BFT for waste recycling

When feed is applied to the aquaculture pond, about 20 to 30 percent of the feed nitrogen is assimilated by fish. The remaining 70 to 80 percent nitrogen, added as feed, is released into the pond environment as waste. This builds up organic residues in the form of mainly nitrogenous waste. Heterotrophic bacteria degrade these organic wastes to some extent, forming microbial biomass. An estimate says that conversion in microbial biomass retains only7% of the feed nitrogen and 6% of the feed phosphorus (Schneider *et al*., 2005). The substrate becomes mostly carbonaceous when external carbohydrate sources are added to the culture environment. In such a situation, the bacteria must take nitrogen from the water to produce bacterial protein (new cell production). This can be achieved by keeping the C/N ratio higher than 10. Once such carbon and nitrogen balance is maintained in the water, the bacteria will take up nitrogen from the water and control the water quality. For example, a concentration of about 10 mg NH_4^+–N L^{-1} could almost wholly be removed within five h after adding glucose at a C/N ratio10, without the accumulation of nitrite and nitrate (Avnimelech, 1999). A schematic calculation of the amount of carbon needed for biofloc growth is presented in Fig. 1 (adapted from Crab *et al*., 2012).

Contribution to nutrition

In the BFT system, the nitrogenous waste is converted into bacterial biomass (containing protein) by adding external carbonaceous material. The floc, thus produced, acts as a feed source for the cultivated organism. Research has shown that the floc contains enough protein, lipids, carbohydrates, and ash for use as an aquaculture feed. However, more research is needed to explore whether these flocs contain adequate amino and fatty acids. However, it is accepted that biofloc meets the nutritional requirements to serve as an aquaculture feed in general. Research with shrimp and tilapia suggests that for every unit of growth derived from feed, an additional 0.25 to 0.50 units of change are derived from microbial protein in biofloc systems. In other words, 20 to 30 percent of shrimp or tilapia growth is derived from the consumption and digestion of microbial protein. This benefit is reflected in improved feed conversion. However, the value of flocs in nutrition is limited at the highest production intensity levels because feed's contribution to the growth of cultured animals is overwhelming (Hargreaves, 2013). With this, the production cost can be reduced considerably.

Daily feeding of 3% of fish
↓
weight 30 g feed added per kg
fish per day
↓ Take a feed with 25% protein
7.5 g protein added per kg fish per day
↓ 16% of protein is N
1.2 g N added per kg fish per day
↓ On average, 75% of the feed-N ends up in the water (ammonification of uneaten feed + excretion)
0.9 g N per kg fish per day ends up in water
↓ Micro-organisms need a C/N ratio
of 109 g C per kg fish per day is required for biofloc production

Fig. 1. Calculation of the daily amount of organic carbon needed by bioflocs to remove the nitrogenous waste from uneaten feed and excreta. The amount of carbon source added will then depend on the carbon content of the carbon source. Regarding acetate or glycerol (both containing 0.4 g C per g), 22.5 g of carbon source would be needed per kg of fish per day.

Biocontrol aspects

In addition to the advantages in terms of waste recycling and contribution to nutrition, BFT can be used as a novel biocontrol strategy to fight against pathogenic bacteria. The floc comprises numerous heterotrophic bacteria, so a natural probiotic effect on the cultured animals is possible. This situation can render the cultured animals more resistant to pathogenic organisms. Moreover, some floc bacterial communities can accumulate a bacterial storage compound called poly-β-hydroxybutyrate (PHB). Previous research shows that PHB and PHB-accumulating bacteria can protect aquaculture animals from bacterial infections.

Managing C/N ratio

In biofloc systems, the balance between carbon and nitrogen in solution (the C: N ratio) significantly controls the nitrogenous waste, mainly ammonia concentration. The C: N ratio of feed and other inputs is critical in maintaining that balance. A feed with 35 percent protein concentration has a relatively low C: N ratio, about 9.2:1. Increasing the C: N ratio of feed to 12 to 15:1 favors the heterotrophic microbial growth and that can efficiently control ammonia. The feed's low C: N ratio can be increased by adding external carbon-rich materials (carbohydrates) or reducing feed protein content. It has been observed that ammonia uptake by heterotrophic bacteria occurs rapidly after carbohydrate supplementation. Ammonia control through such heterotrophic pathway is often more stable, rapid, and reliable than other natural processes of ammonia removal such as algal uptake or nitrification.

The materials used as carbon sources in biofloc systems should be low-cost, easily and quickly degradable, and convenient. Common materials include flour, molasses, cassava meal, glucose, glycerol, tapioca, starch, etc. Simple carbohydrates such as simple sugar (sucrose or dextrose) or starch are the best carbon sources, particularly during system start-up, as the heterotrophic bacteria can rapidly act on simple organic matter within minutes to hours.

If the heterotrophic pathway is to be exclusively encouraged for ammonia control, carbohydrate additions must be made by the feeding rate. According to the calculation depicted in Fig. 1, for every 1 kg of 25 percent protein feed added, 0.75 kg of a carbohydrate source (here glycerol) must be added. To control ammonia levels, large quantities of carbohydrates must be added to the culture environment.

There are some drawbacks if large quantities of carbohydrates are added continually. This heterotrophic pathway encourages the accumulation of bacterial solids, which, in turn, mayreach levels that can cause gill clogging. Moreover, extra oxygen will be required to support the respiratory demands of a more significant microbial load, and additional energy is needed to keep solids in suspension. In such a situation, a provision should be there to remove, treat, and dispose of the accumulated solids.

Species compatible with BFT

Two aspects must be considered before choosing a species cultured in a biofloc system. The cultivable species should be able to tolerate high suspended solid concentration in water, and secondly, they should derive some nutritional benefits from the direct consumption of floc. Species such as shrimp and tilapia (also some carp species) have physiological adaptability to thrive in water with high solid concentrations. These species have also been found to consume and digest the microbial floc, taking advantage of flocs as an additional food resource. Almost all biofloc systems operate elsewhere and use shrimp, tilapia, or carp as cultivable species.

Mixing and aeration

Mixing and aeration are two important prerequisites for a biofloc system. Turbulent mixing is required to keep the solids in suspension uninterruptedly. If the flocs are allowed to settle, they may form piles that will rapidly consume nearby oxygen, and such anaerobic conditions will lead to the generation of toxic gases. Such solids, if accumulated, need to be removed by periodic flushing. The biofloc system has high oxygen demand, which accounts for sufficient aeration. In practice, providing an aerator in the biofloc system serves the dual purpose of mixing and aeration.

System start-up

The biofloc system can be developed in lined ponds or tanks. Before stocking, some amount of organic matter (old feed or molasses) and some nitrogenous fertilizer (@ 5- 25 kg/ha) will be added. Some soil (~ 50 kg/ha) from the pond can be used as inoculum. It may take a few weeks to develop the floc. Initially, there will be green colouration due to the growth of algae, then there will be foam formation, and finally, the colour of the water will turn brown.

Management aspects

- Over time, solids will accumulate within the system, which need to be maintained. Typically, biofloc systems are best operated at a suspended solid concentration below 500 mg/L. Good system functionality and ammonia control without excessive water respiration can be achieved at a total concentration of 200 to 500 mg/L of suspended solids. Simple gravity settling tanks can be used to control solid concentration.
- The nitrification process is responsible for the loss of alkalinity in most of the biofloc system. Alkalinity should be kept between 100 and 150 mg/L as $CaCO_3$ by regular additions of sodium bicarbonate. Other liming agents are less suitable.

- If nitrate accumulation happens due to the nitrification process (though the major ammonia removal occurs through a heterotrophic pathway), it should be minimized by dilution through some water exchange.
- All critical water quality parameters, such as oxygen, pH, total suspended solids, ammonia, nitrite, and nitrate, must be monitored regularly.

Conclusions and perspectives of biofloc technology

Biosecurity is a priority in aquaculture industry. For example, in shrimp farming, considerable impact of disease outbreaks during the past two decades greatly affected the operational management of shrimp farms worldwide. This scenario forced farmers to look for more biosecure culture practices to minimize the risk associated with exposure to pathogens. Biofloc technology brings an obvious advantage of minimizing consumption and release of water, recycling *in situ* nutrients and organic matter. Furthermore, pathogens introduction is reduced, improving the farm biosecurity. Biofloc technology will enable aquaculture grow towards an environmental friendly approach. Consumption of microorganisms in BFT reduces FCR and consequently costs in feed. Also, microbial community is able to rapidly utilize dissolved nitrogen leached from shrimp faeces and uneaten food and convert it into microbial protein. These qualities make minimal-exchange BFT system an alternative to extensive aquaculture. Microorganisms in biofloc might partially replace protein content in diets or decrease its dependence of fishmeal. Large-scale production of biofloc meal for use in aquaculture could result in environmental benefits to marine and coastal ecosystems, as the need for wild fish as an aqua feed ingredient is reduced. BFT may bring higher profit if fresh non-frozen shrimp/fish is sold to near-by market, mainly at inland locations. These advantages certainly should be more explored and niche markets achieved, contributing to social sustainability. Researchers are challenged to further develop this technique and farmers to implement it in their future aquaculture systems. Its further development, fine-tuning and implementation will need further research and development to make this technique a keystone of future sustainable aquaculture.

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Volume: 04 Issue No: 05

CROP IMPROVEMENT THROUGH PRE-BREEDING IN GROUNDNUT

Article ID: AG-V04-I05-36

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Abstract

Pre -breeding is an art of identifying desired traits and incorporation of this into modern breeding material. Its strengthen the primary gene pool and also readily used as a breeding material for the genetic enhancement of the crop. Groundnut is an leguminous crop which is grown in all types of soil and the sufficient amount of variability is reported in wild types/landraces. The success of any breeding program depends on the availability of genetic variability and that should be conventionally usable form. Pre breeding is the most promising alternative to link genetic resources and breeding program. It is the time consuming and cumbersome due to the presence of linkage drag associated with utilizing wild relatives. These can be rectified using genome assisted selection it helps to overcome the linkage drag and also successful transfer of genes / segments from wild relatives to cultivated type for improvement of the crop.

Keywords: Pre breeding, wild relatives, introgression, groundnut

Introduction

The process of transferring useful genes from exotic or wild type into agronomically adaptable background is called enhancement. The term was first given by jones 1983 followed by Rick in 1984 introduce the term pre breeding/ developmental breeding describe the same activity. The aims of the pre beeding also to reduce the uniformity and broaden the genetic material related to increase yield, resistance to pest and diseases and other quality traits through the use of wider genetic material available in gene pool. Peanut or groundnut (*Arachis hypogaea* = 40) is an annual herbaceous plant grown on a wide variety of soil type. India is the second most important producer of groundnut all over the world. Majority of the useful genes exist in the form of landraces and wild relatives which hinders the improvement of crop. In this article we intended to describe how pre breeding play a major role between genetic resources and crop improvement.

Objectives of pre breeding

1. Introgression

   Introgression means transfer of genes from one species to another through hybridization and backcrossing.

2. Base broadening/ Genetic enhancement

   Broadening of genetic diversity which holds larger variation and acceptable performance level.

Pre breeding program

Pre breeding program mainly depends upon the three important factors

1. Selection of suitable donar parent with good expression of the concerned trait
2. Germplasm type (Cultivated/ wild type)
3. Agronomic performance of the donar

Importance of pre breeding

- ❖ Threaten to food security due to usage of limited genetic base.
- ❖ Introduction of modern varieties replace the local cultivars and landraces.
- ❖ Genetic uniformity leads to vulnerable to pest and diseases.
- ❖ Effect of climate change and also evolving of new pest and diseases we need new genes/ traits for better adaptation and source of resistance of the crop.

Groundnut

Groundnut or Peanut (*Arachis hypogaea* L), is a species in the legume or "bean" family and a native species of South America. The peanut was probably first domesticated and cultivated in the valleys of Paraguay. It is a segmental allopolyploid species with a genomic constitution of AABB having a chromosome number of 2n=4x=40. It is an annual herbaceous plant growing 30 to 50 cm (1.0 to 1.6 ft) tall.

Classification of genus Arachis:

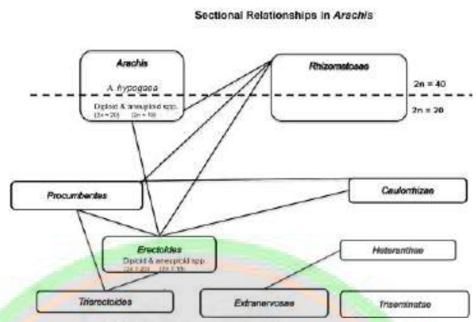
Family – Leguminoseae-Papilionoideae,

Tribe –Aeschynomeneae,

Subtribe - Stylosanthinae,

Genus – *Arachis*.

Genus *Arachis* having nine taxanomic section whereas the cultivated groundnut belong to the section *Arachis* contain 29 *diploid* and one groundnut. Except section *Arachis* and *Heteranthae*, which contain both annual and perennial species, all other sections have perennial species.

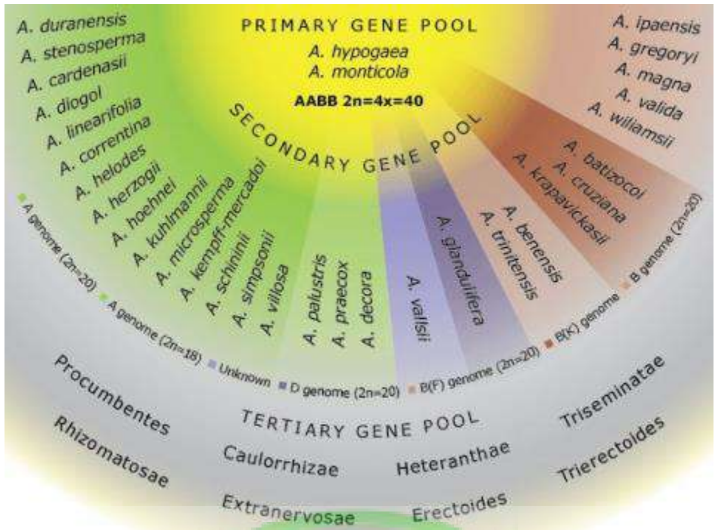


Source: Krapovickas A. and Gregory W.C. 1994

List of resistant sources in wild *Arachis* species

Specific trait	**Wild species/relative contributing gene(s) for resistance**
Early leaf spot (ELS)	*A.chacoense, A. stenosperma, A.glabrata*
Late leaf spot (LLS)	*A.chacoense,A.cardenesii, A. stenosperma, A.glabrata*
Rust	*A.batizocoi, A. duranensis, A. spegazzinii, A. correntina, A.cardenesii, A. stenosperma, A.chacoense*
***Aspergillus flavus* (low *invitro* seed colonization and aflotoxin production)**	*A.cardenesii,A.pusilla, A. chiquitana, A.triseminata*
Groundnut rosette disease (GRD)	*A.appressipila, A.decora, A.diogoi, A.pintoi, A.villosa*
Peanut bud necrosis (PBNV)	*A.cardenasii, A.villosa*
Root-knot nematode	*A.batizocoi, A.cardenasii, A. duranensis, A.villosa, A.diogoi*
High oil content	*A.rigoni, A.chacoense,A. villosa, A.monticola, A. oteroi, A.chiquitana*

Distribution of wild *Arachis* species in gene pool



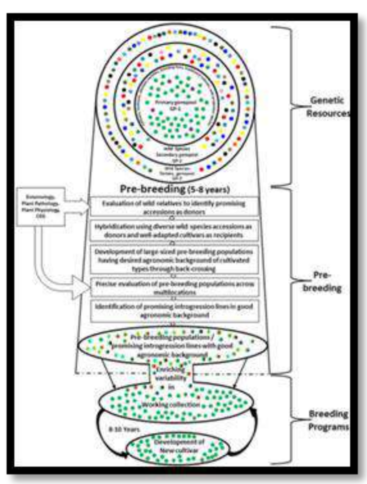
Source: Rami *et al.* 2014

Introgression of genes

In groundnut they are commonly using two pathways for introgression of genes in groundnut *i.e., Triploid-Hexaploid* pathway and *Diploid –Tetraploid* pathway.

Pre breeding for groundnut genetic enhancement

Prebreeding generate an intermediate set of material through transfer of genes from unadaptable germplasm which is having desirable trait to well-adapted genetic background. The generated material which can be used readily by breeders in their breeding program for to develop a new varieties with a broad genetic base.



Lines developed through pre-breeding at ICRISAT

Groundnut is one of the mandatory crop at ICRISAT and conserves 15,622 accessions which contains 15,144 cultivated and 478 wild types.

Interspecific derivative	Beneficial trait	Wild species/relative contributing gene(s) for resistance	Reference
ICGV 86699	Resistant to rust and late leaf spot	*A. cardenasii*	Reddy *et al.* 1996
ICGV 87165	Resistant to rust and late leaf spot	*A. cardenasii*	Moss *et al.* 1997
ICGV-SM 86715 (Veronica)	Foliar disease resistant variety	*A. cardenasii*	Moss *et al.* 1998
ICGV-SM 85048	Foliar disease resistant variety	*A. cardenasii*	Nigam *et al.* 1998
ICGVs 99003, 99005	Resistance to rust	*A. cardenasii*	Singh *et al.* 2003

Utilization of synthetic amphiploid and tetraploid

T x AG -6 is a synthetic amphiploid derived from *Arachis cardenasii* × *A. diogoi* of donar hybrid with AA genome crossing with *A. batizocoi* holds BB genome followed by colchicne treatment of the sterile triploid to produce *hexaploid*. These amphiploid readily combines with cultivated groundnut and produce fertile cultivars, Coan and NemaTAM, carrying genes for root-knot nematode (*M. arenaria*) resistance from *A. cardenasii* (Simpson and Starr, 2001; Simpson*et al.*,2003).

Tetraploid synthetics are developed from many wild types and each synthetics exhibited high level of resistance. Further the advanced backcross population showed considerable variability for morphoagronomic as well as biotic stresses have been developed from synthetics (ISATGR 121250, ISATGR 278-18, ISATGR 265-5 and ISATGR 40) and popular groundnut cultivars (ICGV 91114, ICGV 87846, TMV 2, Tifrunner) for to develop a pre breeding population. The resultant introgressed lines (ILs) which having high level of LLS and rust resistance reported by Sharma *et al*. 2017.

Problems and challenges

Problems	Challenges
Hybrid inviability and sterility.	Knowledge of the genetic diversity
Cross incompatibility in inter-specific crosses	Lack of characterization and evaluation data
Linkage drag	
Lack of availability of donors for specific traits	

Linkage drag

During introgression of genes through interspecific hybridization many undesirable traits related to duration and seed characteristics combined with desirable traits (resistance) reported in *Arachis* species is called linkage drag. These linkage drag gives burden to the breeders while selecting desirable plant from the breeding population. So nowadays use molecular marker based approaches, Genome wide introgression and advanced backcross QTL (AB-QTL) enable enhanced utilization of alleles from wild species.

Conclusion

The sufficient amount of variability available in wild species and landraces of groundnut but they are not available in conventionally usable form. In this regard, pre breeding act as a bridge between genetic resources and improvement of crop through continuous supply of useful genetic material to the breeders for to develop a cultivar with broad genetic base. The linkage drag is encountered in interspecific hybridization should be overcome by using genome assisted pre breeding for the transfer of useful genes/ segments in the precise manner from wild relatives.

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Volume: 04 Issue No: 05

IoT IN AGRICULTURE - A REVIEW

Article ID: AG-VO4-I05-37

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Abstract

Artificial intelligence (AI) techniques and IoT plays vital role in precision agriculture. A hybrid predictive model, customized neural network model works get work with the Raspberry pi to detect the disease symptoms in millets. It works and helps in crop health monitoring, weed detection, ambient air sensing, irrigation etc., and if abnormalities (or) irrelevant readings occur in sensor an alert will communicate to the farmers. By acting as an early warning system, remote sensing (RS) technologies offer a diagnostic tool that enables the agricultural community to take early action to address possible issues before they become widespread and have a detrimental influence on crop yield. Since sensor technologies, data management, and data analytics have advanced recently, the agricultural community now has a number of RS choices at its disposal. However, because of gaps in our understanding of RS technologies' adequacy, appropriateness, and techno-economic viability, the agriculture industry has not yet fully implemented them. This included field preparation, planting, in-season applications, and harvesting.

Keywords

Artificial intelligence, precision agriculture, Utilization of raspberry pi.

Introduction

IoT (Internet of things) in agriculture involves the use of sensors, actuators, and other connected devices to monitor and manage various aspects of agricultural operations. This technology allows farmers to gather real time data on soil moisture, temperature, crop growth, livestock health and more enabling them to make informed decisions to optimize production, reduce waste and increase efficiency.

Precision agriculture (PA) and digital agriculture, terms that are frequently used interchangeably, refer to the application of sophisticated crop and environmental analytical tools to massive data sources in order to assist farmers in implementing the appropriate management practices at the appropriate rates, times, and locations in order to meet environmental and economic objectives. Global interest in PA has grown recently as a potential solution to the enormous demand for increasing the production of higher-quality food and energy in a more sustainable way through externality optimization. One of the PA technologies that enables growers to efficiently and economically gather, visualize, and assess crop and soil health conditions at different phases of production is remote sensing (RS).

Soil moisture and temperature

For the purpose of making management decisions about irrigation, fertilizer application, and planting, a field's temperature and moisture state are crucial. Cool planting circumstances during planting place major strains on the emergence of warm-season crops like maize and soybeans because soil moisture affects soil temperature. Corn germinates and emerges best when the soil temperature is between 30 and 32 degrees Celsius.

Under a similar vein, fertilizers are usually administered under dry conditions to reduce the chance of nitrogen loss and improve crop nutrient uptake. The majority of research to date has concentrated on estimating soil moisture at the landscape scale through the use of optical and thermal remote sensing data. This has been accomplished by taking advantage of the physical relationship between vegetative cover conditions and land surface temperature through an approach known as the land surface temperature-vegetation index, or "triangle" or "trapezoid."

Disease detector

Raspberry pi is a series of single board computers developed by the Raspberry pi foundation, designed to promote computer science education and facilitate affordable access to computing. It is versatile and can be used for various application, (Nyvall, 1989) including programming, web browsing, media playback and even as a home server.

Utilization of raspberry pi

Smart irrigation

Raspberry pi can be employed to create automated irrigation system with sensors that monitor soil moisture levels. This helps optimize water usage and ensures appropriate irrigation for millets.

Weather station

Raspberry pi combined with sensors can be used to create cost effective weather station. (Singh, 2017) Monitoring weather condition is crucial for planning planting and harvesting times, as well as responding to adverse weather events.

Crop monitoring

Raspberry pi cameras or images capturing sensors can be utilized for crop monitoring. (Jukanti and Gowda, 2018) This assists farmer assessing the health of millet crops, identifying pests or disease and taking timely actions.

Mobile application for farmers

Developing mobile application for farmers, powered by raspberry pi, can provide valuable information on millet cultivation, market prices, and weather forecast

Remote sensing

Raspberry pi connected to the internet, allows farmers to remotely monitor their millet fields. This is especially beneficial for farmers who may not be physically present on the farm at all times. (Khanal *et al*. 2020).

The ability of IoT to classify leaves into healthy and unhealthy categories. They fastened the sensors that measure humidity, temperature, and soil quality. They took pictures of the crop plants using the camera. The Raspberry Pi was configured by the authors to interface with sensors and a camera in order to store and interpret the collected data for in-the-moment predictions. To identify whether a leaf is healthy or diseased, they first clustered photos using the K-means techniques and then masked out pixels.

Yield prediction

These days, some crop growers use yield-monitoring devices installed atop combines during harvest to gather data on output. (Brahimi, 2018) When harvesting crops, a yield monitor usually combines yield data from several crop rows (for example, a modern corn combine usually utilizes a 6-, 8-, 12-, or 16-row head). As a result, crop yield per row detection becomes more difficult and yield maps might have extremely coarse resolutions. Studies have shown how RS imagery can be used to create high-resolution yield maps that can be used to evaluate within-field yield variability at both the field and landscape scales. By doing so, researchers can gain a better understanding of the total production potential of agricultural fields. These studies have used empirical approaches.

Conclusion

We can conclude that detection of plant is done successfully with help through the raspberry Pi. We can achieve with very less time work will be reduced when we use raspberry Pi to identify the disease of millets. For any other handling we can use the server. The core goal of the given raspberry Pi is to detect the plant disease and display it on the device and accurately identify the disease and yield more output and prevent plant from disease. If you're referring to using Raspberry Pi in agricultural contexts, particularly with millets, it could offer benefits like data collection for monitoring environmental conditions or automating certain processes. However, the specific conclusion would depend on the goals and applications within the millet farming context.

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Volume: 04 Issue No: 05

MANGO & PAPAYA INFUSED MILLET BARS

Article ID: AG-VO4-I05-38

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Introduction

In recent years, India has witnessed a remarkable shift in dietary habits, with a growing emphasis on health and wellness. This cultural transformation is reflected in the soaring popularity of healthy snacks across the nation. As awareness of nutrition and well-being spreads, consumers are increasingly seeking alternatives to traditional, often processed, snacks. This surge in demand has led to a vibrant market for wholesome, nutritious snacks that cater to a diverse range of tastes and dietary preferences. Roasted Makhanas, or foxnuts, are a popular snack choice due to their low calorie and high nutrient content. Roasted with a variety of spices, they offer a crunchy and satisfying munch. Khakhra, Originating from Gujarat, khakhras are thin, crispy crackers made from whole wheat flour and seasoned with spices. They come in various flavors like masala, methi (fenugreek), and jeera (cumin). Sprouted legumes like mung beans, chickpeas, and lentils are rich in protein, fiber, and essential nutrients. Sprouts are often seasoned with spices, lemon juice, and sometimes mixed with chopped vegetables to create a nutritious snack. Jaggery-Coated Nuts, Nuts like almonds, cashews, and peanuts are coated in natural jaggery (unrefined cane sugar) to create a sweet and crunchy snack. Jaggery adds a touch of sweetness while providing minerals like iron and magnesium. Chia Seed Pudding, Chia seeds soaked in milk or yogurt, often flavored with fruits like mango or berries, create a creamy and nutrient-dense pudding. Chia seeds are rich in omega-3 fatty acids, fiber, and protein. Quinoa

Puffs, Quinoa, a protein-rich ancient grain, is puffed and seasoned to create a light and crispy snack. Quinoa puffs come in various flavors and are enjoyed for their crunchiness and nutritional benefits. Namak pare, a traditional Indian snack made from wheat flour, is baked instead of deep-fried for a healthier alternative. Seasoned with salt and spices, baked namak pare offer a satisfying crunch without the excess oil. A colorful mix of seasonal fruits like apples, bananas, oranges, and pomegranates, tossed with chaat masala (a tangy spice mix) and lemon juice. Fruit chaat is refreshing, hydrating, and packed with vitamins and antioxidants. In the everevolving landscape of health-conscious eating, one trend that has been steadily gaining traction is the rise of millet bars. These bars, crafted from nutrient-rich millet grains and an array of wholesome ingredients, represent a convenient and nutritious snack option for individuals seeking healthier alternatives to traditional processed snacks. As awareness of the importance of whole grains and sustainable food choices grows, millet bars have emerged as a popular choice among consumers looking to fuel their bodies with natural, wholesome goodness. Let's delve deeper into this burgeoning trend and explore the appeal of millet bars in the health food market. Here's a breakdown of the benefits of millets as a nutritious grain:

How the millets are nutritious ?

Millets are packed with essential nutrients such as proteins, dietary fiber, vitamins, and minerals. They are particularly rich in magnesium, phosphorus, manganese, and iron, which are vital for various bodily functions including bone health, energy metabolism, and immune function.

Millets are naturally gluten-free, making them an excellent choice for individuals with gluten intolerance or celiac disease. This characteristic also contributes to the versatility of millets in gluten-free diets. Celiac disease is an autoimmune disorder triggered by the ingestion of gluten, a protein found in wheat, barley, and rye. Millets, including varieties like sorghum (jowar), finger millet (ragi), pearl millet (bajra), and foxtail millet, are naturally gluten-free grains. Avoiding gluten is crucial for individuals with celiac disease to prevent damage to the small intestine and alleviate symptoms such as abdominal pain, bloating, diarrhea, and fatigue. Millets are considered low glycemic index (GI) foods, meaning they cause a relatively gradual increase in blood sugar levels after consumption compared to high-GI foods.

Millets primarily consist of complex carbohydrates, which take longer to digest and convert into glucose compared to simple carbohydrates found in refined grains. The slow digestion and absorption of complex carbohydrates result in a gradual and steady release of glucose into the bloodstream, preventing sudden spikes in blood sugar levels. Millets are rich in dietary fiber, both soluble and insoluble. Fiber slows down the digestion and absorption of carbohydrates, further contributing to the low GI of millets. Soluble fiber forms a gel-like substance in the digestive tract, which helps regulate blood sugar levels by delaying the emptying of the stomach and slowing the absorption of glucose. Insoluble fiber adds bulk to stool, promotes regular bowel movements, and may improve insulin sensitivity. Consuming low-GI foods like millets can improve insulin sensitivity, which is beneficial for individuals with diabetes.

Insulin sensitivity refers to how effectively cells respond to insulin and take up glucose from the bloodstream. By reducing the rate at which glucose enters the bloodstream, low-GI foods help prevent insulin spikes and promote more stable blood sugar levels. The slow and steady release of glucose from millets provides sustained energy over an extended period, helping to prevent fluctuations in energy levels throughout the day. This sustained energy can be particularly beneficial for diabetic patients, as it reduces the risk of experiencing fatigue or sudden drops in blood sugar levels. Certain varieties of millets, such as finger millet (ragi), are rich in antioxidants like phenolic compounds and flavonoids. Antioxidants help neutralize harmful free radicals in the body, thereby reducing oxidative stress and lowering the risk of chronic diseases such as cancer and cardiovascular disease. Antioxidants play a crucial role in fighting against cancer through various mechanisms. Antioxidants neutralize free radicals, which are unstable molecules that can damage cells and DNA, leading to cancer development. Free radicals are produced naturally in the body as a result of metabolic processes or environmental factors such as pollution, radiation, and tobacco smoke. By scavenging free radicals, antioxidants help protect cells from oxidative stress and reduce the risk of DNA mutations that can trigger cancerous changes.

DNA damage is a common precursor to cancer, as it can result in mutations that disrupt normal cell function and promote uncontrolled cell growth. Antioxidants help prevent DNA damage by stabilizing free radicals and reducing their ability to interact with DNA molecules. By protecting the integrity of the genetic material, antioxidants help maintain the normal functioning of cells and reduce the likelihood of cancerous transformations. Some antioxidants have been found to possess anti-cancer properties by inhibiting the growth and proliferation of cancer cells.

Certain antioxidants have been shown to induce apoptosis (programmed cell death) in cancer cells, thereby preventing their unchecked growth and spread. Additionally, antioxidants may interfere with the signaling pathways involved in cancer cell survival and metastasis, further inhibiting tumor progression.

Antioxidants support immune function by enhancing the activity of immune cells such as T cells, B cells, and natural killer (NK) cells. A strong immune system is essential for recognizing and eliminating cancerous cells before they develop into tumors or metastasize to other parts of the body.

Papaya and Mango based millet nutri bar

Processing mangoes into pulp involves several steps to extract the fruit's flesh and convert it into a smooth, homogeneous mixture. Mangoes are thoroughly washed to remove dirt, debris, and any surface contaminants. The fruits are sorted to remove damaged or overripe mangoes, ensuring only high-quality fruits are used for processing. Mangoes are peeled using mechanical or manual methods to remove the skin while preserving maximum flesh. The seeds are removed, and any remaining fibrous material is trimmed to obtain clean mango pulp. The mango flesh is cut into smaller pieces or slices for further processing for blending uniformly sized pieces ensure even cooking and extraction of more pulp.

The extraction of papaya pulp involves several steps to obtain the smooth, homogeneous mixture from the fruit. Here's a detailed overview of the process.

Papaya Pulp Extraction Process:

Papayas are thoroughly washed under running water to remove any dirt, debris, or surface contaminants. The fruits are sorted to remove damaged, overripe, or unripe papayas, ensuring only high-quality fruits are selected for processing. Papayas are peeled using mechanical or manual methods to remove the skin while preserving maximum flesh. The seeds and inner membrane are removed, and any remaining fibrous material is trimmed to obtain clean papaya pulp. Cutting and Slicing, The papaya flesh is cut into smaller pieces or slices to facilitate further processing. Uniformly sized pieces ensure even blending and extraction of pulp. In some cases, the papaya pulp may be strained through a fine mesh or sieve to remove any remaining fibers or seeds and obtain a smoother texture. This step is optional and depends on the desired consistency of the final product.

To prepare these homemade fruit bars, begin by combining papaya pulp and mango pulp in a large pot, maintaining a ratio of 40% papaya pulp to 60% mango pulp. Boil the mixture Prepare sugar syrup with 500 grams of sugar, 30 grams of liquid glucose, and 2 grams of citric acid until fully dissolved. Once the mixture reaches the desired consistency 75 brix and add millet flakes such as ragi and jowar, ensuring they are evenly distributed throughout the mixture. Grease a tray or baking dish and pour the hot papaya and mango fruit enriched millet mixture onto it, spreading it evenly with a spatula. Allow the mixture to cool and set at room temperature until firm, then cut it into bar-shaped sizes using a sharp knife. To preserve freshness, wrap the fruit bars individually in aluminum foil or store them in an airtight container. These nutritious and flavorful fruit bars can be enjoyed as a convenient snack on the go or as part of a balanced breakfast or dessert. Customize them with additional ingredients like nuts, seeds, or dried fruits for added texture and flavor. Remember to maintain proper hygiene and sanitation practices throughout the preparation and storage process to ensure the bars remain safe to consume.

Approximately estimation of the nutritional profile for 100 grams of the homemade fruit bar described in the recipe would be Calories: Approximately 300-350 kcal ,Sodium: 5-10 milligrams, Carbohydrates: 70-80 grams, Dietary Fiber: 3-5 grams, Sugars: 50-60 grams, Protein: 3-5 grams, Vitamin A: 500-700 IU (from papaya and mango pulp),Vitamin C: 30-50 milligrams (from papaya and mango pulp),Calcium: 20-30 milligrams, Iron: 1-2 milligrams, Potassium: 200-300 milligrams. Please note that these values are approximate and may vary based on factors such as the specific ingredients used, variations in portion sizes, and cooking methods. Additionally, the nutritional content of homemade recipes can vary, so it's advisable to use these estimates as a general guideline.

Volume: 04 Issue No: 05

DORMANCY AND ITS BREAKING METHODS IN OIL PALM

Article ID: AG-V04-I05-39

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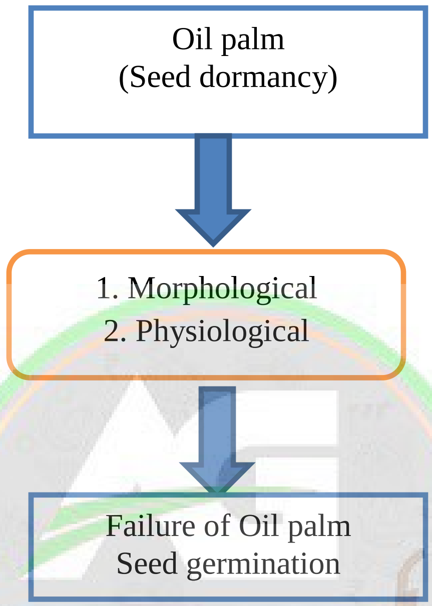
Introduction

The oil palm, *Elaeis sp.*, is a member of the Aracoideae subfamily. Two significant species, *Elaeis guineensis* (African oil palm) and Elaeis *oleifera* (American oil palm), can only be propagated by seeds. Oil palm (*Elaeis guineensis* Jacq.) is grown on 19 million hectares of land, producing 71.4 megatons of palm oil and 0.27 gigatons of fruits annually (FAO Database). Nonetheless, it only accounts for 5% of the world's total area planted to vegetable oil. Globally, palm oil makes up 45% of edible oil and 33% of vegetable oil (Rajinder et al. 2013). Thirty per cent of the global needs for edible fat and oil are met by oil palm. It is the second-largest source of vegetable oil in the world, and rising demand for palm oil has led to an unparalleled expansion in production areas worldwide. It produces crude palm oil and kernel oil, two different kinds of oil. The mesocarp of drupe fruit yields crude palm oil, while the endosperm of oil palm yields kernel oil. The endocarp and kernel combine to form the seed. The kernel is composed of greyish white endosperm and is encircled by a dark brown testa with a fibrous network. A seed may have two or three kernels, which represent tricarpellary ovarian, and may or may not contain a tiny embryo (Latiff, 2000). The primary factor limiting seedling production at the commercial level in oil palm seeds is extended seed dormancy.

Reason for seed dormancy

Seed dormancy in oil palm is primarily caused by the presence of a fiber plug that blocks the germpore of the nut. This fiber plug, known as the operculum, is cemented at the base and forms a plate-like structure that acts as a physical barrier, preventing the entry of water and oxygen into the embryo (Corrado and Wuidart, 1990). In addition to the operculum, there are other factors contributing to seed dormancy in oil palm.

Seed dormancy in Oil palm



The deposition of cell wall storage polysaccharides, particularly mannan, in the endosperm cell wall, results in a thick cell wall. The distal part of the embryo is also covered by a thick seed coat, known as the testa. Furthermore, underdeveloped embryos can also contribute to morphological dormancy in oil palm seeds (Buckeridge et al., 2000; Murugesan et al., 2015). The testa, or seed coat, of oil palm seeds contains oleic and linoleic acid, which act as barriers for external water and the entry of GA3, a plant hormone that promotes germination. Additionally, the kernel of oil palm seeds has a high proportion of saturated lauric acid, which further reduces the germination percentage (Norsazwan et al., 2016).

Conditions favour dormancy

1. Under natural conditions, oil palm seeds remain dormant for six months to one year.
2. Seeds developed at warm temperatures are less dormant compared to those developed in cooler environments (Hoyle et al., 2008).
3. The germination capacity of oil palm seeds decreases with increasing storage duration (Beugr'e-Mane'honon et al., 2009).

Methods to Alleviate Seed Dormancy in Oil Palm

To achieve uniform and rapid germination in oil palm seeds, various methods are being explored to break seed dormancy by manipulating critical factors such as moisture, light, and temperature. By optimizing these factors, structural alterations in the endosperm tissues can be made, weakening the abscission layer and facilitating the easy emergence of the embryo (Alang, 1982). One method used to soften the physical barriers in oil palm seeds for commercial planting material production is pre-heating. Heat treatment also reduces the concentration of abscisic acid in oil palm, which inhibits embryo development and water uptake (Jime'nez et al., 2008). However, different physical properties of oil palm hybrid seeds within a single bunch require different thermal requirements to break seed dormancy and achieve effective germination responses in heat treatment methods (Murugesan et al., 2010). While the action of fungi and other microorganisms on the mesocarp of oil palm seeds can result in natural pre-heating, this process is slow and only a few seeds germinate (Alang et al., 1988). In commercial seedling production, the optimum temperature for overcoming dormancy is between 38 and 40°C (Hussey, 1958).

According to Murugesan et al. (2015a), the duration and temperature of heat treatment significantly affect seed germination in oil palm. They found that heat treatment for 60-70 days at 39±1°C, followed by five days of soaking, is effective in achieving more than 94% germination. For maximum germination in a shorter period of time, heating at 50°C is recommended. However, prolonged heating beyond 70 days leads to a sharp decline in germination percentage due to the prevention of food material translocation from the endosperm to the embryo. Oil palm seeds must contain at least 17% water when subjected to pre-heating treatment for 70 to 80 days at a temperature of 40°C (Rees, 1962). The long duration required for pre-heating is a major disadvantage of this method. Therefore, any effective techniques that can reduce the dormancy breaking period would be highly useful in reducing both the cost and time required for germination.

Mechanical scarification techniques are also employed to alleviate seed dormancy problems in oil palm and minimize the dormancy breaking period. Nut chipping, which involves removing a round piece of endocarp containing the germpore, followed by de-operculum technique, which removes a plate-like structure in the seed coat above the embryo on the kernel, is recommended for wild oil palm (Elaeis oleifera) to achieve fast germination and uniform seedling production. This method takes only 3 to 7 days to achieve maximum germination of 50%, whereas the dry heating method takes 15 days to attain maximum germination of 40% after 60 days of pre-heating (Murugesan et al., 2015b). However, it is important to note that the removal of operculum as a pre-treatment is a laborious process (Carpenter et al., 1993).

Other scarification methods, such as complete endocarp removal and de-operculum, chipping endocarp and scarification with a pile rod, chipping endocarp and scarification with sandpaper, and chipping endocarp and needle insertion in the operculum, have also been studied by Murugesan et al. (2008; 2015b). Among these methods, the highest germination rate of 43.3% was observed in complete endocarp removal and de-operculation within 6 to 7 days. Seeds on which cracks were created at the germpore region of the shell using a hammer remained dormant even after six weeks of sowing, as the operculum might not have been affected by this treatment. To achieve shorter germination time, reliable germination rates, and improved seedling growth in oil palm, heat treatment and scarification methods are routinely used (Myint et al., 2010).

Some studies have explored the use of chemicals to improve germination by disintegrating the operculum and breaking seed dormancy. Acid scarification, for example, involves soaking oil palm seeds in sulfuric acid for 12 minutes, resulting in increased vigor, viability rate, and uniform growth (Wayan, 2011). Sodium hydroxide (NaOH) at concentrations of 0.25 to 0.75M, alone or in combination with thiourea, has been found effective in shortening the seed processing period from 110 days to 30-35 days. This treatment leads to high germination rates (55-72%) and disintegration of the mesocarp and operculum without compromising embryo viability. Interestingly, soaking seeds in water resulted in a higher germination percentage (90%) compared to other chemical treatments, while still maintaining embryo viability without disintegrating the operculum (Ravichandran et al., 2016). Jiménez et al. (2008) used a combination of dry heating and hydrogen cyanide (HC) treatment to overcome seed dormancy in oil palm seeds. They observed a sharp reduction in abscisic acid (ABA) concentration in the endosperm and embryo during the dry heating and HC treatment, resulting in 90% germination after 37 days. Additionally, the HC treatment improved the concentration of indole acetic acid (IAA) in the embryo and endosperm during the imbibition phase. However, the use of growth-regulating substances has not yielded satisfactory results in breaking seed dormancy and promoting germination (Wan and Hor, 1983). Similarly, treating oil palm seeds with hydrogen peroxide after 60 days of heat treatment did not improve the germination percentage compared to seeds soaked in water (Beugr'e-Mane'honon et al., 2009).

In addition to chemical methods, physical factors such as magnetic fields can be used to break seed dormancy and accelerate plant growth and development in oil palm seeds. Magnetic fields have been found to enhance germination rate, growth rate, root growth, and activate protein synthesis in plants (Moon and Chung, 2000; Flores et al., 2007; Martine et al., 2009; Sudsiri et al., 2014, 2015). The hypothesis behind the effect of electromagnetic fields on the biological system focuses on the impact of magnetization on the permeability of ion channels in cell membranes, which affects the mobility of water within the cell by changing osmotic pressure (Reina and Pascual, 2001; Belyavskaya, 2004). Additionally, magnetic fields may weaken the cell walls of the seeds, facilitating the easy emergence of the radicle (Cheng and Bradford, 1999).

Sudsiri et al. (2016) reported that oil palm kernels immersed in 120 mT magnetically treated water (MTW) for 48 hours and subsequently watered with MTW showed 100% germination within 35 days, compared to control seed kernels that were imbibed with normal water (resulting in zero germination after 56 days). Sudsiri et al. (2017) investigated the effect of a range of applied magnetic fields to optimize the germination rate in oil palm seed kernels. They found that the best magnetic parameter for stimulating germination in oil palm is magnetically treated water kernel (MTWK) treatment using 9.0 mT for 4 hours. Furthermore, they discovered that while the success rate was lower in dry magnetically treated kernels, the results indicated that the magnetic triggering of germination in oil palm kernels does not depend on the imbibition of water.

Seed Germination in Oil Palm

The process of seed germination in oil palm involves the rupturing of the operculum, which is caused by the pressure exerted by the growing embryo and the breakdown of the abscission layer of the micropylar endosperm (Hussey, 1958).

For successful germination, the growth of the embryo should be 1.5 to 3 times larger than its initial length, which allows for the breaking of the testa and the production of the radicle and plumule (Perez et al., 2008).

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AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

GENOMIC ADVANCES IN AQUACULTURE: INTEGRATING TRANSCRIPTOMICS, METABOLOMICA, TRANSGENESIS AND NANOTECHNOLOGY

Article ID: AG-V04-I05-40

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Abstract

Sustainable fisheries and aquaculture are crucial for meeting the world's food demand in a long run future, but it's indeed beset by numerous challenges such as overfishing, use of harmful chemicals and antibiotics, inadequate management practices, disease outbreaks and environmental deterioration leading to habitat loss, reducing genetic and species diversity. To address these challenges in aquaculture, leveraging biotechnology is essential. It enables the development of disease-resistant strains, vaccines, and alternative feeds through genetic engineering and bioprocessing techniques. methods such as transgenesis, RNA interference (RNAi), nanotechnology, metabolomics, transcriptomics, and CRISPR-based technologies stand at the forefront of innovation that can enhance productivity while minimizing environmental impact and promoting sustainability. This article provides a comprehensive overview of the latest advancements in biotechnology within aquaculture and fisheries.

Intoduction

Advancements in biotechnologies such as transcriptomics, transgenesis, nanotechnology, and metabolomics offer unprecedented opportunities to revolutionize aquaculture and fisheries. Transcriptomics enables the identification of genes linked to desirable traits like growth and disease resistance (Wylie et al., 2019; Liu et al., 2022). Transgenesis allows the insertion of new genes to enhance characteristics such as growth rate and feed conversion efficiency (Devlin and colleagues, 1994; Devlin et al., 2020). Nanotechnology provides innovative solutions for drug delivery, vaccine development, and water quality monitoring (Florence et al., 1995; Lyons et al

2018). Metabolomics offers insights into metabolic processes, aiding disease diagnosis and stress response (Low et al., 2017; Lulijwa et al., 2022). These technologies hold immense potential to address key challenges in aquaculture, including sustainability, productivity, and disease control. However, addressing socioeconomic, ethical, and regulatory concerns is essential for their responsible deployment and to fully realize their benefits.

Transgenesis

The insertion of a foreign gene or DNA integration into a host genome in a manner that ensures stable maintenance, transmission, and expression is known as transgenesis or transgenics. DNA constructs have been delivered to fish cells and embryos through various methods, including microinjection of eggs (Fletcher and Davies, 1991), electroporation of sperm and eggs (Symonds et al., 1994; Zhao et al., 1993), retroviruses (Lin et al., 1994), and particle bombardment (Zelenin et al., 1991). Microinjection stands out as the most commonly utilized approach, offering a straightforward means to generate germ-line transgenic animals (e.g., Chourrout et al., 1986; Dunham et al., 1987; Fletcher et al., 1988; Devlin et al., 1994).

Advancements in genomic databases, propelled by genome projects and modern techniques like DNA chips, enhanced gel resolution, and high-throughput mass spectrometers, have facilitated gene identification for desired traits. Coupled with advancements in transgenic methods, this offers aquacultural biotechnologists opportunities to enhance growth rates, cost-effectiveness, pathogen and stress resistance, broodstock quality, and diversify product offerings through genetic manipulation.

Transcriptomics

Transcriptome is the total RNA content of cell at a given point of time. Transcriptome sequencing is an ideal option for quick and cost effective interpretation of the functional element of genome and functional genes in the non-model species that lack a reference genome (Garg et al. 2011).

Transcriptome profiling is now widely used in aquaculture to distinguish various pattern of gene expression and development of novel markers for selection. Transcriptome studies have been extensively performed to identify new genes, molecular markers and gene expression and are available for many important aquaculture species, including, *Lates calcarifer* (Xia & Yue 2010), *Oreochromis niloticus* (Zhang et al. 2013), *Epinephelus coioides* (Huang et al. 2011), *Ctenopharyngodon idella* (Chen et al. 2012), *Macrobrachium rosenbergii* (Jung et al. 2011), *Fenneropenaeus chinensis* (Li et al. 2013a), *Eriocheir sinensis* (Li et al.2013b), and *Crassostrea virginica* (Zhang et al. 2014). Transcriptome sequencing in aquaculture has established to be an effective tool to determine genes and pathways responsible for superior performance traits related to immunity, growth and reproduction.

Metabolomics

The metabolomics represents the complete set of metabolites in a biological cell, tissue, organ, or organism that are the end products of different cellular processes. At present two common metabolomic approaches are used in aquaculture i.e., Nuclear Magnetic Resonance (NMR) and Mass Spectrometry (MS) and other approach is Fingerprinting metabolomics i.e., based on the high-throughput analysis of a large set of fish species to build a model based on all analytical variables generated from metabolite detection (Roques et al. 2020).

Metabolomic applications is fish health and welfare monitoring is a strategic research field to counteract extensive losses related with farmed fish diseases due to pathogen infection (Noriaki *et al*. 2014). The main metabolomic applications for fish health concern host–pathogen interactions (Solanky *et al*. 2005; Guo *et al*. 2014; Ma *et al*. 2015), disease characterization (Southam *et al*. 2008) and treatment efficiency (Su *et al*. 2015)

Interpreting fish metabolomics data requires a dedicated fish metabolism database. While existing databases like HMDB and HumanCyc offer insights into metabolic pathways, they're human-centric. Efforts like the livestock metabolome database target animals but overlook fish. A fish metabolomic database would provide spectra of fish metabolites and relevant metadata, enabling precise interpretation of fish metabolomics data and enhancing our understanding of fish metabolism (Goldansaz *et al*., 2017).

Nanotechnology

Nanotechnology is the "*understanding and control of matter at the nanoscale, at dimensions between approximately 1 and 100 nm, where unique phenomena enable novel applications*" (https://www.nano.gov/nanotech-101/what). As a highly promising technology nanotechnology in recent years has opened up new applications and possibilities for aquaculture and allied sector. With a strong history of adopting new technologies the fisheries and aquaculture industry can be revolutionized by using nanotechnology with new tools like rapid disease detection, water treatment, sterilization of ponds, enhancing the ability of fish to rapidly absorb drugs like hormones, vaccines and nutrients (Jimenez-Fernandez et al., 2014;

Bhattacharyya et al., 2015; Huang et al., 2015; Sibaja-Luis et al., 2019). For example, DNA-nano vaccines are been used to improve fish immune system. Similarly, iron nanoparticles can also be used to improve fish growth (Mohammadi and Tukmechi, 2015). Some strategies involve solid core drug delivery systems in the case of labile or thermo-sensitive drugs, (Mitchell & Trivedi, 2010), mesoporous silica particles can be employed (Stromme et al., 2009) for the controlled release of drugs, stabilization of drugs by increased residence time in the gut (Peters & Brain, 2009), as well as improved absorption capability, granted by a higher dispersion rate at the molecular level (Mohanraj & Chen, 2006).

The fisheries and aquaculture industry holds significant promise for nanomaterial applications, particularly in fish health management, ingredient incorporation, aquaculture feeds, food packaging, and value-added products. Currently, most of these applications are in an early stage, and high cost is considered the main limiting factor for their wide implementation. Sustainable development mandates a thorough assessment of potential negative impacts, including life cycle analysis, health risks, and environmental effects.

Conclusion

The integration of transgenesis, transcriptomics, metabolomics, and nanotechnology holds immense promise for revolutionizing the fisheries and aquaculture industry. These cutting-edge technologies offer opportunities to enhance fish health management, improve growth rates, develop disease-resistant strains, and optimize production processes. Despite being in early stages, advancements in genomic databases, transcriptome profiling, and metabolomic approaches provide valuable insights into gene expression, metabolism, and disease monitoring in aquatic organisms. Furthermore, nanotechnology offers innovative solutions for disease detection, drug delivery, and food packaging, albeit with challenges such as high implementation costs and potential environmental risks. Sustainable development requires careful assessment of negative impacts and effective risk management strategies to ensure the responsible use of these technologies. By leveraging the strengths of transgenesis, transcriptomics, metabolomics, and nanotechnology, the fisheries and aquaculture industry can enhance its productivity, sustainability, and resilience in meeting the growing global demand for aquatic food resources while minimizing adverse effects on human health and the environment. Continued research and collaboration are essential to fully realize the transformative potential of these technologies in aquaculture.

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Volume: 04 Issue No: 05

AGROECOLOGICAL CROP PROTECTION: BRIDGING FUNDAMENTAL ECOLOGY AND ECONOMIC ECOLOGY

Article ID: AG-V04-I05-41

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Abstract

National Agricultural Research Project (NARP) has partitioned land mass of India into 127 agroecological zones based on soil characteristics and cropping patterns. This also have importance over crop protection. Agroecology refers to the science of the relationships between an organism and its environment modified by human beings for food production. Insects are the major damaging factor in agriculture and they pose a serious threat to global food production. In order to avoid the crop loss by insect pests, many pesticides are used which pose a very serious threat to environment and other organisms of mother earth. The development of crop production technology with less impact on other lifeform's in the environment raises its demand now which will be a long-term control too. Crop protection measures developed based on agroecological factors are called as "Agroecological crop protection" measure. There are various elements and approaches to be considered for implementing successful agroecological crop protection at various level.

Key words: Agroecological crop protection, pests, natural enemies, one health concept.

Introduction:

According to Duncan *et al.* (2020), Agroecology is referred as both science and social movement where indigenous data as well as circular, social and farmers economies are emphasized. More precisely, by mimicking natural environment processes, agroecology aims to decrease the consumption of external inputs and enhance the production with the components of the system. The positive and synergistic interactions would consequently arise. Many people confuse agroecological production with organic farming, but they are not similar. The key concept of agroecology lies on the agroecosystem and food sovereignty whereas organic farming relies on farming system and value chain within it. There are also some modifications in agroecological crop protection focusing on nutrient cycling, biological crop protection and possibly chemical inputs it actually demands. Regulations and certifications are framed and strictly followed in organic farming but not in agroecological crop production. Though the concept of agroecology uplifted its flag during 1930s, the policies and laws related to agroecological crop production were framed only during 2010's.

Agroecological crop protection and its principles

Agroecological Crop Protection (ACP) defined as the reduction of pest impacts through the reorganization of cropping practices and the improvement of agroecosystem sustainability by harnessing its ecological functions. The concept not only focusses on overcoming biotic and abiotic stresses rather it involves multifaceted approach which involves a deep study including bioecology of pests (Deguine *et al*., 2020).

Deguine *et al*. (2023) created a blueprint for framing ACP strategies based on the six principles which includes

[1] Compliance with regulatory measures;
[2] Agroecological management of pest populations at the landscape level;
[3] Agroecological management of pest populations at the farm level;
[4] Ongoing monitoring of the plots (soil, biodiversity, trophic groups, *etc*.);
[5] Preventive practices at the cropping system level;
[6] Last resort curative practices.

Among these principles, "Preventive measures" is considered as a core principle. The ecological basis for pest management includes the population dynamics, pest biology and behavior, genetic and species diversity, agronomic practices and effect of climate in that area.

Approaches in ACP

- Bottom-up approach
- Top-bottom approach

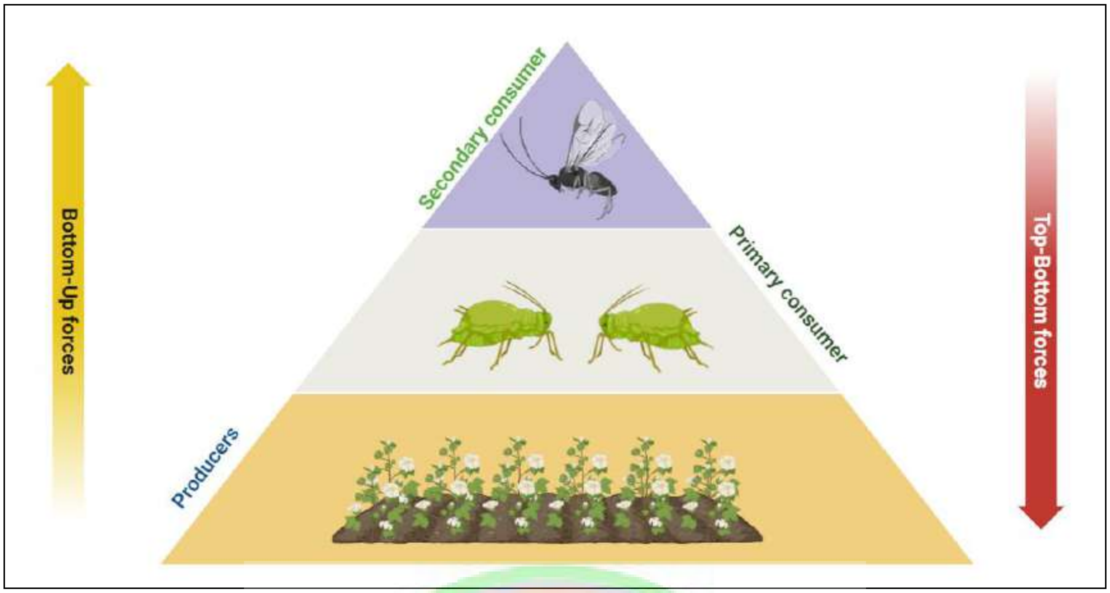

Fig. 1. Pictorial representation of approaches in ACP

Bottom-up forces are the result from lower trophic level creatures or the abiotic environment stepping up towards higher trophic level organisms. This could be triggered by the soil conditions and first trophic level and could alter the pest population through multitrophic interaction. Major factors are irrigation, fertilization, crop factors and abiotic condition so that involves crop diversification, habitat manipulation like vegetative strips, beetle banks, intercropping, trap crop and behavioural manipulation such as using pheromone traps and host marking pheromones. Understanding of nutritional ecology also alters the pest population. **For Example:** Reduced Nitrogenous fertilization for tomatoes hampers the performance of the tomato leaf miner (*Tuta absoluta*) and the whitefly *Bemisia tabaci* but does not affect the predator, *Macrolophus pygmaeus* and the larval parasitic wasp, *Necremnus tutae*. Top-down forces occurs when the organisms from higher trophic level influences the organisms in lower trophic level. Biological control using predators and parasitoids could be an accurate example for this concept.

There are even success stories in various countries where they exploited the spatial and behavioral ecology of the pest for its suppression:

1. One such study has been conducted entitled "ECOGRUBS" coordinated by C.I.R.A.D. EPIC, France. They used tools such as satellite imaging, geographic information system and radio tracking to understand the distribution ecology of *Dermolepida albohirtum*. Informations on tree preference, distance from roosting trees to highly infested patches

have been noted. And, they noted that the most damaged areas are the ones located along the river banks or creeks where feeding trees are plenty. Thereby, they came up with a suggestion of treating these strips from the vegetation edge to 200 meters inside would significantly reduce the damage on a large scale.

2. **GAMOUR (Agroecological management of cucurbit flies on Reunion)** Programme to assess the efficacy of agroecological cucurbit fruit fly management is another major success story. Here they considered three tools such as sanitation using augmentorium technique, trap plant using corn and "attract and kill" using Spinosad based bait. Finally, the GAMOUR zones showed more mean yield compared to Non-GAMOUR zone. A satisfaction survey showed that almost 80 per cent of farmers involved in the GAMOUR program are satisfied with their long-term results (Deguine *et al*., 2012).
3. **Campbell:** An iconic tale for ACP - Campbell, the well-known ketchup maker in New Jersey, acknowledges the public apprehension around pesticide use and residues in food. As a result, it set an audacious target in 1989 to cut the number of synthetic pesticides applied to the company's crops by 50 per cent in 1994. The implementation of ecologically based methods and significant decreases in pesticide use have been the outcomes of the program

- Crop rotation and field selection are examples of cultural activities; vegetable types are chosen according to their resilience.
- Arthropod, weed and disease infestations have been minimised by field sanitary measures.
- At least once a week, pest activity should be monitored.
- Treatment should only be administered when required and in accordance with ecologically sound methods, such as spraying *Bacillus thuringiensis*.
- To control tomato fruit worm, producers are given parasitic wasps, which are grown on-site by Campbell, and microbial pesticides and artificially synthesized pheromones that disrupts the mating are used against tomato pinworm, *Tuta absoluta*.

Food and Agriculture Organisation (FAO) has launched 10 elements of agroecology at the Second FAO International Symposium on Agroecology **[with Ref. Fig. 2.]** (Barrios *et al.*, 2020) and has also created various tools for paving the easy route for "agroecological cultivation" which are listed below.

- AgroecologyLex is a specialized database on different legal framework, policies and programmes concerning agroecology in different countries

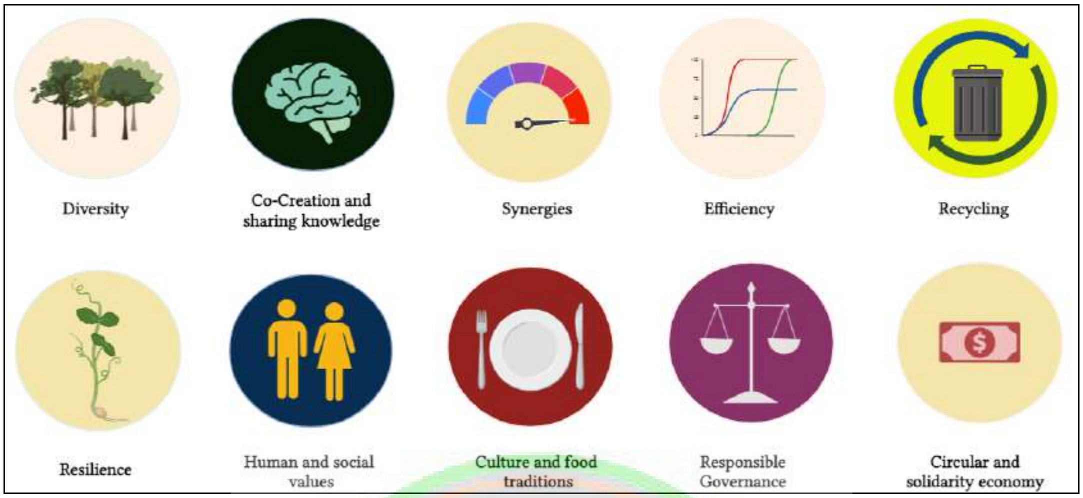

Fig. 2. Ten elements of Agroecology according to FAO

- TAPE (Tool for Agroecology Performance Evaluation) is a global analytical framework on process of agroecology development and guidelines for application
- Access Agriculture is an online global platform for sharing best practices of AEP
- Agroecology Knowledge Hub provides the database from initiation to organizing the existing knowledge on agroecology, collecting articles, videos, case studies and other important article. The objective is to support policy makers, farmers, researchers and stakeholders through knowledge exchange and knowledge transfer.

Conclusion

Agroecology is a productive and useful tool for building safe, secure, and long-lasting food supply chains in the centuries to come. This is an holistic approach to achieve sustainability and “One Health” concept. The crop production methodologies should be modified accordingly, so that the core principle of agroecology crop protection i.e. preventive measures could be incorporated. This also keeps organisms from reaching pest status, improves the natural enemy population and also have more durability compared to other management strategies. The basic ecology in agriculture level have the potential to alter the population ecology and also economical ecology. Thereby experimentations should be encouraged for implementing ACP at community level.

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Volume: 04 Issue No: 05

COLOR TRANSFORMATION TECHNIQUES IN AGRICULTURAL APPLICATION

Article ID: AG-V04-I05-42

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Introduction

Color transforms are fundamental operations in digital image processing used to manipulate the color information in an image. These transforms allow us to change an image's color space, alter color balance, adjust brightness and contrast, and perform a variety of other color-based operations. There are several color models used in digital image processing, each with its unique characteristics and applications. Understanding color transforms in digital image processing is crucial for many image processing applications. The color assessment of fruits , vegetable disease and pest idetntification , discrimination of crop and weed are categorised using image processing and machine learning techniques [1–3]. The color features are one of the key parameters to define the quality of an agricultural product [4, 5]. The color is probably the first factor that consumers use to determine the appearance of a product [6]; appearance is a subjective factor that leads the consumer to accept or reject a food product [7]. This significantly affects the sales and profits of the industry. Therefore, a considerable effort has been made in the area of automation to improve the quality of agricultural products in the food industry in order to decrease losses.

Color Transformation Model

A color model, also known as a color space, is a mathematical representation of colors used in digital image processing. It defines how colors are represented in terms of `numerical values that can be stored, processed, and displayed by computers and other digital devices.

RGB color model

RGB stands for Red, Green, and Blue, and it is the most commonly used color model in digital image processing. In this model, each pixel in an image is represented by three values that denote the amount of red, green, and blue light that makes up its color. The RGB model is an additive color model, which means that combining red, green, and blue light in varying proportions produces a wide range of colors.

CMYK color model

CMYK stands for Cyan, Magenta, Yellow, and Key (Black), and it is a subtractive color model used in printing. In this model, colors are created by subtracting different amounts of yan, magenta, yellow, and black ink from a white background. Unlike the RGB model, which is an additive model, the CMYK model is a subtractive model, which means that it starts with a white background and subtracts colors from it to create the desired hue.

HSL and HSV color models

HSL stands for Hue, Saturation, and Lightness, while HSV stands for Hue, Saturation, and Value. These color models are often used for color manipulation and adjustment in image processing. The HSL model represents colors in terms of their hue (the actual color), saturation (the intensity of the color), and lightness (the brightness of the color). The HSV model represents colors in terms of their hue, saturation, and value (a measure of the brightness of the color). The HSL and HSV models are particularly useful for adjusting color balance and enhancing color contrast in an image.

YCbCr color model

The YCbCr color space is essential to mastering the technical aspects of image quality. Unlike the RGB color space that aligns more with the way displays emit light, YCbCr plays a critical role in the way images are compressed and processed. This color space separates the brightness information (Y) from the color information (Cb and Cr), which aligns well with the human eye's differing sensitivities to luminance and chroma, thereby allowing for more efficient compression without a significant loss in image quality.

Lab color model

The Lab color model is a device-independent color model that represents colors in terms of their lightness (L), a (the green-red component), and b (the blue-yellow component). Unlike the RGB and CMYK models, the Lab model is designed to approximate human perception of color, making it useful for color correction and other color-based operations. The Lab model is particularly useful for tasks such as color matching, color grading, and image segmentation.

Color space conversion for Agricultural Applications

Color space conversion transforms are used to convert an image from one color model to another. For example, an RGB image can be converted to the HSL or HSV color models for color manipulation and adjustment. Color space conversion transforms are often used in image compression, where converting an image to a different color space can reduce its file size without significant loss of image quality.

Methodology

The images of agricultural application are collected and stored in JPEG format. These images are color transformed from RGB image to one of the color space named by YCbCr, HIS and CIELAB color spaces. The color transformed images are passed through median filter to remove unnecessary spots. In last step Otsu threshold is applied on RGB image, 'A' component of CIELAB color space, 'H' component of HSI color space and 'Cr' component of YCbCr color space is used to detect the disease spot. The disease spot segmented images, obtained by all the three methods are compared to get the best method for disease spot detection. During image collection, some noise may be introduced because of camera flash. This noise can affect the detection of disease. To remove unnecessary spot, Image smoothing method median filter is used for the input image.

Matlab coding

Imread function can be used to rean an image.

```
rgbImage = imread('E:\input.jpg');
labImage = rgb2hsv(rgbImage); ycbImage = rgb2ycbcr(rgbImage);
ycbcr= rgb2ycbcr(rgbImage); figure,imshow(ycbImage);
```

imshow function can be used show the image.

```
rgbmedfil = medfilt2(rgbImage);
```

Result and Discussion

The disease spots of RGB image is first converted into YCbCr color space using color transform formula. Then median filter is used for image smoothing. Disease spots are detected by applying Otsu threshold on 'Cr' component of filtered YCbCr color space.Compared to the three methods rgb to Ycbcr method detect disease are accurately.

Challenges and future directions

Challenges

- **Computational complexity**: Some color transforms can be computationally expensive, especially for high-resolution images or real-time applications. This can limit their practical use, particularly in resource-constrained environments.
- **Robustness to noise and variation**: Color transforms can be sensitive to variations in lighting, image noise, and other sources of variation. This can reduce their accuracy and reliability, especially for applications such as medical imaging or computer vision.
- **Subjectivity of color perception** Color perception can vary across individuals and cultures, which can make it difficult to establish consistent color standards or to achieve specific color effects.

Future directions

- **Real-time implementation**: There is a growing demand for real-time image processing in various applications, including computer vision, gaming, and virtual reality. Future research could focus on developing faster and more efficient color transforms that can be implemented in real-time.
- **Machine learning-based approaches**: Machine learning algorithms, such as deep neural networks, can be used to learn color representations directly from data, and can potentially improve the robustness and accuracy of color transforms.

Conclusion

In this paper YCbCr, HSI and CIELAB color models are studied. All these color models are compared and finally Ycbcr color model is used. Color transformed image is passed through median filter. In last, disease spots are segmented by applying OTSU threshold . In this method different disease spots are detected accurately and results are not affected by background, type of disease spot and camera. Further to this it is needed to compute disease spot area for assessment of loss in agriculture crop. Disease can be classified by calculating dimensions of disease spot.

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AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

PADDY STRAW: AN OVERVIEW

Article ID: AG-V04-I05-43

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Introduction

Paddy straw refers to the stalks and leaves left behind after harvesting its grains. It's a byproduct of rice cultivation and is widely produced in rice-growing regions around the world. It is composed mainly of cellulose, hemicellulose, lignin, and silica, and it has various uses across different industries. In agriculture, paddy straw is commonly used as animal feed, mulch for soil conservation, and substrate for mushroom cultivation. Additionally, it can be used in biofuel production, crafts and handicrafts, composting for soil enrichment, and traditional construction for thatched roofs and walls. The versatile nature of paddy straw makes it an important resource with applications in agriculture, renewable energy, and traditional crafts.

I. OVERALL USES OF PADDY STRAW

1. **Agricultural Use**: Paddy straw is commonly used as animal feed, especially for livestock such as cattle, goats, and sheep. It can also be used as bedding material for animals.
2. **Mulching**: Paddy straw can be used as mulch in agriculture to conserve soil moisture, suppress weed growth, and improve soil fertility.
3. **Mushroom Cultivation**: Paddy straw is a popular substrate for cultivating certain types of mushrooms, such as oyster mushrooms.

It provides a suitable medium for mushroom growth

4. **Biofuel Production**: Paddy straw can be used as a feedstock for biofuel production, such as bioethanol or biogas, contributing to renewable energy sources
5. **Crafts and Handicrafts**: Paddy straw can be used in crafts and handicrafts, such as making decorative items, baskets, mats, and even paper
6. **Composting**: Paddy straw can be composted to produce organic fertilizer, enriching the soil with nutrients and improving its structure
7. **Building Material**: In some regions, paddy straw is used as a building material for thatched roofs or walls in traditional construction methods.

II. BIOFUEL PRODUCTION FROM PADDY STRAW

Biofuel production from paddy straw offers a sustainable alternative to fossil fuels and can help mitigate environmental impacts associated with traditional energy sources. Biofuel conversion needs some process.

Here's an overview of the process

1. **Pre treatment**: Paddy straw needs pre-treatment to make its cellulose and hemicellulose content more accessible for enzymatic hydrolysis. Common pre-treatment methods include steam explosion, acid or alkaline pretreatment, or biological methods
2. **Enzymatic Hydrolysis**: After pre-treatment, enzymes are added to the paddy straw to initiate saccharification. These enzymes, typically cellulases and hemicellulases, break down the cellulose and hemicellulose into simple sugars like glucose and xylose.
3. **Fermentation**: The resulting sugar solution obtained through saccharification is fermented by yeast or other microorganisms to produce ethanol. This fermentation process converts the sugars into ethanol and carbon dioxide
4. **Distillation**: The fermented solution undergoes distillation to separate ethanol from water. Distillation removes impurities and concentrates ethanol for use as a biofuel.
5. **Dehydration:** Ethanol is further dehydrated to remove any remaining water and increase its purity and energy content.
6. **Utilization:** The final product, bioethanol, can be blended with gasoline to reduce greenhouse gas emissions from vehicles or used as a standalone fuel in flex-fuel vehicles

Biofuel production from paddy straw contributes to renewable energy sources, reduces greenhouse gas emissions, and provides economic opportunities for rural communities.

However, challenges such as recalcitrant compounds in paddy straw, process efficiency, and scalability need to be addressed to enhance the viability and sustainability of biofuel production

III. SACCHARIFICATION RELATES TO PADDY STRAW

Saccharification is the process of breaking down complex carbohydrates into simple sugars, typically using enzymes. When it comes to paddy straw, saccharification is often employed in biofuel production, particularly in the production of bioethanol

1. **Feedstock Preparation**: Paddy straw needs to be pre-treated to make its cellulose and hemicellulose content more accessible to enzymes. This pre-treatment often involves physical or chemical processes to break down the lignin and other barriers in the straw structure
2. **Enzymatic Hydrolysis**: After pre-treatment, enzymes are added to the paddy straw to initiate saccharification. These enzymes, typically cellulases and hemicellulases, break down the cellulose and hemicellulose into simple sugars like glucose and xylose.
3. **Fermentation**: The resulting sugar solution, obtained through saccharification, is then fermented by yeast or other microorganisms to produce ethanol. This fermentation process converts the sugars into ethanol and carbon dioxide

IV. HINDRANCES IN BIOFUEL PRODUCTION

In the context of biofuel production from paddy straw, there are certain recalcitrant compounds present in the straw that can pose challenges to the process. These compounds are mainly lignin and silica

1. **Lignin**: Lignin is a complex polymer found in the cell walls of plants, including paddy straw. It provides structural support to the plant and acts as a barrier to enzymatic hydrolysis during biofuel production. Lignin needs to be broken down or removed to access the cellulose and hemicellulose for saccharification
2. **Silica**: Paddy straw contains a significant amount of silica, which is deposited in the plant tissue as a defense mechanism against pests and diseases. Silica can interfere with enzymatic processes during biomass conversion and can also cause abrasion and wear in processing equipment

Addressing the recalcitrance of lignin and silica in paddy straw is essential for efficient biofuel production. Pre-treatment methods, such as steam explosion, acid or alkaline pretreatment, or biological methods, are often employed to overcome these challenges and enhance the accessibility of cellulose and hemicellulose for enzymatic hydrolysis. Additionally, advances in biotechnology and enzyme engineering are continually improving the efficiency of biomass conversion processes

V. DIFFERENT COMPONENTS RECEIVED DURING BIOFUEL PRODUCTION

1. **Biogas production :** Paddy straw can be used in anaerobic digestion to produce biogas, a renewable energy source composed mainly of methane and carbon dioxide. Biogas can be used for cooking, heating, or electricity generation
2. **Bioethanol Production**: Paddy straw can also be used to produce bioethanol, a type of biofuel that can be blended with gasoline to reduce greenhouse gas emissions from vehicles. Bioethanol is typically produced through a process called fermentation, where sugars derived from paddy straw are converted into ethanol by microorganisms
3. **Biomass Power Generation**: Paddy straw can be burned directly or converted into pellets or briquettes for use in biomass power plants. These plants generate electricity by burning biomass materials, including paddy straw, and are considered a renewable energy source.

Paddy straw for biofuel production not only helps reduce greenhouse gas emissions but also provides an alternative source of energy, thereby contributing to energy security and sustainable development.

Volume: 04 Issue No: 05

HYDROPONIC CULTIVATION: THE FUTURE OF AGRICULTURE

Article ID: AG-VO4-I05-44

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Introduction

Growing the plants in a soilless environment supporting them with essential nutrients is called hydroponics. The global population is inclining at a greater rate and is not at par to the production the farms are holding. The future in this scenario is expected to be turning worse. To meet this challenge, more technologies are needed to be introduced and existing technologies are to be upgraded for its utilisation. One among the recently boomed technology is hydroponics. It extended the borders alongside the challenges erasing the limitations in conventional agriculture. Over the years, it not only improved the yield but also improved the quality and nutrition of the food produced. The exploitation of space horizontally and vertically by a hydroponic unit will gift with higher yields per unit area. Because of its unconditional indoor applicability, it is of a much greater use to the times of extremities with regard to the climatic conditions and photo and thermo sensitivities. Hydroponics optimises the use of water and chemicals to get rid of potentially hazardous waste and residuals by employing smart greenhouses outfitted with many technologies to regulate crucial factors for healthy plant physiology (van et al., 2021).

With this advantage in the method, greater production can be achieved regardless of the limitations. Hydroponics has several benefits for food production since it is easy to change the composition of the hydroponic solution, which can affect physicochemical phenomena and change how efficiently nutrients are acquired by the plants through a series of nutrient interactions. Both quality and quantitative aspects of plant production have improved as a result of this. Because of this cultivation's greater efficiency in using water and nutrients, it presents an unquestionably significant prospective approach with benefits ranging from environmental benefits (Goodek et al., 2019, Paolo S et al., 2019). The world not only suffers with scarce food but also the climatic stress created on the planet due to the hazardous chemicals used, pollution created, global warming etc.(Velazquez-Gonzalez et al., 2022).

There are various components that contribute to successful establishment and yielding of a hydroponic unit.

1. **Hydroponic unit:**

There are various types of hydroponic units based on the design of the system. They are:

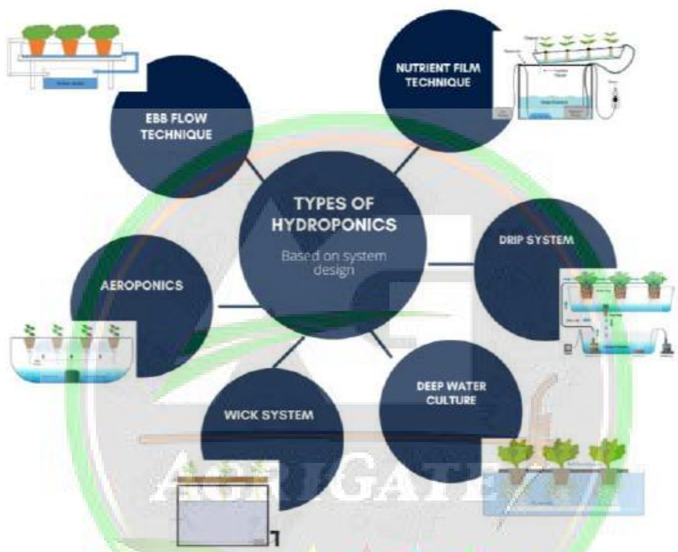

Fig 1 Types of hydroponics units based on design

Wick system: This is the system where nutrients are supplied by means of a nylon wick which connects the plant's root and the reservoir with nutrient solution through capillary action (M Kannan et al., 2022).

Drip system: With the drip method, the nutrient solution is kept in a reservoir while the plants are grown independently in a soilless medium. Through nozzles, a pump distributes water or fertilizer solution to each plant root in the proper amount (Rouphael Y, et al., 2005). The gradual release of nutrients makes it possible to gather extra solutions and either circulate them again or release them. Plant kinds can be grown simultaneously thanks to the Drip method.

Deep water culture: DWC hydroponic systems are stationary in nature and consist of floating rafts supporting plants positioned over nutrient-rich water-filled containers. These systems have a low cost and minimal supervision requirements, but they have little room for automation (K.

Nemali, 2018). The DWC hydroponic system's low cost and comparatively simpler maintenance requirements draw in a lot of farmers. But there are several disadvantages to this kind of arrangement. For larger plants or ones with longer growth periods, DWC systems are not advised. Moreover, oxygen is necessary for plant roots to grow and flourish; otherwise, they risk drowning. For DWC hydroponic growers, oxygen monitoring and management are therefore essential. Venturi systems or air bubblers are used to maintain the oxygen levels required for plant growth and development (Syed Abreez Gillani, et al., 2023).

Nutrient film technique: Using this technique, the nutritional solution is continuously pushed through channels, allowing it to circulate throughout the entire system. The nutritional solution passes via these tubes that hold the plants, allowing the plants to come into contact with the nutrient solution (Domingues *et al.*, 2012). This is one among the few systems which has great potential for automation and for altering the plant density (R. Abbasi, et al., 2021, Syed Abreez Gillani, et al., 2023).

Ebb Flow technique: The flood and drain principle governs how the first commercial hydroponic system, Ebb and Flow, functions. It is made up of a nutrient-rich solution reservoir and a grow tray. The solution is periodically flooded into the grow tray by a pump, and it then slowly drains. This system can be used to grow a variety of crops, but it is frequently plagued by problems like mold, algae, and root rot (Nielsen CJ, et al., 2006), which calls for the use of a modified system that includes a filtering unit.

Aeroponics: Aeroponics, a less common kind of hydroponic system, operates by sprinkling plant roots with a thin mist of nutrient-rich solution. Static sprinklers sprinkling a nutrient-rich solution directly onto plants is made possible by panels placed horizontally or vertically to support the plants (C. A. Espinal., 2019). Aeroponic systems, which are designed for smaller horticultural species, are less popular than hydroponic systems since they demand a large initial investment and ongoing costs.

In addition, there's a chance that the nozzles can clog, which could be disastrous for the plants. Positively, this approach gives the roots more oxygen exposure, which promotes better growth and development (Syed Abreez Gillani, et al., 2023).

1. Nutrient solution:

Nutrient composition is the most important component in running a successful hydroponic crop. Nutrient solution in the unit will judge the nutrient levels, taste, and quality of the yielding crop

3. The majority of the plant nutrients used in hydroponics are ionic and inorganic, and they are dissolved in water. A crucial step in growing crops in hydroponic systems is creating a nutrient solution that offers a favourable ratio of ions for plant growth and development. All the elements required for plant growth are supplied through various chemical combinations (Nguyen VQ, 2021). Nutrient uptake by plants can only occur when they are present in a form that allows for absorption. Standard nutritional solutions come in a variety of forms, including those available commercially and those developed by Hoagland and Snyder (Hoagland DR, 1933), Hoagland and Arnon (Hoagland DR,, 1938) Steiner 1961, Bollard 1966, and others. Although these standard solutions are useful as a general reference, they are not tailored to particular growing environments.

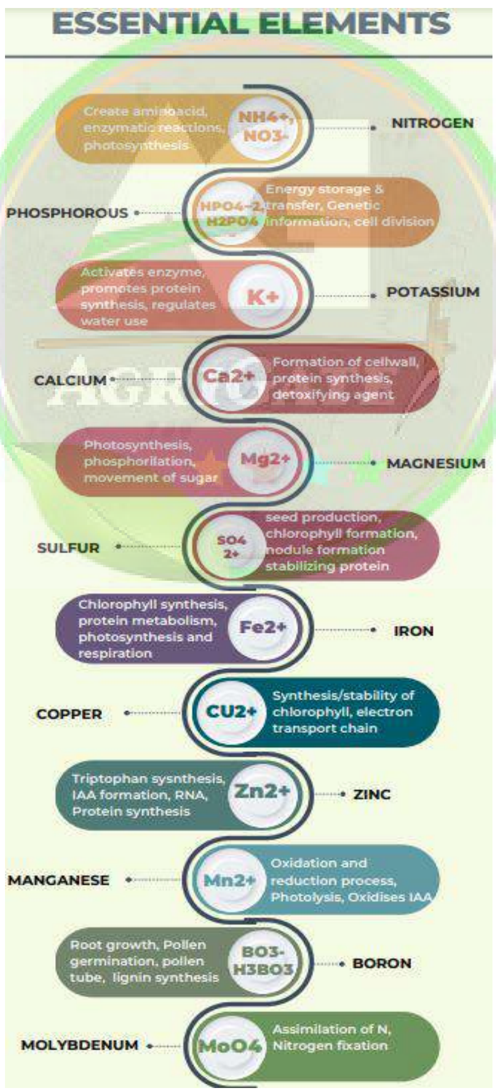

Fig 2 Essential element for plant growth and their functions

There are also few commercially available nutrient solutions like city greens hydroponics, Rimi garden A&Z nutrients, Garden Genie Hydro Grow, Garden King Hydroponic, Inhydro Hydroponic Nutrients, General Hydroponic flora, Green Loop Hydroponic, Radongrow etc. Plants need 17 essential elements like Carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, copper, zinc, manganese, molybdenum, boron, chlorine, and nickel to grow and produce healthy yield. All these elements have a crucial role in the physiological functioning of the plants. The important functions of these nutrients are mentioned in Figure 2 below. In case of deficiency of any of the elements, the plant will not be able to perform its role and thus shows out its symptoms of deficiency. Therefore, in the preparation of a nutrient solution, all the recommended and necessary concentrations are to be provided for the plants to perform normal

2. Automation:

"Agriculture 4.0," stands out to be a revolution that aims to combine cutting-edge technology, such as information technology, machinery, sensors, and devices, with traditional agricultural practices in a seamless manner. The concepts such as artificial intelligence (AI), Internet of Things (IoT) and Big Data (BD) were integrated into autonomous food production systems for precision irrigation, pest control, plant disease identification, and production management (Choo, K.K.R., et al., 2020). Complex technologies that improve the entire food value chain and make businesses more profitable, efficient, safe, and environmentally friendly are being used more and more, including robots, temperature and moisture sensors, aerial and satellite imaging, and GPS technology (De Clercq, M.,2018).

Given that big businesses are increasingly utilizing advancements in artificial intelligence, plant biology, and indoor vertical farming to produce a wide range of products, hydroponics fits in nicely with the framework of Agriculture 4.0 (Hati, A.J. et al., 2021). We can state with confidence that hydroponics has secured a central position in future food production systems, supported by cutting edge and disruptive technologies as well as solid scientific knowledge to ensure high yield. Bringing these technological advancements down to the medium- and small-scale operations found in urban and peri-urban settlements is the challenge at hand. In these settings, hydroponics may play a significant role in achieving SDG 11, which is about the sustainability and resilience of urban communities.

Gnauer et al.(2020) provided a framework that integrates heterogeneous devices on various computing layers to monitor and optimize the production process, which includes some technologies suitable for indoor farming. In addition, they created the aeroponics-based AgroRobot robot for the production of microgreens. The AgroRobot has a touch-screen graphic interface created with Nexion and is managed by an Arduino Nano8 for lighting and irrigation. Additionally, this work uses 3D printing technology to produce some accessories, like culture trays. This way there are many inventions and applications that have and are impacting indoor farming. In any of the implementations of these technologies, Velazquez-Gonzalez et al., 2022 have concluded a few steps for integration of these technologies.

1. The project approach: To understand and analyse the requirements like market consumption and local demand.
2. Automation level: To decide if the system to be implemented is fully or partially automated. This can be done based on the investment, necessity and the facilities available.
3. Design: To decide on the type of control system to be induced in the system.
4. Technology: to select the apt technology that is to be implemented in the system like, sensors, actuators, processing units etc.
5. Development and implementation: the decided structures are to be developed and programmed and installed. These are to be tested and debugged post the installations.

4. Crops in hydroponics:

There are a variety of crops that are suitable and are optimised for growing in hydroponic units. Few of them are mentioned in the table below. All these crops have performed better and are considered suitable for growing them in these conditions.

Table 1 : Crops grown in hydroponics

Cereals	**Fruits**	**Vegetables**	**Spices/ Condiments**	**Flowers**	**Fodder crops**
Rice, Maize	Strawberry, Watermelon	Brinjal, Tomato, Chilli, BellPepper, Cauliflower, Cabbage,	Mint, parsley, oregano and sweet basil, Saffron	Rose, Marigold, Chrysanthemum, Carnations	Bermuda grass, Barley carpet grass, Sorghum, Alfalfa, and Maize grass

		Broccoli, Green bean, squash, Carrot, radish, onion, Lettuce, Zucchini, Cucumber, Pea, Bean			

Challenges:

The biggest challenge that hydroponics faces is the initial cost. This drawback stops many from practising this type of agriculture. This is a challenge for both small scale and for the commercial cultivations. Though the investment is to turn out into profit in the long run, for it to turn out into the believed returns, the system has to be maintained at a very optimal level. The system placed indoors has to maintain proper intensity of light, temperature, pH, EC. For this purpose the electricity acts as one of the most important elements for running the unit. In case of a short failure in the power, there is a chance for the crop to be affected and the plants may even be led to irreversible damage. The air movement which is to be maintained, in case of restriction can also affect the plants health and may lead to many pathogenic infections. To maintain these perfect conditions in the unit, there needs to be a skilled person with superior knowledge in plants and in technology og hydroponics. Only these conditions will lead to a perfect unit and will result in successful crops turning out into funds.

Future outcomes:

The fastest-growing field in agriculture is hydroponics, which has enormous potential for food production. With so many developing and underdeveloped nations using it to produce food in constrained spaces, it has a bright future. To feed its citizens, Tokyo has begun producing rice hydroponically. In an arid country like Israel, hydroponics has also been successfully used to grow large quantities of citrus fruits, bananas, and berries. In regions like Africa and Asia where crops and water are scarce, this method can feed millions of people. This technology is widely used in the EU to produce herbs, melons, strawberries, eggplant, peppers, and vegetables. Premium garden vegetables, such as tomatoes, cucumbers, and lettuce in particular, are widely grown in the USA. Hydroponics is the ideal method for examining the interplay between various elements that affect plant growth, and it is a suitable technique for biological research. NASA has large hydroponics research plans in place, especially for current and future space exploration long-term colonisation of the Moon or Mars, so this technology shows promise for the space program's future.

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Volume: 04 Issue No: 05

THE FUTURE OF FISHERIES: EXPLORING ORGANIC AQUACULTURE IN INDIA

Article ID: AG-VO4-I05-45

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Introduction

Declining fishery harvests, wild fish food-safety issues, environmental concerns, increased fish consumption, and the increasing market share of organic foods have combined to focus attention on "organic aquaculture". Consumer demand may well drive the organic production of finfish, shellfish, and other aquatic species into the mainstream during the next decade. Organic aquaculture has attracted the attention of researchers from several academic disciplines as well as environmental advocates and entrepreneurial innovators (Dube and Chanu, 2012). Converting to organic aquaculture brings a wide range of environmental benefits, including biodiversity conservation, ecosystem maintenance, improved nutrient management, soil fertility, water quality, and disease resistance. The new organic market niche has significant potential for growth in the future.

Organic Aquaculture

Organic fish farming is the process of farming aquatic organisms, including prawns, fish, bivalves and aquatic plants without using any manufactured antibiotic or chemical fertilizer. Organic aquaculture is a holistic approach to farm management and food production that combines best environmental practices, maintains biodiversity, conserves natural resources and requires high fish welfare with the preference of certain consumers (Lembo and Mente 2019). The origins of organic aquaculture can be found in the organic agriculture movement

(International Federation of Organic Agriculture Movements, 2010). As early as 1995, the first certified organic cultured fish (specifically carp) was approved and certified by the German-based agency Naturland (Potts *et al.*, 2016). A decade later, the International Federation of Organic Agriculture Movements (IFOAM) approved the final version of its organic aquaculture standard by the General Assembly in 2005 (Auld, 2014). Fig.1 shows that organic aquaculture has a positive impact towards the Producer benefits (Sustainable livelihood, reduced input costs, High market price, Increased income and export earning) consumers' benefits (Food quality, health safety, consumer acceptance and eco-labelling) and environmental enhancement (Biodiversity conservation, maintaining ecosystem, disease protection, enhance soil fertility and maintain water quality)

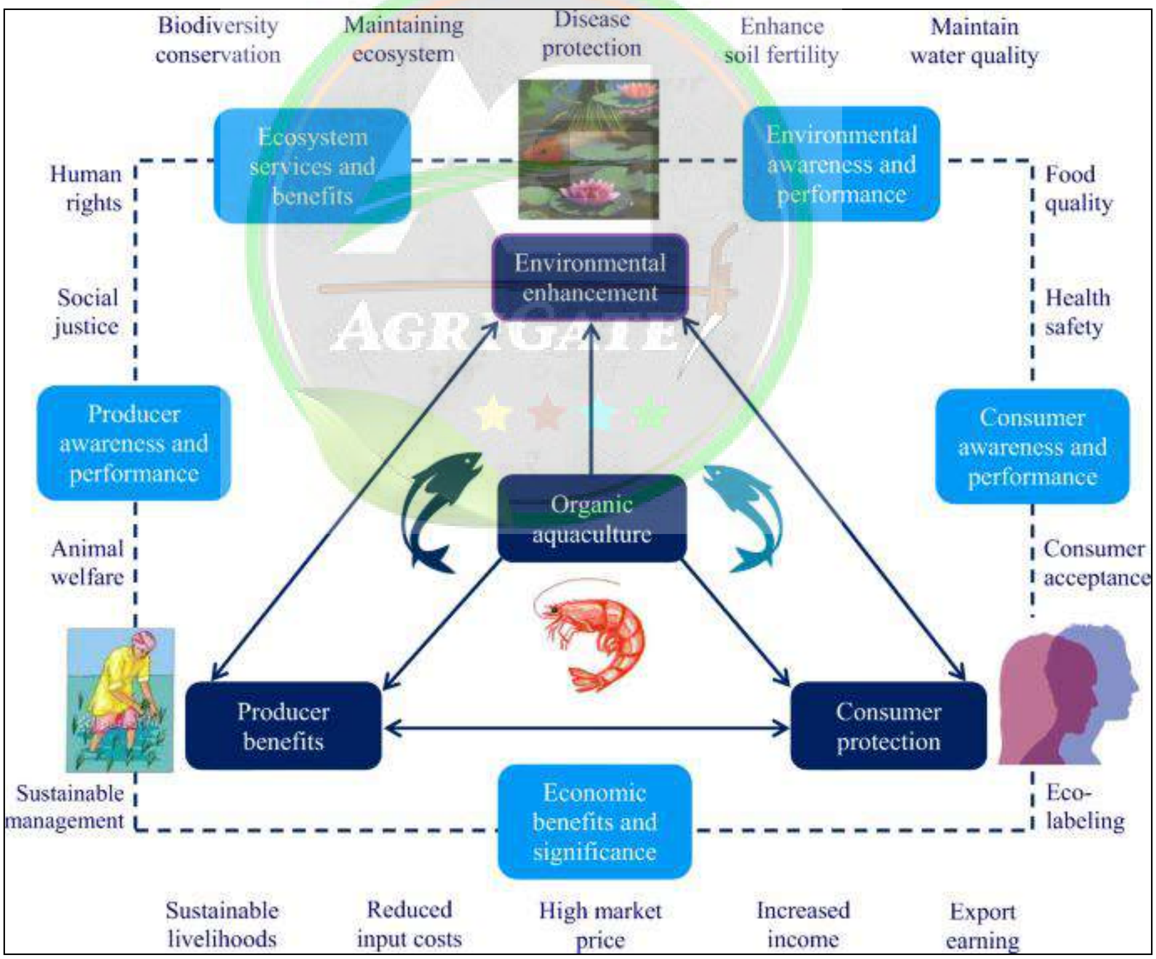

Fig.1 Organic aquaculture provides three interlinked benefits: (1) producers, (2) consumers and (3) environment (Source: Ahmed *et al.*, 2020)

Principles of Organic Aquaculture:

1. There should not be any presence of Genetically Modified Organisms (GMOs) or the substances produced through such processes in fish feed and stocks.
2. As per the ecological carrying capacity and behaviour of the aquatic animals like fish, prawn etc., there should be a limitation in the stocking density as per the standards issued for the country.
3. The source of organic feed and fertilizer should be certified as authentic organic as per the norms, and no artificial feed additives should be added.
4. The farm's natural diversity should be maintained by not using any scientific pesticides, herbicides, or inorganic fertilizers.
5. Prefer natural remedies for any stress or disease in fish, prawn or invertebrate aquaculture or live feed culture.
6. There should be restrictions on energy consumption related to aeration by reductions in input and intensification operations.
7. Proper environmental impact monitoring by the culture operations should be done to ensure the protection of neighboring ecosystems and incorporate natural plant communities into farm management.
8. A final product must be processed following organic principles to be certified organic.

Global Status of Organic Aquaculture:

Globally, aquaculture covered 18.8 million ha of land in 2010 (Waite et al. 2014). However, only 2,09,900 ha of aquaculture farms were certified organic, with a total production of 162,878 tonnes in 2018 (Willer et al. 2020). Globally organic aquaculture represents just 1.12% of the aquaculture area, returning 0.20% of total fish production. The highest volume of organic aquaculture production was found in Europe (56%), followed by Asia (mainly China) (Willer et al. 2020). Specifically, the highest organic aquaculture production per country was found in China (44% of the total), followed by Ireland, Norway, Romania, Italy, Germany, Spain, Hungary, Denmark, and Bulgaria. Globally, Mussels are the most produced in organic aquaculture followed by salmon, carps, trout, sturgeon, aquatic plants, seabream, shrimps, seabass, oysters, bream, and bass (Willer et al., 2020).

The Status of Organic Aquaculture in India

Considering the growing market for organic products, the Marine Product Export Development Authority (MPEDA) has identified organic aquaculture as one of the potential thrust areas for development. To implement the program, MPEDA initiated the **India Organic Aquaculture Project (IOAP)** in 2007, with the support of the Swiss Import Promotion Programme (SIPPO), Switzerland. The IOAP project was successful in developing certified stakeholders such as (1) A certified organic shrimp/scampi hatchery (2) certified organic feed mill (3) certified organic shrimp/scampi farm and (4) certified organic seafood processors. During the first phase of IOAP, the certified hatchery for both scampi and shrimp and feed mill for the production of organic feed processors have been established. It is a proud achievement of the IOAP that the organic scampi farmers from Kuttanad (Kerala), were the first producers of organic scampi in the World (2008).

National Programme for Organic Production (NPOP):

The European Union (EU) has made it mandatory for organic aquaculture products imported into its member countries to follow the EU Standards from July 2009. Therefore, framing country standards would be a more viable option, to equate the same with EU standards. In this connection, the National Standards for Organic Aquaculture are being finalized by the National Programme for Organic Production (NPOP) under the Government of India in consultation with various organizations.

The organic standards for aquaculture products are mainly prescribed by certifying agencies from the private sector. However, the higher cost of certification appears to be one of the major constraints for farmers to commence immediate development of the programs. In this regard, the Agricultural and Processed Food Products Export Development Authority (APEDA) has taken steps to evolve National Standards for Organic Aquaculture Products in India.

Importance of Organic Aquaculture:

Organic aquaculture practices prioritize sustainability by minimizing the use of synthetic chemicals, antibiotics, and pesticides. This approach has several positive effects:

Environmental Sustainability: Organic fish farming emphasizes sustainable practices that minimize environmental impact. By avoiding the use of synthetic chemicals, antibiotics, and genetically modified organisms, organic farming helps preserve water quality, protect biodiversity, and maintain ecosystem health in aquatic environments.

Healthier Food: Organic fish farming prioritizes the well-being of both the fish and the consumers. By prohibiting the use of harmful chemicals and antibiotics, organic fish are raised in cleaner, healthier conditions, resulting in safer and more nutritious seafood for consumers.

Reduced Pollution: Conventional aquaculture practices often contribute to pollution through the release of excess nutrients, antibiotics, and waste into water bodies. Organic fish farming, on the other hand, promotes responsible waste management and minimizes pollution, thereby safeguarding aquatic ecosystems and public health.

Consumer Demand: With increasing awareness of health and environmental issues, there is a growing demand for organic and sustainably produced food, including seafood. Organic fish farming allows producers to tap into this lucrative market segment and meet the preferences of eco-conscious consumers.

Economic Viability: While transitioning to organic practices may initially entail higher costs and lower yields, organic fish farming can offer long-term economic benefits. By improving resource efficiency, reducing input costs, and accessing premium markets, organic fish farming can enhance the profitability and competitiveness of aquaculture operations.

Regulatory Compliance: As organic certification becomes increasingly important in global trade, adopting organic farming practices ensures compliance with stringent regulatory standards. Certification assures consumers and facilitates market access, especially in regions with strict organic labelling requirements.

Challenges of Organic Aquaculture:

Regulatory Hurdles: The absence of universally accepted standards and variations in regulations among countries or certification bodies make navigating the regulatory landscape complex and challenging for farmers.

Certification Process: The certification process for organic fish farming is often lengthy, rigorous, and costly, acting as a barrier for farmers, particularly small-scale producers, who may struggle to afford the certification fees.

Lower Yields and Higher Input Costs: Organic fish farming tends to have lower yields and higher input costs compared to conventional aquaculture. Factors such as expensive organic feed, limited farm sizes, and the need for additional labour contribute to higher production costs.

Sourcing Organic Juveniles: Finding and certifying organic juveniles for stocking ponds or cages can be challenging, as there may be limited availability of certified organic fingerlings or hatchlings.

Limited Government Support: Inadequate government involvement and support for organic aquaculture initiatives, including funding, technical assistance, and infrastructure development, hinder the growth of the sector.

Marketing and Export Challenges: Limited marketing support and promotional efforts for organic fish products, coupled with the need to navigate overseas certification processes for export, pose challenges for reaching international markets.

Consumer Awareness: There is often limited consumer awareness and understanding of organic aquaculture standards and the benefits of organic fish products, particularly in developing countries, which can impact demand and market acceptance.

Environmental Considerations: While organic fish farming aims to minimize environmental impact, ensuring sustainable practices, maintaining water quality, and preventing pollution remain ongoing challenges.

Conclusion

Organic fish farming is a new concept that is still in the early stages of development. It strives to re-establish a proper balance in aquaculture systems for the benefit of fisheries, the environment, and consumers. Organic aquaculture farming has become more important as consumers have more conscious about the environment, sustainability and harmful impacts of intensive and sustainable aquaculture. This aims to provide fish and fishery products that are economically, environmentally and socially viable.

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Volume: 04 Issue No: 05

CULTIVATING TOMORROW: CRISPR REVOLUTION IN AGRICULTURE

Article ID: AG-VO4-I05-46

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Introduction

As the global population continues to grow at an unprecedented rate, the challenges of feeding everyone become increasingly daunting. However, hope is on the horizon in the form of CRISPR technology. CRISPR, which stands for **Clustered Regularly Interspaced Short Palindromic Repeats**, has emerged as a groundbreaking tool in the world of agriculture. With its potential to enhance crop traits and revolutionize farming practices, CRISPR holds immense promise in nourishing the expanding global population. In this article, we will delve into the ways in which CRISPR technology can transform crop improvement, enhance crop resistance to pests and diseases, improve crop yield and quality, and adapt crops to changing environmental conditions. Additionally, we will discuss how CRISPR contributes to sustainable agriculture and food security by reducing waste and losses, promoting biodiversity, and addressing nutritional challenges.

History

Jennifer Doudna, American biochemist best known for her discovery, with French microbiologist **Emmanuelle Charpentier**, of a molecular tool known as **(CRISPR)-Cas9**.

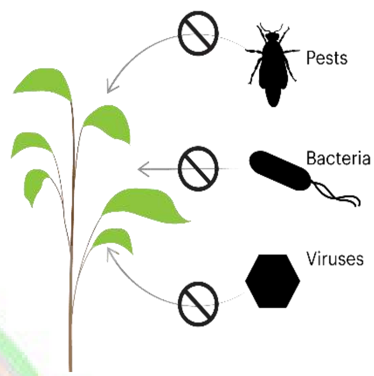
CRISPR more efficient and technically simpler than earlier methods. Using the CRISPR-Cas9 system, scientists were able to alter DNA to correct genetic defects in plants and animals. Doudna and Charpentier shared the **2020 Nobel Prize in Chemistry** for their discovery and development of gene editing technologies.

How the CRISPR works:

Enhancing Crop Traits through CRISPR

Increasing crop resistance to pests and diseases

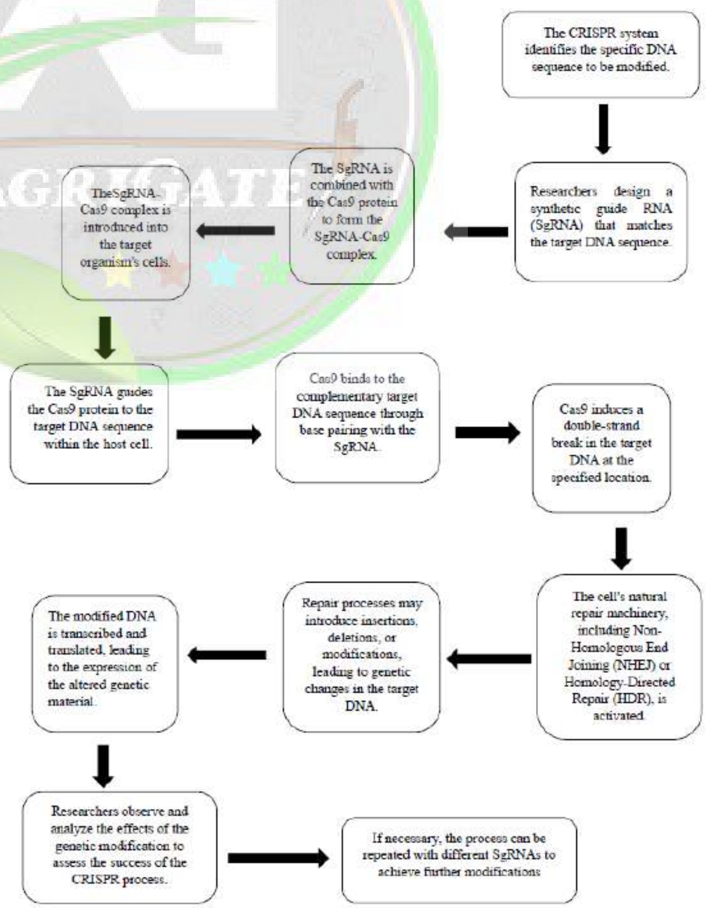
In the battle against pests and diseases that threaten global food security, CRISPR technology offers innovative solutions. By harnessing the precise gene-editing capabilities of CRISPR, scientists can develop plants that are resistant to common pests, such as insects and fungi.



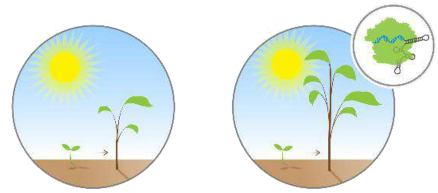
This eliminates the need for

- excessive pesticide use,
- reducing the environmental impact and
- potential human health risks associated with chemical pesticides.

Furthermore, targeted gene editing through CRISPR enables the enhancement of disease resistance in crops by modifying specific genes responsible for susceptibility to diseases. This not only ensures higher crop yields but also minimizes losses caused by disease outbreaks.



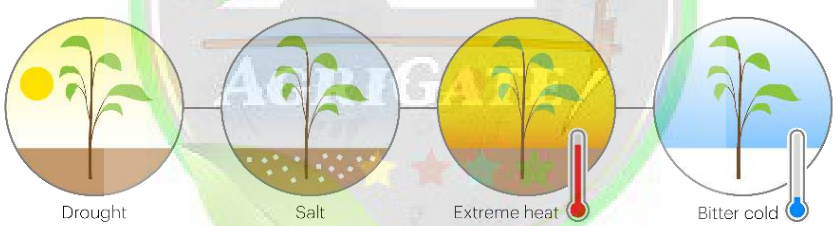
Improving crop yield and quality



The potential of CRISPR technology to improve crop yield and quality is tremendous. One way is by enhancing photosynthesis in crops. Scientists can use CRISPR to target specific genes involved in the photosynthetic process, optimizing it for maximum efficiency. This approach enables plants to convert sunlight into energy more effectively, ultimately increasing their yield potential.

Adapting crops to changing environmental conditions

As climate change continues to pose serious threats to global agriculture, the need for climate-resilient crops becomes increasingly urgent. By CRISPR technology targeting genes associated with drought tolerance, heat and cold resistance, and salinity tolerance, scientists can create crops that are better equipped to withstand the challenges of a changing climate. This ensures agricultural productivity and food security, even in the face of environmental uncertainties.



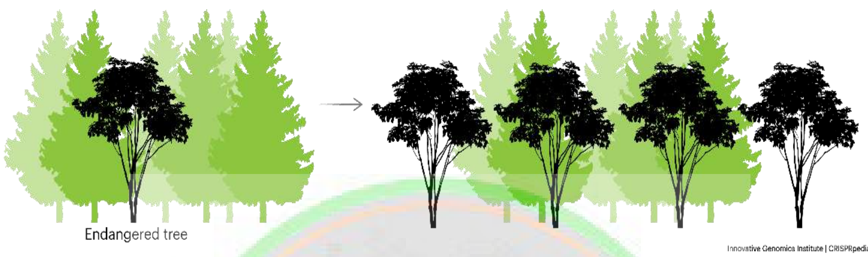
Reducing agricultural waste and losses

CRISPR technology plays a crucial role in reducing agricultural waste and post-harvest losses. By prolonging the shelf life of crops through gene editing, scientists can minimize spoilage and increase the availability of fresh produce. Additionally, CRISPR enables the enhancement of crop uniformity, reducing variations in size, shape, and quality. This results in less wastage during harvesting, transportation, and storage, contributing to sustainable agricultural practices.

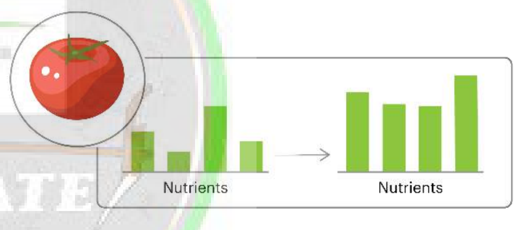
By modifying specific genes involved in the ripening process or sensitivity to external factors, crops can be engineered to have improved transportation durability and longer storage life. This helps preserve food quality and reduces losses along the supply chain.

Promoting biodiversity and preserving natural resources

Preserving biodiversity is crucial for maintaining ecological balance and long-term food security. CRISPR technology offers a means to conserve native and endangered plant species. By using targeted gene editing techniques, scientists can protect and restore genetic diversity within these species, safeguarding their survival in the face of habitat destruction and climate change.



Addressing nutritional challenges through CRISPR crops



Global nutritional challenges is another area where CRISPR technology shows great promise. By developing biofortified crops through gene editing, scientists can combat micronutrient deficiencies that affect vulnerable populations. These crops are enriched with essential vitamins and minerals, such as iron, zinc, and vitamin A. CRISPR offers a precise and efficient means to fortify staple crops, ensuring that they provide sufficient nutrition for individuals who rely heavily on them. CRISPR enables the customization of crops to address specific dietary needs. This expands the availability of nutritious food options and promotes inclusivity in the global food system.

Some important crops developed by CRISPR:

Rice

- knockout of the Waxy gene in rice resulted in the development of new transgene-free rice lines with lower amylose content
- *OsERF922* in rice, has been successfully established to increase resistance to blast disease caused by *Magnaporthe oryzae*

Wheat

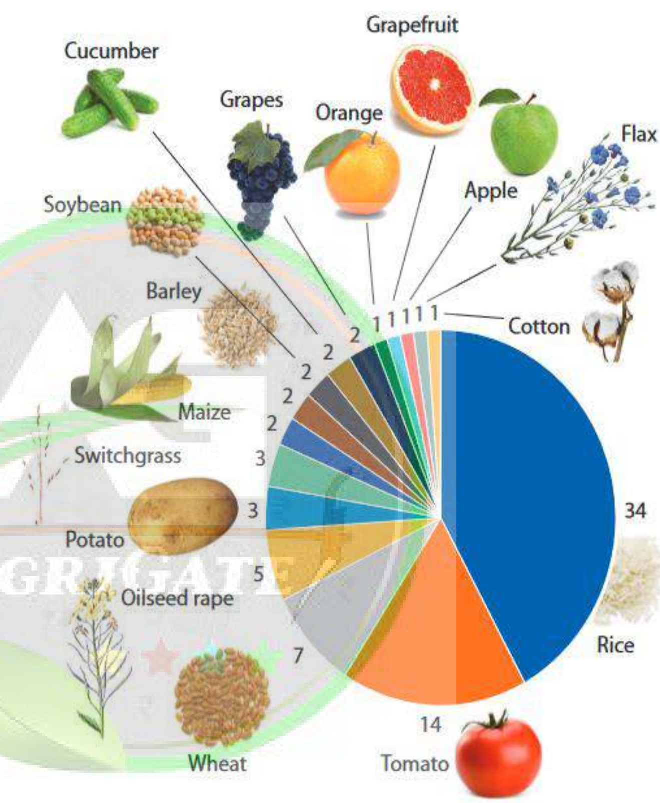
- CRISPR/Cas9 strategy applied in wheat protoplasts for TaMLO gene conferring resistance to powdery mildew
- CRISPR/Cas9 technology can be used to precisely and efficiently reduce the amount of α-gliadins. It could be used to produce low-gluten foodstuff

Cotton

- Resistance to *Verticillium dahliae* infestation was achieved through gene editing of the Gh14-3-3d gene.

Tomato

- CRISPR was applied to improve disease resistance by targeting genes related to powdery mildew resistance (SlPMR4) and altering the γ-aminobutyric acid (GABA) shunt pathway
- CRISPR/Cas9 was employed to target the ripening inhibitor (RIN) gene, a master regulator controlling tomato fruit ripening.



List of crops modified by CRISPR

Citrus

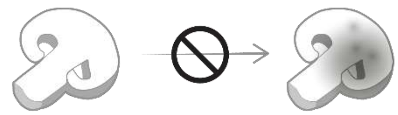
- CRISPR was applied to modify the susceptibility gene CsLOB1, enhancing resistance to citrus canker in sweet orange and *Citrus paradisi.*

Grapes

- knockout of the transcription factor gene VvWRKY52 in grape increased disease resistance to fungal infection (*Botrytis cinerea*).

CRISPR tools could change fruits and vegetable traits include:

- Preventing bruising
- Increasing shelf life
- Creating seedless fruits
- Changing color/appearance/flavor
- Improving nutrient profile
- Decaffeinating coffee



Browning in mushroom

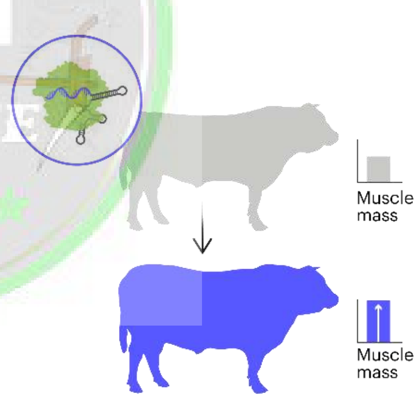
CRISPR tools used in animal husbandry:

Sex Selection:

- CRISPR tools are utilized to introduce specific DNA sequences in cattle breeds, ensuring the production of offspring of a desired sex, such as generating only male offspring for superior meat quality.
- In regions like India, where there are restrictions on cattle slaughter, genome editing for single-sex offspring can be a solution to manage the population of bulls.

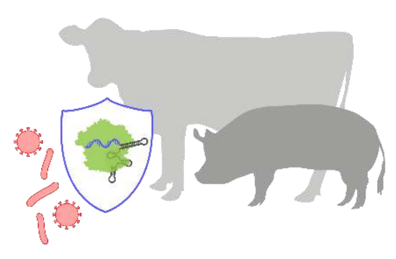
Enhanced Muscle Mass:

- Increased muscle mass in animals, achieved through genome editing, contributes to higher meat quality, efficiency in resource utilization, and potentially increased yields for farmers.



Disease Resistance:

- CRISPR tools are employed to delete specific DNA sequences associated with pathogen "handles" in livestock, providing resistance to infectious diseases.
- Current targets include diseases like tuberculosis in cattle and PRRSv - **Porcine reproductive and respiratory syndrome** in pigs, which are prevalent in crowded conditions.

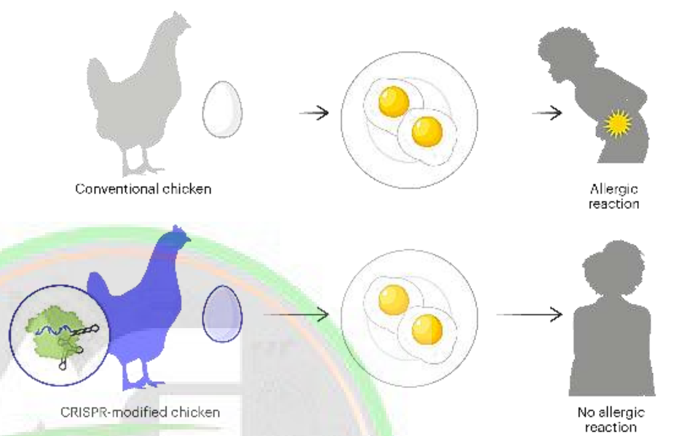


Improved Heat Tolerance:

- Genome editing is used to replicate the genetic traits of "slick" cattle, naturally adapted to higher temperatures, in breeds like American beef cattle.
- This application helps livestock withstand heat stress, ensuring stable production even in warmer climates.

Allergen Reduction:

- Researchers aim to use CRISPR tools to delete or disable DNA sequences encoding allergenic proteins in animals, reducing allergenicity in food products.
- For example, removing allergens from chicken eggs can address concerns related to allergies in consumers



Challenges & disadvantages of CRISPR in agriculture

Despite the significant advantages of using CRISPR to genetically modify crops, there are also considerable challenges. These include:

- **Precise delivery**. Delivering CRISPR/Cas9 components to the correct cellular location remains a significant challenge, particularly *in vivo* in rigid plant cells. This may require novel delivery strategies or adaptation of existing ones
- **Off-target effects**. There is significant concern about gene editing techniques, including CRISPR, having off-target effects on non-target genes. Although the fidelity of CRISPR is relatively high, more work is required to improve this
- **Efficiency**. CRISPR is not efficient in all species of plants or at targeting some traits that are controlled by several different genes. Some crops or gene targets show lower transformation and editing efficiencies and do not obtain the desired genetic changes
- **Loss of genetic diversity**. Many people are concerned that genome editing using CRISPR and other techniques will lead to the narrowing of the genetic pool, making crops more susceptible to pests and disease in the long term and harming biodiversity

- **Legal and regulatory challenges**. Being a relatively new and rapidly advancing area of research, genetic modification of crops using CRISPR is subject to legal and regulatory challenges stemming from the lag in the time taken for laws and regulations to be updated in line with technological advances. Moreover, to gain approval, robust evidence must demonstrate safety and efficacy

Conclusion

The CRISPR crop revolution holds immense promise in shaping the future of agriculture and ensuring global food security. With its potential to enhance crop traits, minimize environmental impact, and address nutritional challenges, CRISPR technology offers a powerful tool for nourishing the expanding global population. As research and innovation in this field continue to progress, the significance of CRISPR in agriculture will only continue to grow.

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AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

GRAFTING TECHNIQUES IN VEGETABLE CROP: AN OVERVIEW

Article ID: AG-VO4-I05-47

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Introduction

Grafting is a friendly and innovative technique that was mostly used across the world as in continuous cropping systems. Grafting has become extremely important these days, and the demand for grafted plants has skyrocketed due to its high yielding nature and greater tolerance to biotic and abiotic challenges. Grafting has been used to improve resistance to a variety of soil-borne diseases and stressors. It has also been shown to increase fruit output and nutrient uptake. Without requiring extensive screening and selection, a resistant cultivar can be produced by grafting the susceptible scion onto a resistant rootstock. Compared to creating new resistant cultivars, it offers quicker results in the control of soil-borne infections.

Grafting of vegetables was first attempted in Korea and Japan in the late 1920s by grafting watermelons onto gourd rootstocks. In India, grafting work first started at Indian Institute of Horticultural Research, Bangalore by Dr. R M Bhatt and his associates. CSKHPKV, Palampur identified more than 22 rootstocks in solanaceous and cucurbit vegetables to impart resistance against biotic stresses.

Different method in vegetable grafting

Tounge grafting

The 'whip and tongue' graft is probably the most widely adopted method. Ideally choose rootstock and scion material of the same thickness as this maximises the chance of cambial contact all the way around. Joining the cambium layers of the root and scion is crucial to the success of the graft. Although this method is applicable for both Solanaceous and Cucurbitaceous vegetables, it is most widely practiced on the latter. One week before rootstock raising, scion seeds are sown to ensure consistent scion size. Cucumber and pumpkin seeds are planted 10-13 days and 7-10 days before rootstock seeding, respectively.

In this method, make a slanting cut through the scion wood with a sharp grafting knife. Aim to create a flat oval cut face between about one and two inches long. Make another cut downwards into the scion wood, about one third of the way from the top of the cut face, about half an inch deep. Make a corresponding slanting cut in your rootstock. The rootstock and scion are then attached together at the point of cut and held together with grafting clips. This method requires rootstock and scion of equal diameter so, sowing time of scion and rootstock seedlings should be adjusted accordingly.

Cleft grafting

It is a very old method of vegetative propagation, it is very simple and very frequently used method, for this the rootstock must be split or made a cleft right from the centre of the stock a smooth perpendicular cut to the main axis, then from the base of the scion make a tapered cut, make sure there is a bud near the basal end of the scion. Then make a smooth fit of both stock and the scion and joined together by applied a clip to make contact between the scion and the rootstock. The lower stem of the scion plant is cut to a slant angle to produce a tapered wedge, and a clip is applied to make contact between the scion and the rootstock. Solanaceous crops are the most commonly used crops for this strategy.

Top insertion grafting

This is the most widely used method for cucurbits; hollow hypocotyls scion and rootstock are highly preferable. This is highly recommended for grafted watermelon transplant production because watermelon seedling size is comparatively small than bottle gourd or squash rootstock. Optimum temperature for this method is 21-36 °C up to transplanting. In this method 7-8 days old rootstock in bottle gourd and 3-4 days old rootstock in squash should be selected. Rootstock and scion both should be similar in thickness, robust and strong at the time of grafting. The scion is placed within the hole that has been created in the rootstock. Despite requiring more skill, this method is more common among commercial farmers because it does not require additional labour for clipping, transplanting, cutting and removal of the grafting clip.

Splice grafting

Commercial makers of transplant and growers mostly use this method. It is done by hand or machine for most of the vegetables. This technique can be applied to crops in the solanaceous and cucurbit families. Both the rootstock and scion are cut at 45º angle with matching cut and are clipped together with a grafting clip. The great thing about this process is that it ensures strong and healthy grafted seedlings as vascular bundles are properly joined together.

Pin grafting

Pin grafting is similar to splice grafting. Instead of placing grafting clips, especially designed pins are used to hold the grafted position.

Table: List of rootstock use in different vegetable crops for grafting

Scion Plant	**Rootstock**	**Use for**	**References**
Cucumber	Fig leaf Gourd	Good Fusarium resistance and low temperature resistance	Davis *et al*., 2008
	Burr cucumber (*Sicyos angulatus*)	Southern Root-knot Nematode resistance	Davis *et al*., 2008
	Cucurbita moschata	"Blooming-less" cucumber fruit	Davis *et al*., 2008
	TRC 15NTB4	Resistance to soil-borne diseases and abiotic stress factors.	Davis *et al*., 2008
Watermelon	Bottle Gourd (*Lagenaria siceraria*)	Fusarium wilt and chilling tolerance	Davis *et al*., 2008
	Wax Gourd	Greater drought tolerance	Davis *et al*., 2008
	Pumpkins (*Cucurbita pepo*)	Vigorous root system, resistant to fusarium and low temperature	Davis *et al*., 2008
	Interspecific hybrid squash (*Cucurbita maxima* x *C. moschata*)	Resistant to fusarium wilt and vigorous root system,	Davis *et al*., 2008

		high temperature tolerance	
Summer Squash	Fig leaf Gourd (*Cucurbita ficifolia*)	Low soil temperature tolerance	Davis *et al.*, 2008
Bitter gourd	Sponge Gourd (*Luffa cylindrica*)	Resistant to fusarium wilt, good tolerance to heat and flooding	Davis *et al.*, 2008
Melon	**Squash**	Good fusarium and low temperature tolerance	Davis *et al.*, 2008
	Cucurbita pepo	Good fusarium resistance, low and high soil temperature tolerance, and high soil moisture tolerance	Davis *et al.*, 2008
Tomato	*Solanum pennelli*	Tolerance to drought and salt	(Bolger *et al.*, 2014)
	S. chessmanii	Resistant to salt	(Rush and Epstein, 1976)
Brinjal	*S. macrocarpon*	Tolerant to flooding	(Bhatt *et al.*, 2014
	Solanum elaeagnifolium	Resistant to drought	(Christodoulakis*et al.*,2009
S. torvum	Birgah' eggplant	increase Iodine-stress tolerance of eggplant, mproved total anthocyanins concentration	Consentino *et al.* (2022)

Importance of grafting in vegetable crops

To improve yield

The net return that a grower receives is directly correlated with the total yield that the plant produces. A plant's yield is determined by when it flowers and fruits produce at optimum time. Vegetable plants with grafting yield more than non-grafted plant, according to a well-established paradigm. Sakata *et al*. (2007) observed that watermelon grafted onto bottle gourd rootstocks resulted in early formation of female flowers. Cucumber scions when grafted onto pumpkin rootstocks yielded 27% more fruits per plant than the non-grafted ones (Seong *et al.*, 2003).

To improve fruit quality

One of the key elements influencing how marketable the gathered produce is its quality. It is frequently discovered that grafted plants provide fruits of a far higher grade than self-rooted ones. In order to produce fruits of higher quality, the robust rootstocks' broad root systems aid in the uptake of vital minerals and nutrients from the soil. Scions of mini watermelon grafted onto the commercial hybrid rootstock 'PS 1313' (*Cucurbita maxima* × *Cucurbita moschata*) exhibited higher titratable acidity (TA) and a higher TSS/TA ratio (Proietti *et al*., 2008). The total sugar content of watermelons grafted onto bottle gourd [*L. siceraria* (Mol.) Standl.] rootstock was reported to be lower than in self-rooted watermelons (Yao *et al*., 2003; Liu *et al*., 2006). They reported that some *Cucurbita spp*. rootstocks decreased the total soluble solids of watermelon fruit, but that fruit from the scion grafted onto bottle gourd did not significantly differed from control fruit.

To combat soil borne diseases

Grafting of vegetables have been used most extensively and successfully for the control and management of soil borne diseases in both open and protected cultivation since grafted plants have proved to offer resistance to a large number of diseases. Cucurbit crops are highly affected by Fusarium, a soil borne fungus that causes serious damage reducing the yield and productivity. A large number of studies on vegetable grafting have exhibited successful control of major soil borne diseases like Verticillium wilt (Papadaki *et al*., 2017), Fusarium wilt (Sakata *et al*., 2008) and Bacterial wilt (McAvoy *et al*., 2012).

To improve tolerance to abiotic stresses

One of the most significant environmental factors producing significant economic yield losses is temperature, which stunts plant growth and development and results in wilt and necrosis. Abiotic stress impact of grafting grafting is a technique used to lessen the impact of abiotic stressors.

Mini watermelons grafted on to a commercial rootstock PS1313 (*Cucurbita maxima* Duchesne × *Cucurbita moschata* Duchesne) shown that an increase of over 60 % higher yield when grown under scarcity of irrigation conditions in contrast to ungrafted melon plants (Rouphael *et al*. **2008**).

Conclusions

From the above discussion it is clear that using rootstocks for grafting in vegetable crops boosts crop productivity, quality and yield. Compared to their non-grafted counterparts, grafted plants are more resilient to disease and exhibit greater flexibility. For the grafted plant to produce a higher fruit output and superior quality attributes, it is crucial to choose and apply highly compatible scion and rootstock. In order to generate rootstocks that are resistant of different biotic and abiotic challenges, it is necessary to find, assess, and screen new genotypes by utilizing elite and wild germplasm.

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AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

GLIMPSES OF PALMYRA AND PALMYRA PRODUCTS

Article ID: AG-VO4-I05-48

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Introduction

The palm tree known as "Karpaghadaru" is one of the traditional symbols of our Tamil Nadu. Palmyra has a special status as the national tree of our Tamil Nadu. Palm trees are mostly found in Tamil Nadu in India. Especially in southern Tamil Nadu districts like Tirunelveli, Thoothukudi, Thenkasi and Kanyakumari, palm trees are found in abundance. Palm tree is an excellent cash crop. From this more than five hundred products are available for our benefit.

Among them, we also get natural products such as palm leaves, palm fronds, nungu, neera, toddy, palm tuber, palm fruit, thavun, palm nuts, palm fruit, palm jaggery and palm fiber. It is said that it takes at least ten to fifteen years for a palm tree to grow and produce sap. A mature palm tree can live for about a hundred years. Although there are said to be more than thirty varieties of this palm tree, nowadays its varieties have narrowed considerably. The palm tree also has a male palm and a female palm. Only female palm trees flower and bear fruit. It is from it the food items like nungu and neera has obtained. From male palm trees we get palm fronds and countless handicrafts.

So we can grow palm trees without any cost and get more benefits from the products. This is why even today in the rural areas, the expression "Thousand gold is worth a palm tree" and "Thousand gold is a palm tree cut"" is still in use.

Palm products and their uses

1. Palm prints

Palm prints are obtained from the fronds of the palm tree. We can use these palm prints to make plates, house cleaning broom and airy baskets. Use these baskets to store vegetables and fruits to keep them from spoiling. Approximately fifty to sixty impressions can be obtained from a palm frond.

2. Palm Bat

The palm bat is the part between the fronds and the fronds stalk portion. Both sides are very sharp, and if these sharp parts are cut and combed, a kind of material called karuku is obtained. It is from this part that palm fiber is produced. After extracting this palm fiber, the remaining part is used to make papers. The beds in the houses were woven earlier with this palm fiber. As this palm fiber is high demand in abroad. Hence palm fibers are largely exported.

3. Neera

Neera is a natural drink obtained from the palm tree. This water quenches our thirst in summer and is a cooling elixir for the body. In order to obtain this water, a specific sap in the palm tree is cut and limed earthen jugs are tied to it. A little of the liquid that seeps from this cut sap is collected in the pot. This liquid which joins with the lime is called "Neera". The liquid obtained without the addition of lime is called "Toddy". This water provides nutrients and cooling to our body. During the summer months of March to June, neera is the most productive.

4. Palm Jaggery

One of the products obtained from the palm tree is palm jaggerry known as palm vellam. This contains many types of nutrients required by the human body. Jaggery is prepared by distilling the neera obtained from the palm tree and pouring the nera water into the coconut shell.

5. Palm candy

Just as palm jaggery is obtained from palm sap, palm candy is produced by pouring distilled neera into earthen pots and burying it under the soil. In this candy there are rich in various medicinal properties. If children drink milk with palm candy, their physical development will be healthy. It is said that an average of twenty five kilos of palm jaggery and ten kilos of palm candy can be obtained from one palm tree per year.

6. Nungu

Nungu is produced from the palm tree in certain seasons. Nungu is especially abundant in summer season. Nungu keeps the body cool and protect our health. Nungum and Neera are sold more during summer. Then if tie green palm leaves into strips and scratch the nungu, drink it with neera, the taste is unmatched. Drinking neera with the scent of green palm leaves gives a kind of refreshment to the body.

7. Palm tuber

Nuts are extracted from the palm fruits obtained from the palm tree and the palm tuber is produced. One Palm fruit yields three nuts. Palm tuber is produced by burying these nuts close together in the soil. Generally palm tuber takes 90 days to grow after sowing of nuts. This palm tuber is rich in countless nutrients. Nowadays, as foreigners also want to buy it after knowing its medicinal properties, these tubers are also exported abroad

8. Palm fruit

When the matured palm nungu of the palm tree ripen, the palm fruit is obtained. This palm fruit is full of countless nutrients. It is rich in fiber which gives health to the body. The fruit has a fleshy texture with juicy fibers. When we cut a ripe fruit, we can feel that the aroma that comes from it creates a kind of freshness.

9. Thavun

Thavun is a nutritious and delicious food product obtained from the fruit of the palm when the fruit is fully riped. It is only available where there is a lot of palm trees. Thavun has innumerable medicinal properties. It cools the body and protects our health. People with diabetes can eat and it as a remedy for stomach ulcers.

10. Palm fronds

The leaves of palm trees are called palm fronds. **Small** fans are made from well-dried palm leaves. These fans provide air to cool us from the summer heat. Also mats are made using palm leaves. Sleeping using these mats is very comfortable for the body. Various handicrafts can be made from palm fronds Also these palm leaf mats are used to cool the common hot rice used for cooking and to keep chopped fruits. Each part of the palm tree gives us different benefits so it is given the name Karpaghadaru.

Volume: 04 Issue No: 05

DOCUMENTING LEAF SPOT DISEASES CAUSED BY VARIED ALTERNARIA SPECIES IN NAMAKKAL DISTRICT

Article ID: AG-V04-I05-49

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Abstract

Alternaria is a fungus that falls under the phylum Ascomycota, encompassing several species that infect various crops. Namakkal, situated in the northwestern zone of Tamil Nadu, is characterized by its semi-arid and arid climatic conditions. Alternaria requires warm temperatures and high relative humidity for its growth. The favorable conditions for Alternaria coincide with the months from June to December in Namakkal. In total, five different species of Alternaria were reported in Namakkal district, namely *Alternaria sesami*, *Alternaria tenuissima*, *Alternaria cucumerina*, *Alternaria helianthi*, and *Alternaria alternata*, infecting sesame, groundnut, cucumber, sunflower, and chilli crops, respectively.

Introduction

The emergence of fungal diseases poses a significant threat to agricultural productivity, with *Alternaria spp.* being a prominent culprit affecting various crops worldwide. Within the context of plant pathology, Alternaria fungi are notorious for inducing blights, leaf spots, and stem rots across a spectrum of host plants. Namakkal district, situated in the North Western Zone of Tamil Nadu, India, experiences a predominantly semi-arid to arid climate, punctuated by distinct wet and dry seasons. Despite its climatic variability, Namakkal's warm temperatures and occasional high humidity levels create favorable conditions for Alternaria infections in crops. In this narrative, we explore the distinct manifestations of Alternaria-induced diseases in crops such as sesame, groundnut, cucumber, sunflower and chilli within the context of Namakkal's agricultural landscape. Understanding the symptoms, causative agents, and environmental conditions conducive to Alternaria infections is crucial for implementing effective disease management strategies tailored to Namakkal's unique climatic conditions and agricultural practices.

Symptoms

Leaf spot of sesame caused by *Alternaria sesami* (*A. sesami*)

Brown to black lesions, varying in shape from round to irregular and often displaying zonate patterns, emerge on the leaves, reaching sizes of up to 1 cm in diameter. During severe attacks, affected leaves desiccate and detach from the plant. Stem lesions manifest as dark brown spots or streaks. Circular, dark brown lesions develop on the capsules, potentially resulting in capsule drop. Notably, dark irregular patches occur predominantly on leaf edges and tips. Despite their subtlety, stem rots can inflict more substantial damage. *A. sesami* induces seed rot, pre- and post-emergence losses, alongside stem rot and leaf spot formation.

Figure 2 Alternaria blight of sesame

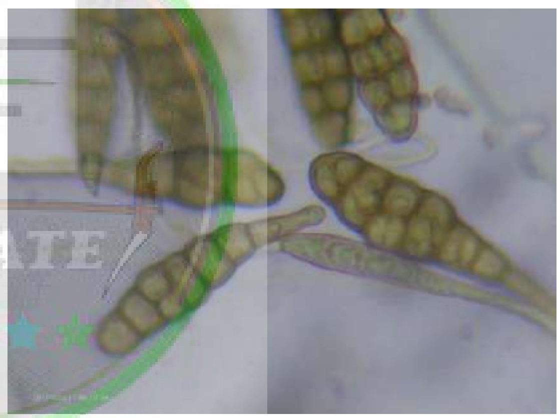

Figure 1 Conidia of *Alternaria sesami*

Leaf blight of groundnut caused by *Alternaria tenuissima* (*A. tenuissima*)

There are various species of Alternaria infecting groundnuts. In the Namakkal region, *A. tenuissima* has been observed. *A. tenuissima* induces a 'V' shaped blighting on the apical portions of leaflets, followed by dark-brown lesions extending to the midrib. This results in the entire leaf exhibiting a blighted appearance, curling inwards, and becoming brittle (leaf blight). The central portions rapidly dry up and disintegrate, giving the leaf a ragged appearance and ultimately leading to plant defoliation.

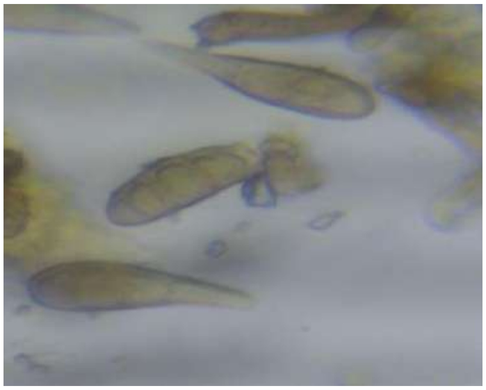

Figure 3 Conidia of *Alternaria tenuissima*

Figure 4 Alternaria leaf blight of groundnut

Leaf spot of cucumber caused by *Alternaria cucumerina* (*A. cucumerina*)

A. cucumerina primarily affects leaves, with symptoms occasionally extending to fruits. Initially, small (0.5 mm in diameter), brown-yellow lesions appear on old leaves near the crown, bordered by a light green to yellow halo. These spots gradually enlarge, coalesce, and form large necrotic brown areas, often showing concentric patterns. Many leaves eventually necrotize and die, leaving fruits vulnerable to sunburn. Stems and petioles remain unaffected.

On ripe fruits, concave and concentric lesions several centimeters in diameter may develop. These lesions are often covered with a dark olive-green felting consisting of *A. cucumerina*'s conidiophores and conidia. The fungus can also cause similar damage during the transport and storage of fruit, particularly affecting melons and squash.

Figure 6 Alternaria leaf blight of cucumber

Figure 5 Conidium of *Alternaria cucumerina*

Leaf spot of sunflower caused by *Alternaria helianthi* (*A. helianthi*)

The fungus induces brown spots on various parts of the host plant, including leaves, petioles, stems, sepals, and petals. On leaves, the lesions are dark brown with a lighter margin and a yellow halo. Initially small, they expand to approximately 2-3 cm in diameter and eventually merge to form irregularly shaped lesions. On stems, lesions appear as circular, elongated, or striated black spots. On sepals and petals, the spots resemble those on leaves but are smaller (0.5-2 cm in diameter) and coalesce. Infection leads to blight, defoliation, destruction of flowers and seed heads, wilting, stem cracking, and ultimately plant death.

Figure 7 Conidium of *Alternaria helianthi*

Leaf spot of chilli caused by *Alternaria alternata* (*A. alternata*)

Diseased leaves exhibit small round spots, typically measuring 0.5 to 2.0 mm in diameter (averaging 1 mm). These spots appear white to grey, with a sunken centre, and are surrounded by a dark brown edge and a chlorotic halo. Over time, these spots gradually enlarge and coalesce into larger, often circular or irregularly shaped lesions, some reaching up to 3 cm in length. The lesions on leaves are characterized by a dark brown to black coloration, often displaying concentric rings ranging from small dots to larger patches. Surrounding the spots, yellowing occurs, creating a halo effect. As the lesions continue to grow and merge, extensive damage to the leaves occurs, ultimately resulting in leaf withering, drying, and eventual drop. Additionally, *Alternaria alternata* has the capacity to infect chili stems and fruits, inducing similar lesions and decay symptoms. Plants affected by this disease may suffer from stunted growth and reduced fruit production due to leaf damage and decreased photosynthetic efficiency. In conditions conducive to fungal growth, dark-colored fungal spores (conidia) may be visible on the surfaces of the lesions, imparting a dusty appearance to the leaves.

Figure 8 Conidium of *Alternaria alternata*

Characterization of *Alternaria spp.*

Alternaria spp. produces olivaceous-brown conidia with a muriform shape, characterized by several horizontal and 2-4 vertical septations. The conidia feature a long beak and are arranged in chains. The mycelium is light brown, profusely branched, and septate. Microscopic examination revealed the germination of conidia.

Favourable conditions required for *Alternaria spp.*

Alternaria fungi thrive in warm and humid conditions. For many Alternaria species, temperatures between 20°C to 30°C (68°F to 86°F) are considered optimal for disease development. Additionally, high humidity levels, typically above 80%, further promote the growth and spread of Alternaria fungi.

Namakkal district falls under the North Western Zone of Tamil Nadu and experiences a predominantly semi-arid to arid climate with some variations. The region generally maintains high temperatures throughout the year. Summers can be hot, with temperatures often exceeding 35°C (95°F) and occasionally reaching above 40°C (104°F). Winters are relatively mild, with temperatures dropping to around 20-25°C (68-77°F). During the monsoon season, temperatures may decrease slightly due to increased cloud cover and precipitation, with daytime highs ranging from 30-35°C (86-95°F).

The North Western Zone receives moderate to low rainfall compared to other parts of Tamil Nadu. However, the region experiences a distinct wet season during the northeast monsoon (October to December), with most of the annual rainfall occurring during this period. Rainfall during the southwest monsoon (June to September) is comparatively less significant.

During the monsoon period, relative humidity levels tend to increase significantly due to increased moisture in the air from precipitation. Relative humidity during this time can range from 70% to 90%, creating a humid environment in the region, which correlates with the optimal conditions for Alternaria blight development.

Conclusion

In conclusion, the study highlights the significant threat posed by *Alternaria spp.* to agricultural productivity in Namakkal district, Tamil Nadu. The diverse manifestations of Alternaria-induced diseases in crops such as sesame, groundnut, cucumber, sunflower, and chili underscore the importance of understanding the symptoms, causative agents, and environmental conditions conducive to Alternaria infections. With Namakkal's semi-arid to arid climate and distinct wet and dry seasons, warm temperatures and occasional high humidity levels provide favorable conditions for Alternaria growth. Implementing effective disease management strategies tailored to these unique climatic conditions is essential for safeguarding crop yields and ensuring food security in the region.

Acknowledgement

The glass slides with Alternaria pathogens were examined under an Almicro compound light microscope, and the pictures were captured with the help of a Strange View electronic eyepiece, plant pathology laboratory, department of crop protection, PGP college of agricultural sciences, Namakkal.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

Article ID: AG-VO4-I05-50

PRUNING AND IT'S SPECIAL TECHNIQUES

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Introduction

Trees are typically pruned in two ways each year. A few branches or shoots that are deemed unwanted are cut off completely, leaving no stub behind. ***'Thinning out'*** is the term for this procedure. ***'Heading back'*** is the alternative procedure that entails removing the terminal portion of the shoots, branches or limb while keeping the basal portion intact. Bulk pruning is the process of thinning out large limbs, as in old and diseased trees.

Special Pruning Techniques

a. Root Pruning

It has long been known that cultivating dwarf fruit trees involves the use of root pruning. Every year, a sharp knife is used to chop off the roots, creating a circular trench 45 cm from the stem. The ditch is heavily filled with manures after pruning. The tree is thus fed and watered artificially in a restricted area. Because of this, the tree produces short, stocky, fully matured shoots and its circular network of fibrous roots grows extremely slowly every year. As the years pass, the circular ditches' diameter may gradually increase. Each year 4 to 5 cm of the stumps of the previous year growth are pruned. This aids to increase the production of mass fibrous root, dwarf the trees and bears abundantly.

b. Ringing

It is one of the methods that is known to help certain fruit crops to produce more fruit buds. A complete ring of bark is removed from a branch or the trunk throughout this procedure. Carbohydrates accumulate in the portion of the tree above the ring because ringing prevents them from passing *via* the phloem downward. Scoring the bark and inverting a ring of bark also accomplish the same effect. Mango ringing is done to force flowering on vegetative plants that don't typically produce enough fruit. This practice cannot be recommended for all fruit crops and it is found beneficial in promoting fruit set in certain vigorously growing grape varieties and they often result in large size fruits.

c. Notching

Notching is a partial ringing of a branch above a dormant lateral bud. The operation consists of removing a small narrow strip of bark just above and close to a dormant bud. Notching above a bud increases the yield of fig trees in Pune. Nothing aids in the production of a robust shoot in apples. By notching a bud, one can boost the availability of water and nitrogen from below through the xylem and prevent some substances from having an inhibitory effect on the bud. Carbohydrates are supplied through the phloem from above. It works well to initiate a flower shoot by notching below a bud. It lowers the amount of water and nitrogen coming from below and increases the concentration of carbohydrates in the bud.

d. Bending

In the Deccan, branch bending is a common method of improving guava fruit production, particularly in the erect growing varieties. Its large branches in their erect upright position have a natural tendency to produce fruit bearing shoots near the terminal portion, while their lower portions remain more or less dormant. The fruiting area is significantly enhanced when such huge branches are bent towards, tied to, and attached with similarly bent branches of the surrounding trees. This is because more lateral branches are created on the lower portions of the main limbs. Bending practice is not recommended to those varieties of guava in which the branches naturally spread obliquely and droop giving rise to side branches.

e. Smudging

It refers to the method of smoking mango trees, which is widely used in the Philippines for producing off-season crops. Burning branches and leaves that have fallen to the ground produces smoke, which is then allowed to enter the centre of the tree crowns. For a week, the tree is heavily and continuous smoked. As soon as the terminal buds from the previous season start to swell, smoking can be stopped.

f. Coppicing

This is the process of completely removing the trunk from trees such as Eucalyptus and Cinchona, leaving behind a 30 to 35 centimetre stump. After around six months, the coppiced stump begins to produce several vigorous shoots. Each stump only keeps two or three shoots; the remaining ones are entirely thinned out. These left out shoots attain coppicing stage in about 10 years depending upon the locations and other factors.

g. Containment pruning

High density plantations of temperate fruits use this kind of pruning. The primary objective is to maintain or confine the plant within the designated area without compromising its yield. Generally, this pruning method involves "heading back," although on occasion, extremely vigorous branches that commenced at the periphery are "thinned out." The plants are trained from the start to place the majority of their bearing wood, such as spurs and laterals, inside the tree's narrow canopy. Every year, 15 to 20% of the branches on these trees that have reached full bearing are removed from their periphery. In this way, within 5-6 years the whole of the periphery is renewed. Thus in a period of 11-12 years, the whole of the productive area of the tree will be renewed without affecting its productivity.

h. Disbudding

Disbudding is the process of removing undesired flower buds from a cluster in order to promote the growth of the remaining buds into a big, eye-catching, high-quality bloom. This technique is frequently applied to cut flowers, such as zinnia, dahlia, marigold, carnations and chrysanthemums.

i. Pinching

Pinching is a term used to describe the process of removing the terminal growing point of an herbaceous plant in order to produce more laterals or other side shoots. It is commonly used in flower crops such as carnation and chrysanthemums to reduce the plant's height and encourage axillary branching.

j. Pollarding

This is the process of cutting down the growing point of shade trees, particularly silver oak, to encourage the growth of side branches.

k. Lopping

This refers to the practice of reducing the canopy cover in shade trees in order to permit more light.

l. Alternate differential pruning

It describes the use of both mild and severe pruning methods to regulate the alternating bearing of some fruit species. Since the physiology of plant is different in "off and 'on' years of production, special type of pruning techniques is required to induce regular bearing in these plants. The aim of the "off year" is to promote the growth of numerous shoots while regulating the overproduction of flower buds. During the 'on' year, when there is excessive blossoming and formation of less number of fruit buds for the next year crop, the aim must be to reduce the number of fruit buds before the 'on year'.

Volume: 04 Issue No: 05

BIO MINERALIZATION – SIGNIFICANCE, CHALLENGES AND FUTURE PROSPECTIVES

Article ID: AG-VO4-I05-51

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Abstract

Collecting minerals inside or outside living cells is known as biomineralization, and it has major impacts on microbial biology, ecosystem dynamics, and technological development. Microbes are essential for mediating mineralization processes, affecting microbial diversity and the mobility of organic pollutants. Though biomineralization has possible advantages, including particle production and bioremediation, converting lab findings for commercial use presents challenges. In addition, more research is needed to determine if microbial nanorobots are suitable for use in biomedical applications. Future options for study include tissue engineering with materials generated from biological sources and targeted drug delivery. Solving these challenges and possibilities may improve our knowledge of biomineralization and its use in various technological and scientific fields.

Keywords: Biomineralization, Microbes, Environmental hazard and Nanoparticles

Introduction

The deposition of minerals inside or outside the cells of living things is called biomineralization. Examples include silicates in algae and diatoms, carbonates in diatoms and non-vertebrates, iron and gold deposits in bacteria and other unicellular creatures, and calcium phosphates and carbonates in vertebrates. This analysis focuses on the similarities and differences between the mechanisms involved in creating these deposits, but each case has some differences. Biomineralization, a significant development in the history of life, changed the functional biology, evolutionary path, and biogeochemical influence of many clades in plants, protists, and animals. The evolution of biomineralized structures probably benefited greatly from predation, but it also developed a range of other abilities, such as buoyancy, movement, grinding, reproduction, and the ability to sense light, magnetic fields, and gravity.

The significance of biomineralization in ecosystems

All microorganisms have the ability to affect the movement of inorganic contaminants by offering surfaces on which they can sorb, as demonstrated earlier. As previously indicated, the biominerals produced are not necessarily well bound to the cells, making it challenging to determine the precise amount of minerals precipitated by microbial mediation. The mobility of inorganic pollutants can be further impacted by specific types of bacteria catalyzing specific metabolic reactions by altering their speciation (e.g., redox state). These microorganisms can be recognized phylogenetically by cultivation-dependent or -independent methods with the provided challenges. The significance of biomineralization in the retention of inorganic pollutants is apparent, particularly in field sites where microorganisms' metabolic activity has been selectively promoted for the aim of bioremediation.

It has been demonstrated, for instance, that at both acidic and alkaline pH levels, the release of phosphate groups caused by phosphatase activity can significantly immobilize uranium in the form of autunite. When glycerol-3-phosphate is injected as the only supply of carbon and phosphorus, phosphatase activity can be increased. Yet, the relationship between a single enzymatic action and the precipitation of minerals is not always clear-cut, making it more challenging to determine how much microbes contribute to capturing inorganic contaminants. More naturally occurring instances of mitigating inorganic pollutants can be seen in acid mine drainages (AMD). Numerous bacterial strains, including acidophilic and neutrophilic Fe-oxidizing bacteria like *Acidithiobacillus ferrrooxidans* and neutrophilic and acidophilic Fe-oxidizing bacteria like *Thiomonas sp*., were found to have the potential to encourage the precipitation of Fe- and As-containing mineral phases. Furthermore, studies have shown that seasonal and regional differences in microbial populations may be related to changes in precipitated minerals. These findings suggest a potential relationship between the variety of microbes and the effectiveness of inorganic pollution sequestration.

The effect of biomineralization on microbial biology

Microbial diversity could significantly affect the extent to which inorganic pollutants are deposited. On the other hand, microbial communities might be impacted by biomineralization. Biologically induced biomineralization has been shown to be harmful to cells in numerous investigations. However, the same procedure is advised to develop resistance to the toxicity of these elements when inorganic contaminants like lead or uranium are present (Levinson *et al*., 1996; Mire *et al*., 2004). Cells may die due to biomineralization because it might cause cellular membrane breakdown or mineral phases to form, obstructing the exchange of nutrients between cells and their surroundings. The microbial community residing in these habitats may have evolved mechanisms to localize mineralization away from cells if this lethality is high, indicating that biomineralization is a major stress in some heavily mineralizing environments. As a result, some strains may be able to control biomineralization processes that may be considered to be a first approximation as being ‘‘biologically-induced’’. Assessing the lethality of biomineralization is not trivial and has been poorly addressed in various studies to date.

This finding implies that encrustation is not a significant source of stress in these cultures. One method to reconcile these findings is assuming that encrustation only occurs in dead cells and/or that encrusted cells build up over time due to their inability to be lysed while viable cells gradually shrink to a limited percentage of the total number of cells as determined by TEM. This illustration demonstrates how difficult it is to address how biomineralization affects cell viability. It is interesting to note that some studies have addressed the issue of the survivability of microbial cells trapped in mineral matrices. They have demonstrated that after several weeks of association with mineral matrices, more bacteria are still culturable in mineral gels than in an aqueous solution, and the bacteria's metabolic function may also be sustained. It remains to be determined whether this type of mineral matrix, which is typically silica gels, may be likened to nano-biominerals coating cells, but these investigations unmistakably highlight concerns regarding the potential effects of mineral phase precipitation on cell survival.

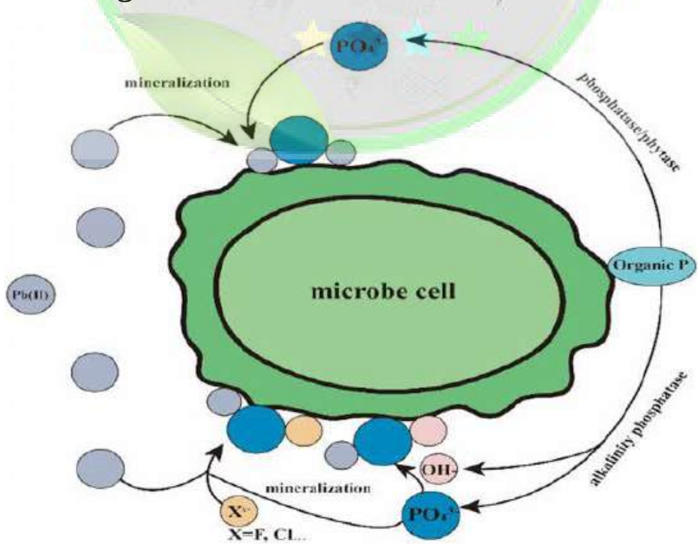
The Mechanisms of Mineralization Mediated by Microbes

In nature, biogenic mineralization can be either biologically caused or regulated. Cell metabolism leads to biologically induced mineralization, however the cells have no direct influence over the location or mode of precipitate production. Within separate compartments of a live organism, biologically controlled mineralization produces highly organized precipitates whose size, texture, and orientation are all regulated by the organism. These mineralization mechanisms are referred to together as "microbe-mediated mineralization" for convenience.

Extracellular and intracellular mineralization are two basic categories into which microbe-produced minerals can be divided. When a cell engages in extracellular mineralization, it creates an organic matrix outside or around the cell, which eventually becomes the mineralization site. The cell may actively pump cations into the intended mineralization site across the cell membrane. Alternatively, the cations may be concentrated inside the cell's vesicles, exported through the membrane and broken down in the matrix.

Microbe-produced minerals fall into two primary categories: extracellular and intracellular mineralization. An organic matrix is formed outside or around the cell during extracellular mineralization, eventually turning into the mineralization site. The cell may actively pump cations to the desired mineralization location across the cell membrane. An alternative scenario would be for the cations to be concentrated inside the cell's vesicles, exported through the membrane, and degraded in the matrix. The following are examples: i) oxygenic photosynthesis (such as Cyanobacteria); ii) ureolysis (such as *Bacillus sp.* that use urea as a nitrogen source); iii) ammonia oxidation (such as nitrifying bacteria); iv) nitrate reduction (such as denitrifying bacteria); v) ammonification of amino acids (such as soil Myxobacteria); vi) iron oxidation (e.g., iron-oxidizing bacteria). The biominerals might stay inside the cell or be transferred outside of it once they have been created.

Figure 1: Process of Biomineralization



Common mechanisms in biomineralization

Both vertebrates and invertebrates share biomineralization in a number of ways. It takes several steps for crystalline minerals, such as calcium phosphate, calcium carbonate, or iron oxide, to develop in an orientated pattern on a cellular extracellular matrix. The ions that will make up the crystal lattice must align properly for a stable structure to form during crystal formation. This stable structure is similar to the crystal phase that is forming. This "nucleation" process can be aided by either supplying surfaces that in and of themselves resemble the nucleus crystal (heterogeneous nucleation) or by raising the local ion concentration, which will increase the possibility of connection.

These surfaces may be found in the organic matrices of teeth, bones, and shells. As soon as the first crystals appear on these surfaces, crystals cluster, and crystal expansion happens as ions add to particular lattice positions. Foreign molecules not only give this surface to aid in the initial process of crystal formation, but they can also inhibit the growth of minerals by obstructing growth sites, which affects the size and shape of the created crystals. It is reasonable to expect that proteins that bind avidly and specifically to the crystal nucleus, stabilizing the nucleus and promoting growth, can bind to similar sites at higher concentrations and inhibit growth since these processes depend on stable interactions between the crystal and the protein.

Applications

Environmental application

Pollutants like radionuclides and hazardous metals pose environmental hazards. Using microorganisms for bioremediation is a crucial tactic to solve these issues. Toxic metals like strontium, nickel, chromium, lead, uranium, cadmium, arsenic, and cadmium from contaminated soil and aquatic environments have been immobilized and bioremediated via a process called microbe-induced carbonate precipitation (MICP). For most bacteria, high quantities of heavy metal ions are hazardous, leading to osmotic imbalance, disruption of oxidative phosphorylation, and nucleic acid derangement. However, some species of bacteria have developed complex intracellular and extracellular heavy-metal tolerance mechanisms to change these toxic metal pollutants into nontoxic or less toxic species.

Industrial Applications

Microbes offer innovative ideas for creating new materials for the transportation, storage, and concentration of energy. Microbe-mediated biomineralization has been applied to electrochemistry. Fungi-induced manganese carbonate precipitation has emerged as an innovative method for synthesizing electrochemical materials. When used in lithium-ion batteries, the carbonized fungal biomass–mineral composite shows good electrochemical performance and a high specific capacitance as a supercapacitor. One of the most typical instances of extracellular mineralization by single-cell organisms, microbe-induced calcite precipitation, is also acknowledged as emerging. Technology for subsurface engineering applications, such as altering a rock formation's permeability and utilizing the ureolytic bacteria *Sporosarcina pasteurii* for MICP to seal wellbore cement flaws. A wellbore is a hole bored to help in gas or oil exploration and recovery.

Biomedical Application

Compared to those physical and chemical means, metal nanoparticles generated via microbe-mediated mineralization are more biocompatible and less hazardous. Antibacterial solid properties are exhibited by microbe-based metal nanoparticles, which find significant uses in antibacterial surgical dressings, linings, and coatings for implants and other medical devices. Magnetic resonance imaging (MRI) is a frequently used imaging modality for clinical illness diagnosis because of its superior soft tissue contrast and spatial resolution. MRI contrast agents, such as iron oxide nanoparticles, can improve the contrast between healthy and sick tissues in the picture. Proton magnetic resonance absorption is increased by magnetic nanoparticles, which improves MRI sensitivity and specificity. The technique of magnetic hyperthermia is used to eradicate cancer cells. An alternating magnetic field melts iron oxide nanoparticles applied to malignancies. To apply a very concentrated thermal energy dosage.

Challenges and Opportunities for the Future

Since the beginning of life on Earth, microbes have played a role in producing minerals. From natural minerals to the creation of minerals within living beings, microbe-mediated mineralization encompasses a broad spectrum of processes, the study of which has accelerated since the year 2000. Microbes create biominerals, which are widely employed in various industries, including radioactive and heavy metal removal, building material cleanup, and diagnosing and treating diseases that are difficult to treat in humans. Toxic pollutants are often absent from metal nanoparticles produced by microorganisms, which is necessary for biomedical applications. Generating stable and pharmacologically active nanoparticles, otherwise necessary for synthesis based on physical or chemical processes, is typically not required for biogenic synthesis pathways. Still, there's a lot to learn and explore. A crucial obstacle to fully using the advantages of microbe-mediated mineralization is the conversion of scientific discoveries frequently made in lab settings into practical technological solutions that must be developed on an industrial scale. Scale-up attempts to handle many objects tend to diminish the level of control exercised at the single-object level, which is one of the issues related to this topic. Ensuring that the biological systems involved do not undergo significant changes when transitioning from laboratory-scale culturing settings to a production level relevant to industry is crucial.

Timely and cost-effective product introduction, along with high-quality nanoscale products, can only be ensured by a meticulously planned scale-up process. Another matter of concern is the biocompatibility of bacterial microrobots intended for application in biomedicine. Biomedical micro/nanorobots are intended for settings with complex biological processes and fluctuating physiological states. How these self-propelling micro/nanostructures interact with the human body is still unknown. At best, animal models are used to study the usage of magnetotactic bacteria as microswimmers; however, these models only offer qualitative data on cytotoxicity based on histological examinations. Understanding how foreign materials accumulate throughout the body and minimizing the dissemination of the supplied live bacterial microrobots to nontarget tissues, which could result in unintended and unexpected consequences, are essential for precision-targeted delivery. Micro robotic units are also expected to move independently to target the disease site. Compared to a single microrobot, the coordinated action of multiple nanorobots is beneficial for large-scale therapeutic processes or the delivery of therapeutic payloads. Adopting group communication and synchronized coordination algorithms at the nanoscale to improve the precision treatment capability is a difficult problem. Research on the difficult task of solving these problems is still in its early stages and needs to be accelerated before practical applications of these systems can be realized. In the future, there will be chances to use this knowledge to create medications or genes to treat illnesses where mineralization is compromised or excessive and to develop innovative biologically based materials (tissue engineering) to restore mineralized tissue that has already sustained damage.

Conclusion

In brief, biomineralization is an important step in advancing life, as it significantly impacts microbial biology, ecosystems, and technological development. The function of microbes in mediating mineralization processes is becoming better recognized. This includes the retention of inorganic contaminants and the production of stable mineral particles for biological purposes. Promising prospects exist for further research and innovation, despite continuing challenges in providing microbial technology's biodegradability in medicine and scaling laboratory findings to commercial applications. We could imagine new treatments, improvements in tissue engineering, and environmentally friendly remediation methods by exploring the mechanics of biomineralization and using its potential health. The relationship between life and minerals will grow more stable and connected as we keep finding the workings of biomineralization, which may have profound implications for human health and natural ecosystems.

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Volume: 04 Issue No: 05

SIGNIFICANCE OF ROLLING STEM APPLICATION ON COTTON CROP TO BOOST FARMERS INCOME

Article ID: AG-V04-I05-52

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Abstract

Cotton is a major commercial crop in Bharat, contributing for over 25% of world production. It is Telangana State's most significant commercial crop, covering an area of 44.92 lakh acres during kharif 2023. The lower prevalence of bollworms following the introduction of Bt cotton, minimum pesticide spraying was decreased. After the second most serious problem in cotton is sucking pests including thrips, white flies, aphids, and mealy bugs. These sucking pests devour plant sap from sowing until harvesting. To manage the problem of sucking pests, the rolling stem applicator (a new trending technology for treating sucking pests) is both cost-effective and ecologically friendly. By employing systemic insecticides, such as monocrotophos in a 1:4 ratio at 20 DAS (Prohibition) and imidacloprid 16.8% SL in a 1:20 (1ml chemical & 20ml water) apply with rolling stem applicator on upper stem portion (green area) of cotton plant at 40 and 60 DAS. Front Line Demonstrations (FLDs) on Rolling stem applicator at Bidekannna Village, Jharasangam Mandal, Sanga Reddy District, Telangana. When compared to farmer methods, rolling stem applicators provided 19.76 percent more precise outcomes. The study's findings revealed that farmers earned an additional Rs.17,260 in net income and a Rs.3,400/ha decrease in cultivation costs.

Key Words: Rolling stem applicator, Imidacloprid, Front Line Demonstrations, Bidekanna village

Introduction

Bharat is the only country that cultivates all four cotton species: *G. Arboreum* and *G.*

Herbaceum (Asian cotton), G. *Barbadense* (Egyptian cotton), and *G. Hirsutum* (American upland cotton). *G. Hirsutum* accounts for 90% of Bharat's hybrid cotton production. The present Bt cotton hybrids are all *G. Hirsutuim* cotton production in Bharat is primarily produced in nine major cotton-growing states divided into three agro-ecological zones:

1. Northern Zone (Punjab, Haryana, and Rajasthan).
2. Central Zone (Gujarat, Maharashtra, and Madhya Pradesh).
3. Southern Zone (Telangana, Andhra Pradesh, and Karnataka).

#Chemical applying with rolling stem applicator only on upper stem portion (green area) of plant

Bharat ranks second in the world, with an expected production of 343.47 lakh bales (5.84 million metric tonnes). During the 2022-23 cotton season, 23.83% of the world's 1441 lakh bales (24.51 million metric tonnes) were produced. Bharat consumes 311 lakh bales (5.29 million metric tonnes) of cotton, accounting for 22.24% of the world's total consumption of 1399 lakh bales (23.79 million tonnes). Telangana is Bharat's major cotton growing state, ranking third in area and production after Maharashtra and Gujarat. In Bharat, there are around 162 insect pest species in the cotton ecosystem, with a monetary value based on predicted production. Insect pests cause estimated losses of Rs 3,39,660 million yearly. The primary bollworms include pink bollworm (*Pectinophoragossypiella*), American bollworm (*Helicoverpa armigera*), and Spotted bollworm (*Earis spp*.). Boll guard technology (Bt) introduced in 2002 boosted cotton yield, reduced insect pest losses, and reduced the need for insecticides. Although transgenic Bt cotton can efficiently manage particular Lepidopetrous species, it lacks resistance to sucking insect pests results highly damaged the crop. Farmers Spraying insecticides and mixtures (e.g., acephate, monocrotophos (Prohibition), imidacloprid, thiamethoxam, acetamiprid) 6-8 times. Spraying crops as early as 20-25 days will significantly reduce beneficial insects, leading to a rise in sucking pests and the need for more applications and burden cost of cultivation increase to farmers.

FRONT LINE DEMONSTRATIONS (FLDs) ON ROLLING STEM APPLICATOR IN BIDEKANNNA VILLAGE

During my RAWEP (Rural Agricultural Work Experience Programme), EL-NINO circumstances occurred during the monsoon season, causing inconsistent rainfall and droughts. These conditions impact on cotton farmers is investing more to combat sucking pest infestations. To support farmers, we conducted Front Line Demonstrations (FLDs) at Bidekannna Village, Jharasangam Mandal, Sanga Reddy District, Telangana. Rolling Stem Application is an alternative method for controlling sucking pests in cotton. Imidacloprid 1:20 (1ml chemical & 20ml water) and applied with rolling stem applicator on upper stem portion (green area) of cotton plant in 40 and 60 days after sowing. Cotton aphids, thrips, Jassids, white fly, mealy bugs and other cotton sucking pests can, effectively managed. When compared to farmer methods, rolling stem applicators provided 19.76 percent more precise outcomes. The study's findings revealed that farmers earned an additional Rs.17,260 in net income and a Rs.3,400/ha decrease in cultivation costs.

#Conducted a demo on how to usage of rolling stem applicator to farmers

EQUIPMENTS

1. 4-Inch Medium-Density Foam Paint Roller along with handle.
2. 1-meter wooden stick or plastic stick. (Based on comfortable to farmer)
3. Standard gloves.
4. Plastic tub/Gamela.
5. Monocrotophos, Imidacloprid (16.8% SL).

Hand Gloves are Mandatory while mixing of chemicals during application times

Results of Rolling Stem Applicator in Cotton Crop

Sl. No	Specification	Rolling Stem Applicator
1.	Insecticide quantity per hectare.	Imidacloprid – 200 -250 ml. Approximately.
2.	No. of labour required/ ha	4-5
3.	Area covered/day (6 hr)	1.6-2.4 ha

4.	Money spent on pesticide/ha	Rs.400/-
5.	Drift losses	No
6.	Amount of water needed / hectare.	1000-1250 ml
7.	Required time/ha.	3-4 hr
8.	Toxicity to natural enemies	Negligible
9.	Environmental pollution	Nil
10.	Inhalation of pesticide while application.	Negligible
11.	No. of plants covered/hour	500-600
12.	Ease of application.	Very easy and comfortable

fluctuating of prices dependent on location and availability

BENEFITS OF USING ROLLING STEM APPLICATOR IN COTTON

- Decreases of sucking pest population and increases of beneficial insects.
- The method is useful in areas with severe water shortages since very little water is used.
- Only 4 or 5 labour is required per hectare.
- Neither specialized knowledge nor pricey equipment is needed.
- Natural enemies are unaffected by the chemical since it is not exposed to the winds
- The applicator is light and does not require slinging over one's shoulder, so there is no drudgery. No more burden to farmers.
- Saving insecticide while hand spraying loses chemical because of spread and higher water needs, the chemical will be absorbed into the sponge and given to the plant straight.
- There is no environmental pollution since the chemical is not exposed to the environment, results to develop good health conditions to farmers.
- Very little amount of money is spent since not much chemical is utilized.
- A higher cotton yields and boosting farmers income.

Conclusion

The expense of agriculture will grow day by day and become more burdensome for small and marginal cotton farmers. Rolling stem applicator since it is very simple to use and apply, poses little risk to people, Eco friendly and no harmful to beneficial insects. The study's findings revealed that farmers earned an additional Rs.17,260/ha approximately in net income and a Rs.3,400/ha decrease in cultivation costs which benefits the poor small and marginal farmers.

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Volume: 04 Issue No: 05

BENEFICIAL HONEYBEE HIVE BYPRODUCTS AND THEIR USES

Article ID: AG-VO4-I05-53

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Introduction

Honeybees are one of the most useful insects for human beings. Besides honey, which is a nutrient-rich elixir for life, bees produce several other products that are equally, if not more, useful for humans. The bee by-products like beeswax, bee pollen, royal jelly, propolis, bee venom, bee bread, and honeycomb are all produced by bees for various purposes. Since ancient times, people all over the world have been using these products to treat illnesses, and they continue to be the go-to options for boosting immunity the natural way during the COVID-19 pandemic. Apitherapy or alternative therapy using products derived from honeybees was practiced by ancient Egyptians, Greeks, Romans, and Chinese, among others. Conditions like arthritis, allergies, immune or neurologic diseases, thyroid, gingivitis, etc., were commonly cured using bee products.

Over the years, various pieces of research have proved the medicinal and healing properties of these products. Let's take a detailed look at each of them and their varied benefits.

Beeswax:

Worker bees secrete wax from their abdominal glands from a young age for building the walls of the honeycomb and sealing the cells filled with honey to preserve it. Freshly prepared beeswax is white, but it turns yellow with time due to the presence of pollen and propolis colorants in it. Beeswax contains various compounds like hydrocarbons, esters, and free acids.

Over the years, this bee by-product has proved to be a beneficial component for medicines, cosmetics, and haircare products.

Benefits

Beeswax is a great moisturizing agent with anti-allergic and anti-inflammatory properties. It soothes irritated skin and is, therefore, used as an ingredient in applicants for healing eczema and rosacea. It is also used in hair care products as it moisturizes hair, reduces hair loss, and helps stimulates growth. It helps hair retain moisture for a long time. Beeswax forms a layer on your skin to protect it from environmental irritants during extreme weather conditions. The by-product also has properties for relieving pain. Candles, lip balms, and salves made of beeswax are quite popular. It is used in aromatherapy as well.

Royaljelly:

Nurse bees secrete royal jelly from their hypopharynx glands to feed the larvae and the adult queens. It is white, brown, or gray to yellow and has a sour taste due to low pH. The gelatinous and viscous substance that becomes compact over time contains various minerals, vitamins, carbohydrates, amino acids, fatty acids as well as sugars like glucose and fructose.

Benefits

Royal jelly fights anemia and lagging development in children. It helps treat viral infections, depression, anxiety, constipation, hypertension, diabetes, malnutrition, hormonal imbalances, and many more diseases in adults. This by-product has antibacterial, antioxidant, antifungal, antimicrobial, and anti-inflammatory properties. It is also beneficial for the immune system. It can directly be applied to stimulate the skin and the scalp and speeds up the process of wound healing. The jelly-like bee product is also recommended for curing symptoms related to menopause and PMS.

Propolis:

One of the most popular bee products, propolis, is a mixture of resins collected from flowers and leaf buds and beeswax. Bees use it to line the insides of the nest cavities and brood combs as well as to seal cracks within the hive. They also use propolis to seal dead animals that they cannot remove and mix it with beeswax to shut the brood cells. A significant product for the bees, its antifungal and antibacterial properties help protect the colonies from diseases and infections and restrain the growth of decomposing bacteria. The color, composition, odor, and medicinal properties of propolis may vary as per the regions, seasons, and plant species around the hives. It boasts a variety of vitamins, minerals, flavonoids, fatty acids, polysaccharides, and polyphenols, among other things.

Benefits

Propolis is a natural antioxidant with antibacterial, antifungal, and antiviral properties. It is used in medicines to cure inflammation, boost immunity, and reduce free radicals. It is a common ingredient in cosmetics and skin applicants due to its ability to help regenerate tissues. The by-product is also known for treating the cardiovascular system, respiratory infections, dental problems, wounds, burns, digestive problems, and more. Propolis also has some immune-boosting properties.

Beepollen:

Honeybees tend to collect pollen from the flowers and bring them back to their hives, which is then enriched with their hormones and digestive enzymes. Bee pollen is basically a mixture of various substances like nectar, pollen, wax, honey, enzymes, and other bee secretions. The final product is used as food for the bee colony. This highly nutritious bee by-product stored in the form of tiny balls contains various active substances as well as nutrients, amino acids, lipids, and vitamins.

Benefits

Bee Pollen is rich in all the nutrients that humans need, making it a highly nutritious superfood. Containing vitamin B12, it boasts antiviral and antibacterial properties. The by-product is also used for lower cholesterol levels and strengthening capillaries. Active enzymes found in bee pollen help us fight multiple diseases like cancer, diabetes, asthma, arthritis, and skin conditions like rash, eczema, and hives. Bee pollen is useful in boosting fertility, managing weight as well as strengthening immunity. It is frequently given to children to aid their physical and brain development.

Bee bread:

Bee bread is a source of protein produced by honeybees for the larvae and young ones. A mixture of pollen, lactic ferments, and honey is prepared and sealed within the cells of the honeycomb that turns into bee bread roughly after three months of fermentation. Like most other bee products, this by-product, too, contains vitamins, minerals, enzymes, lactic acid, and amino acids, among other things. Bee bread stored carefully at room temperature tends to retain its beneficial properties for a very long time.

Benefits

A great source of energy, bee bread has detoxifying properties along with the ability to increase hemoglobin and boost energy. It is an immune-boosting product recommended for children and people with mineral and selenium deficiencies. Bee bread also reduces appetite, helps with weight management, and regulates cholesterol and triglycerides. This bee by-product is known for treating liver disorders, intestinal problems, and constipation.

BEEVENOM:

Bee venom has been used for thousands of years as a traditional medicine in various parts of the world. This colorless substance is acidic in nature and is excreted through the bee stingers. It contains enzymes, sugars, amino acids, and minerals, along with inflammatory and anti-inflammatory compounds. The peptides found in the bee venom do act like toxins, but they also possess pain-relieving and anti-inflammatory properties. Some of the enzymes in this by-product also show immune-protective properties.

Benefits

Bee venom immunotherapy is given to people who are allergic to bee stings. It highly reduces the chances of getting a reaction for about a decade. Some clinical trials have proved that bee venom can treat inflammatory skin conditions like psoriasis. It is believed to be beneficial for treating pain. Apipuncture, which is a form of acupuncture, is being tested for drug-free pain relief. Some of the other diseases that bee venom can treat include arthritis, Parkinson's disease, and frozen shoulder, among others.

HONEYCOMB:

Honeycomb is the home that honeybees build to store their honey, bee products, and their young ones. Constructed using propolis and beeswax, it features hexagonal cells that are filled with honey, bee pollen, bee bread, or royal jelly. This hive product is edible, including its waxy cells. Rich in carbohydrates and antioxidants, the honeycomb features pure, unfiltered honey intact with all the natural goodness, enzymes, and antioxidants. Considering that it contains all the beneficial bee products, it is quite a healthy product to eat.

Benefits

As honeycomb contains the goodness of all the bee products, it helps keep your heart healthy.Most of the bee products are antibacterial, antifungal, antimicrobial. Thus, honeycomb can help you keep infections at bay. Apart from honey, honeycomb can replace sugar in beverages, too. Honeycomb can also be consumed to cure respiratory tract infections and cough in children as its main ingredient is honey.

BEE BROOD:

Harvest recently capped worker pupae by uncapping and shaking into pan. Pickle or cook rapidly. Pupae are the highest in protein when compared to the eggs and larvae, and have protein content equivalent to that of beef or poultry. Brood is rich in carbohydrates, dietary minerals, B vitamins, vitamin C, vitamin D, saturated fat, monounsaturated fatty acids and polyunsaturated fatty acids.

BEEHIVE AIR:

Becoming more popular, natural therapist have included the ability to inhale beehive air. This is done by attaching a hose and mask to the cover of the beehive then the patient will sit inhaling the air circulated in the hive. We can't say we have ever tried inhaling beehive air directly with a mask but there seems to be results for asthma sufferers. Beekeepers will tell you the smell of a beehive especially when bees are on a honey flow, can be quite pleasant and unlike anything in nature.

MEAD:

Simply put, it is honey wine. It is the first alcoholic drink brewed by men, earlier than wine or beer. Today mead has evolved and expanded its flavors to include fruits such as blueberry and cherry, malt as well as various herbs and spices. Bees can also be supplied for aiding in pollination in various crops. Nucleus colonies (NUC), Packages, Queens, Brood, Full Colonies can also be supplied to new apiaries.

Volume: 04 Issue No: 05

NUTRIGENOMICS AND ITS APPLICATION IN SHELLFISH AQUACULTURE

Article ID: AG-V04-I05-54

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Abstract

This article explores the impact of diet and nutrients on gene expression in crustaceans, focusing on growth, molting, lipid metabolism, antioxidant defenses, immunity, and reproduction. Proper nutrition is essential for crustacean development, and research indicates that dietary components can modulate gene expression related to these crucial processes. Nutritional interventions, such as prebiotics, Chinese herbs, and dietary lipids, have been shown to influence gene expression in crustaceans, impacting their growth, immune response, antioxidant capacity, and reproductive performance. Understanding the molecular mechanisms underlying these effects is vital for optimizing crustacean diets and improving aquaculture practices. Further research using omics techniques is needed to fully elucidate the gene-nutrient interactions in crustaceans, enhancing their growth and spawning rates for sustainable aquaculture practices.

Keywords: Nutritional requirements, Gene expression, Crustaceans, Aquaculture and Nutrigenomics

Introduction

Diet and feed ingredients are significant challenges in aquaculture, accounting for a substantial portion of operating costs. The growth and development of aquatic animals, including crustaceans, depend largely on the availability and quality of their diet. These animals require various essential nutrients, classified into macro- and micro-nutrients. Macro-nutrients are needed in larger quantities and can be derived from plant and animal sources, while micro-nutrients are required in smaller amounts. Both types of nutrients are crucial for the growth and metabolism of crustaceans. Proper diet and nutrient intake play key roles in enhancing development, growth, reproductive performance, larval quality, stress tolerance, disease resistance, immune function, intestinal health, and overall gut health in finfish and shellfish. Research studies and feeding trials in aquatic organisms have revealed that nutrients play a significant role in modulating gene expression at the cellular level. This modulation of gene expression directly impacts the overall physiological functions of crustaceans, including immunity, growth, reproduction, and molting (in crustaceans).

Nutrigenomics

Nutrigenomics investigates how diet influences gene expression, aiming to understand how nutrition impacts health. It uses genomics, transcriptomics, proteomics, and metabolomics to study these interactions. Nutrigenomics has advanced our understanding of nutrition-related diseases and improved recommendations for aquatic organisms' nutrition, affecting growth, metabolism, reproduction, and immunity. Nutrients can affect gene expression through signalling pathways, influencing transcription rates. This field also has applications in studying aquatic microbial populations and optimizing feed for aquaculture. Nutrigenomics may eventually lead to personalized dietary recommendations based on genotype, but it is still evolving.

Applications of Nutrigenomics in Aquaculture

The scientific approach is crucial in advancing the aquaculture industry, and nutrigenomics tools are particularly important. These tools have specific applications in understanding and addressing nutritional deficiencies in various growth stages of finfish and shellfish. Nutrigenomics can help study how fish respond to nutrients, develop diets based on nutrient acceptance, understand cellular responses to nutrients, establish sustainable hatchery protocols, identify metabolic changes in response to environmental factors, and determine organ and tissue-specific nutrient requirements. Nutrigenomics tools have the potential to address these challenges in aquaculture.

Application of nutrigenomics in Crustaceans

1) Influence of the nutrients on expression of growth and molting-related genes

A well-balanced nutritional diet and suitable water quality are essential for crustacean exoskeletons' rapid growth and hardening. Feeds and feedstuffs provide the necessary energy for growth, reproduction, and health. Studies show that diverse diets, including live feed or single sources with varied ingredients, can modulate growth and molting in aquatic animals. The mRNA expression profiles of growth and molting-related genes in crustaceans can vary in response to different nutrients and feed additives.

A recent study investigated the effects of dietary prebiotics, specifically arabinoxylan-oligosaccharide (AXOS) and inulin, on the expression of growth-associated genes in *Littopenaeus vannamei* shrimp. The study found that supplementation with either AXOS or inulin at 4 mg/g diet resulted in the highest growth stimulation and increased expression of growth-linked genes such as cathepsin L, chitinase, chymotrypsin, and extracellular signal-regulated kinase (*erk*) genes. Additionally, simultaneous supplementation of both prebiotics for eight consecutive weeks significantly improved shrimp growth indices and gene expression compared to a single prebiotic application (Li *et al.*, 2021).

During the molting process of crustaceans, the ecdysone receptor (*EcR*) forms a heterodimer with retinoid X receptor (*rxr*), affecting downstream genes in the ecdysteroid signaling pathway. Studies have shown that the mRNA expression levels of the *EcR* gene in mud crab (*Scylla paramamosain*) juveniles were slightly decreased with increasing dietary protein levels up to 42.92% and then increased noticeably when dietary protein levels increased to 52.09%. Despite these findings, information about the impact of nutrients and feed additives on growth and molting-related gene expressions in crustaceans remains limited (Zheng *et al.*, 2020). Further research is needed to understand the potential influences of these elements on genes associated with growth and molting in crustaceans.

2) The influences of nutrients on the expression of lipid metabolism-associated genes

Variations in lipid metabolism-associated enzyme gene expression can lead to different responses due to dietary fatty acid composition differences. Key transcription factors and enzymes involved in lipogenesis and lipolysis, such as lipoprotein lipase (*lpl*), fatty acid synthase (*fas*), sterol regulatory element-binding protein 1 (*srebp1*), and carnitine palmitoyltransferase I (*cpt1*), play significant roles. Long-chain fatty acid transporters (lcfat) like scavenger receptor B2 (*SR-B2*) and fatty acid-binding protein (*fabp*) are also important for fatty acid transportation. The hepatopancreas in crustaceans is crucial for food absorption, nutrient storage, and metabolism, particularly for lipids. It stores energy-supplying nutrients, including lipids, for various physiological processes such as ecdysis, hunger, reproduction, and limb regeneration.

The mRNA transcripts of lipid metabolism-associated genes in the hepatopancreatic tissues of *S. paramamosain* fed diets with different n-3 PUFA lipid sources showed significant variations. Crabs fed with krill oil (KO) had higher expression levels of *fas* and *6gpd* genes compared to those fed linseed oils (LO). KO-fed crabs also had higher expression levels of *hsl* and *cpt1* genes, while LO-fed crabs had lower *hsl* gene expression. KO-fed crabs exhibited higher expression levels of *srb2, srebp1*, and *hnf4α* genes than those fed fish oil (FO) or LO-based diets (Li *et al.,* 2021). Additionally, in the same crab species, administering n-3 LC-PUFA at different dietary lipid levels and DHA/EPA ratios stimulated the expression of *fas, aco3,* and *fatp4* genes, while *cpt1, hsl*, and *ldlr* genes were downregulated, particularly in crabs fed a 7% lipid diet with a higher DHA/EPA ratio (Wang *et al.*, 2021).

In crustaceans, the intestine is responsible for dietary lipid assimilation. Dietary n-3 PUFA, particularly DHA and EPA, can inhibit the proteolytic processing of srebp1 and decrease *fas* gene expression. However, *srebp* gene expression may increase with diets high in soybean oil (SO), indicating a need for increased cholesterol biosynthesis. In red swamp crayfish, dietary lipid sources can affect the expression of lipid metabolism-associated genes such as *fas, srebp1*, and *rxr*, with fish oil (FO)-based diets decreasing their expression and certain vegetable oils increasing it (Gao *et al.*, 2020).

3) The influences of nutrients on the expression of antioxidant-associated genes

Dietary application of dry marine red yeast (*Rhodosporidium paludigenum*) significantly increased the expression levels of antioxidant-related genes, such as *Mnsod* and *cat*, in the hepatopancreas of *L. vannamei*. Additionally, the expressions of *Mnsod* and *ferritin* genes were more significant in the live yeast group than in the basal diet (Yang *et al.,* 2013).

Astaxanthin influences colouring and has additional benefits on shrimp growth, immune responses, reproduction, stress tolerance, survival, and disease resistance. Dietary supplementation with astaxanthin significantly influences the transcription of antioxidant-related enzymes in *L. vannamei* (Wang *et al.*, 2015).

Chlorogenic acid (CGA) has various biological functions, including anti-inflammatory and anti-carcinogenic activities, with stronger antioxidant activity than ascorbic acid and vitamin E. CGA scavenges superoxide radicals effectively, inducing strong antioxidant reactions and increasing antioxidant production. In *L. vannamei*, diets supplemented with CGA led to significantly higher *gpx* gene expression levels than the control group. However, there were no statistically significant differences in the mRNA expression level of the cat gene between the control and CGA-treated groups at 100 and 200 mg/kg feed. Interestingly, adding 400 mg/kg CGA to the diet significantly decreased the mRNA expression of the *cat* gene after 56 days (Wang *et al*., 2015).

4) The influences of nutrients and feed supplements on the expression of immune-associated genes

Based on the carbohydrate chain length, Prebiotics can be divided into polysaccharides and oligosaccharides. Various oligosaccharides, such as galactooligosaccharides, arabinoxylan-oligosaccharides (AXOS), fructooligosaccharides (FOS), xylooligosaccharides, and mannan oligosaccharides (MOS), have been effectively used to enhance the growth performance and immunity status of crustaceans. In a recent study by Li *et al*. (2021), it was found that the hemolymph of *L. vannamei* fed diets containing a combination of arabinoxylan-oligosaccharide (AXOS) and inulin showed significantly higher expression levels of immune-related genes like *erk*, *MyD88*, and *po* compared to diets with either AXOS or inulin alone, as well as compared to the control group, after an 8-week feeding period.

Angela et al. (2020) found that treating *L. vannamei* with Chinese herbs like *Astragalus membranaceus* and *Bupleurum chinense*, either alone or in combination, significantly affected the expression of *imd* and *tlr* genes in the shrimp's gills. Another study showed that feeding *L. vannamei* with a combination of two *Bacillus subtilis* strains (L10 and G1) upregulated the expression of immune-associated genes. Both diets supplemented with *B. subtilis* increased the expression of *proPO, pe, sp,* and *lgbp* genes in the entire body after 55 days of feeding and experimental infection with *Vibrio harveyi* (Zokaeifar *et al.*, 2012).

Shrimp fed diets containing mannan oligosaccharides (MOS) and inulin showed significantly increased mRNA expression levels of immune genes, including *proPO, tlr1, tlr2, tlr3, crustin,* and signal transducer and activator of transcription (*stat*) genes. The extent of this expression change depended on the concentration of the prebiotics in the diet. Additionally, the expression of these genes was significantly upregulated in shrimp fed MOS and inulin diets after exposure to white spot syndrome virus (WSSV) and *Vibrio alginolyticus* (Li *et al.*, 2018).

After a feeding experiment with different amounts of dietary starch, the relative mRNA expression levels of immune-related genes such as *adam10, ilf2, il-16, litaf,* and *relish* were increased in crab intestines. The highest expressions of *il-16, ilf2, adam10*, and *relish* genes were observed in crab groups fed 32% dietary starch. These results suggest that beyond a certain quantity of dietary starch, the expression of pro-inflammatory factors in crab intestines may enhance the inflammatory response (Li *et al*., 2017).

5) The influences of nutrients on the expression of reproduction-associated genes

Understanding species-specific nutritional needs is crucial for crustacean growth and spawning success, especially for broodstock. Broodstock diets, particularly lipid and fatty acid composition, are vital for reproductive success and offspring survival. Certain species can incorporate dietary unsaturated fatty acids into eggs, aiding in reproduction. Vitellogenin (*Vtg*) is an egg yolk precursor providing nutrients to embryos. Fatty acid-binding proteins (FABPs) transport fatty acids and are important during rapid ovarian growth in crustaceans, with *fabp* gene expression varying with ovarian development. Dietary lipid sources affect the expression of reproductive-related genes; for example, crayfish fed soybean oil had the highest *Vtg* expression, about 8-fold higher than controls, while fish oil-fed crayfish had the second-highest expression, about 3-fold higher than controls (Li *et al.*, 2011). Ding et al. found that dietary SL levels significantly influenced the expression of hepatopancreatic *fabp1* and *Vtg* genes in *Portunus trituberculatus*, suggesting positive impacts on ovarian development (Ding *et al.*, 2017). While many studies have investigated the effects of nutrients on the reproductive system's development, more research using omics techniques is needed to understand the gene expression changes induced by these nutrients in other crustaceans.

Conclusion

The growth, immunity, antioxidant capacity, and reproductive performance of crustaceans are significantly influenced by their nutritional status and dietary components. This article explores the current literature on how proper nutrition affects the expression of genes related to growth, molting, lipid metabolism, antioxidant defenses, immunity, and reproduction in crustaceans. Existing studies highlight the intricate relationship between nutrients, feed additives, and the molecular mechanisms governing crustacean productivity. However, further research is needed to fully understand the nutritional requirements of broodstock and how diet influences gene expression related to reproduction in decapod crustaceans. In conclusion, investigating nutrigenomics in crustaceans is essential for enhancing growth and spawning rates in aquaculture, ultimately contributing to the sustainability of the crustacean industry.

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AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

CONNECTED AGRICULTURE: HARNESSING INTERNET OF THINGS (IOT) FOR SMART FARMING

Article ID: AG-VO4-I05-55

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Abstract

Smart farming is a technological advancement that focuses on the use of information and communication technologies in machinery, equipment, and sensors to monitor and manage farms efficiently. The integration of innovative technologies such as the Internet of Things (IoT) and cloud computing is expected to stimulate expansion and facilitate the use of robotics and artificial intelligence in the agricultural sector. These revolutionary deviations are causing unease in current agricultural practices, while also posing a variety of obstacles.

Key words: Smart farming, Internet of Things, Technology, Agriculture

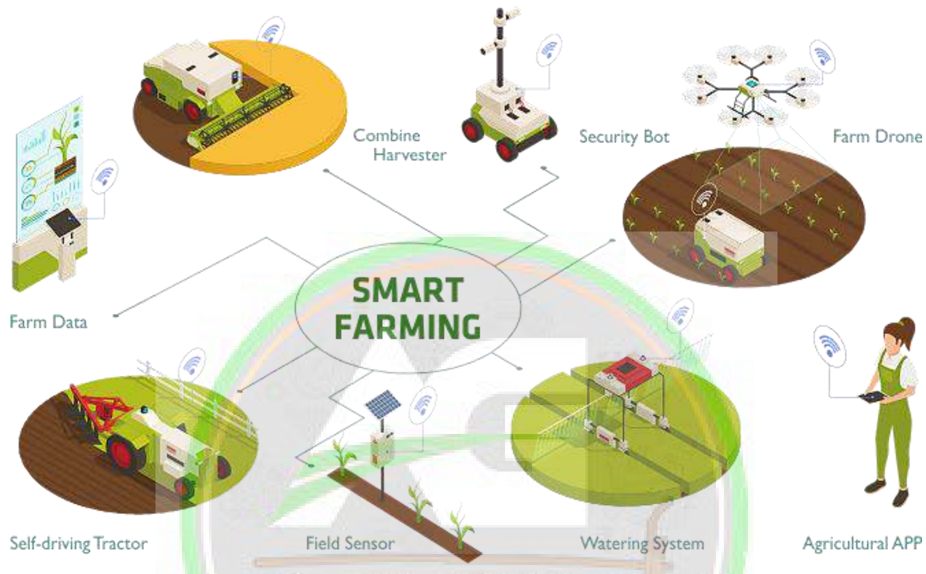
Introduction

In the past, farming aimed growing food on cultivated ground so that people could stay alive and animals could breed (Tekinerdogan *et al.*, 2018). This time period was known as the "traditional agricultural era 1.0." Mostly, this was done with people and animals. Simple tools like sickles and shovels were used for farming. Since most of the work had to be done by hand, output stayed low. At the beginning of the 19th century, new types of farm equipment called steam engines came out. The widespread use of farming equipment and a lot of chemicals by farmers marked the beginning of the second agricultural era, which made farmers and farms more effective and productive. At the same time, though, very bad effects like chemical pollution, damage to the environment, waste of natural resources and overuse of energy began to happen. Due to the fast growth of computers and technology in the 20th century, the agricultural era 3.0 began.

Robotics, programmed agricultural machines, and other technology have improved agricultural efficiency. Work allocation, accurate irrigation, reduced chemical usage, focused nutrient delivery, and effective pest management technologies solved agricultural era 2.0 problems and adapted policies to era 3.0. Agriculture 4.0 uses IoT, big data, AI, cloud computing, and remote sensing. New technologies have made sensor and network platforms inexpensive, improving agriculture. These platforms improve production efficiency, water and energy efficiency, and environmental effect (Pastor *et al.*, 2016). Agriculture technology, especially the Internet of Things, has changed farming (Quy *et al.*, 2022). ICT optimizes farm labour and improves product quantity and quality in modern smart farming. Farmers' demands are identified and solved using modern ICT like the Internet of Things, GPS, sensors, robotics, drones, precise equipment, actuators and data analytics. Advances boost agricultural productivity and judgment accuracy. International organisations and underdeveloped nations promote smart farming technologies to increase agricultural output (Kumar *et al.*, 2021). Sensors track crops throughout their life cycle, finding issues early. Modern agriculture uses smart seeding, harvesting, storing, and transportation. Using many sensors boosts output and profits. Regional agriculture is possible with internet-connected sensors that quickly collect data for study. In agriculture, smart agriculture and monitoring address soil, climate and moisture challenges. These methods attempt to boost agricultural productivity, spatial management, and fertilizer and pesticide use (Nahry *et al.*, 2011). The ANN models in smart irrigation water management (SIWM) models regulate irrigation scheduling support systems (DSS) manage irrigation scheduling support systems (DSS) and provide real-time irrigation efficiency, water productivity index, demand and supply data. CSA enhances food security, farming system resilience, and greenhouse gas emissions, making it promising in developing nations (Palombi *et al.*, 2011). Smart agriculture uses IoT for real-time irrigation monitoring, plant protection, product quality improvement, fertilizing and disease prediction (Adamides *et al.*, 2021).

What are Internet of Things?

The Internet of Things (IoT) is an emerging technology that enables objects to establish remote connections in order to facilitate intelligent farming (Patil *et al.*, 2016). The Internet of Things (IoT) is having a significant impact on various industries, including healthcare, commerce, telecommunications, energy and agriculture. Its purpose is to improve efficiency and performance across all sectors (Sisinn *et al.*, 2018). Existing applications offer insights into the impacts of the Internet of Things (IoT) and the practices that have not yet been witnessed. With the progress of technology, it is clear that IoT technologies play a vital role in various farming activities. This includes using communication infrastructure, collecting data, using smart objects and sensors, utilizing mobile devices, accessing intelligent information stored in the cloud, making informed decisions and automating agricultural operations.



Global Positioning System (GPS):

GPS precisely captures data on latitude, longitude and elevation. GPS satellites emit signals that enable GPS receivers to calculate their real-time location and offer uninterrupted positions during movement. The precise location information provides farmers with the option to determine the exact position of field data, including insect occurrence, soil type, weeds and other obstacles. The system enables the identification of different field locations in order to subsequently administer the required inputs (such as seed, fertilizer, herbicide, insecticide and water) to a specific field (Batte *et al.*, 1999).

Sensor Technologies:

Photovoltaic, electromagnetic, conductivity and ultrasound measure soil texture, structure, nutrition, vegetation, humidity, vapour, air, temperature and more. Remote sensing can detect crops, pests, weeds, soil and plant stress, and drought (Chen *et al.*, 2004). Soil moisture, nutritional availability, light, humidity, rainfall and leaf colour affect plant health. Plants are monitored by micro-irrigating and controlling temperature and light. Sensors measure many factors. When the sensor detects a change above a limit, the microcontroller acts to restore the parameter to its optimal level. Sensors measure temperature, humidity, soil pattern, airflow, location, CO_2, pressure, light and wetness. Sensors excel in reliability, memory, mobility, durability, coverage and computational efficiency for agricultural applications (Muhammad *et al.*, 2020). Present wireless sensors are essential for crop data and more. Independent sensors can be integrated into high-tech agricultural and heavy machinery, depending on the application.

Geographic Information System (GIS):

The GIS consists of specialized hardware and software that are specifically designed to compile, save, retrieve, analyse and make maps using location data. It is also capable of analysing characteristics and geography for statistical and spatial analysis purposes. The GIS database contains data on several aspects of farming fields, including soil types, nutrient levels, topography, irrigation, drainage, chemical treatments and crop production. It also helps to determine the connections between different factors that influence crop growth on specific fields. In addition to storing and displaying data, GIS is utilized to evaluate current and alternative management strategies by combining and modifying data layers to facilitate decision-making.

Crop Management:

Satellite images show soil condition changes and how field topography affects crop performance. Therefore, farmers may closely monitor production components including seeds, fertilizers, and pesticides that boost agricultural output and efficiency. Due to their vast geographic coverage and frequent revisits, satellite images provide near-real-time regional information. Vegetation indices, especially red and near-infrared combinations, are used to predict the relationship between crop spectral characteristics and biomass/yield trials. This monitors green foliage. Many consider the normalized difference vegetation index (NDVI) the best indicator of vegetation health and agricultural output. It is significantly correlated with green vegetation's leaf area index (LAI) and photosynthetic activity. Crop monitoring methods compare present crop conditions to past or typical circumstances using remote-sensing-derived indicators. Vegetation indices help predict agricultural productivity before harvest. Automated field management includes complex data collecting, processing, monitoring, decision-making, and farm management. These functions include agricultural yields, profit and loss analysis, farm weather prediction, field mapping and soil nutrient tracking.

Conclusion

There is a need for more intelligent and effective methods of growing crops to tackle the problems of diminishing fertile land and the growing food requirements of a rising global population. It is imperative for all individuals to possess knowledge about food security in relation to sustainable agriculture. The proliferation of novel technologies aimed at enhancing agricultural productivity and fostering the acceptance of farming as a viable occupation among forward-thinking youth. This study highlights the significance of various technologies, specifically the Internet of Things (IoT), in enhancing the efficiency and effectiveness of agriculture to meet future demands. Scholars and engineers are guided by the recognition of the present difficulties encountered by the sector and the potential opportunities that lie ahead. Therefore, it is crucial to utilize sustainable IoT-based sensors and communication technologies to optimize crop yield by effectively managing every inch of farmland.

Challenges and Future Scope

The 2030 Agenda for Sustainable Development set a goal to eradicate hunger by 2030, as agreed upon by the United Nations and the worldwide community. Presently, the World Health Organization has shown that over 800 million individuals are experiencing food shortages on a global scale. Moreover, the burgeoning global population is driving up the need for high-quality food. Consequently, cultivating both food and cash crops has the potential to enhance overall crop production.

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Volume: 04 Issue No: 05

SPILL OVER OF H5N1 INTO MAMMALS RAISES "RED FLAGS"

Article ID: AG-V04-I05-56

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Introduction

Influenza, also called as '*common flu*' is a respiratory disease of man and animals. The name influenza is derived from an Italian version of the Latin word *influentia*. Although the earliest scientific record of Influenza infections dates back to 1650, the causative agent of the infection could be identified as virus only in 1931 (Potter, 2001). Since 1590 AD, several influenza pandemics have been recorded in humans, *'Spanish flu'* being the most significant and devastating one in the human history killing more than 50 million people globally between 1918 and1920.

Avian influenza, often known as bird flu, refers to disease caused by infection with avian influenza Type A viruses. Avian influenza is a highly contagious viral infection that primarily affects birds. Avian influenza viruses have been isolated from more than 100 different species of wild birds, specifically those belonging to the orders Anseriformes and Charadriiformes (Pikuła et al., 2014). Transmission of Avian Influenza from wild birds to poultry is a relatively frequent event, but fortunately, most infections result in none or only mild symptoms (Pikuła et al., 2014).

However, there are two distinct types of avian influenza viruses that infect poultry based on their disease-causing capabilities (Tasiame et al., 2020). The first type is low pathogenic avian influenza (LPAI), which typically leads to mild symptoms in domestic birds. Direct contact with infected and dead birds is the most reported mode of transmission to humans. The second type is highly pathogenic avian influenza (HPAI), which causes severe illness in domestic birds and can result in high mortalities (Tasiame et al., 2020). To date, only the H5 and H7 subtypes have been proven to be HPAI viruses. These highly pathogenic strains, poses a significant threat to the poultry industry. Outbreaks of highly pathogenic avian influenza can result in severe economic losses for poultry farmers due to high mortality rates and the need for culling infected birds. Most wild birds infected with bird flu viruses are asymptomatic (i.e., do not exhibit signs or symptoms of illness). Some bird flu viruses can infect domestic poultry and other domestic and backyard birds, and outbreaks of bird flu in domestic poultry occur worldwide.

In the recent past, there were several reports of Avian influenza infections in mammals. Specifically, H5N1 and H7N9 caused majority of the human infections so far, while, infections due to H5N6, H9N2, H6N1, H10N3, H10N7 and H10N8 are also implicated. The Inluenza Type A (H5N1) variant has become “a global zoonotic animal pandemic”. The greatest concern of course is that in infecting ducks and chickens and then increasingly mammals, that virus now evolves and develops the ability to infect humans and then critically the ability to go from human to human.

Bird flu is spreading in cows. Are humans at risk? (Pic courtesy: https://amp.cbc.ca/player/play/video/1.7168637)

An outbreak that began in 2020 has led to the deaths or killing of tens of millions of poultry. Most recently, the spread of the virus within several mammal species, including in domestic cattle in the US, has increased the risk of spillover to humans, as stated by WHO.

During March, 2024, cows and goats joined the list of species, a surprising development for experts because they were not thought susceptible to this type of Influenza. Another shocking revelation states that, a person in Texas was recovering from bird flu after being exposed to dairy cattle, with 16 herds across six states infected apparently after exposure to wild birds, as reported by US authorities. Genomic analysis and epidemiological investigation showed that a reassortant event in wild bird populations preceded a single wild bird- to- cattle transmission episode

So far, there is no evidence that H5N1 spreads between humans. But in the hundreds of cases where humans have been infected through contact with animals over the past 20 years, “the mortality rate is extraordinarily high”, because humans have no natural immunity to this virus. From 2003 to 2024, 889 cases and 463 deaths caused by H5N1 have been reported worldwide from 23 countries, according to the WHO, putting the case fatality rate at 52%. The recent US case of human infection after contact with an infected mammal highlights the increased risk. When a virus enters into the mammalian population, it is evident that the virus is getting closer to humans. Virus always looks for new and novel hosts (From Newspaper: *The Gaurdian*).

WHO authorities called for increased monitoring, saying it is “very important to understand how many human infections are happening ... because that’s where adaptation (of the virus) will occur”. Efforts were under way towards the development of vaccines and therapeutics for H5N1, and stressed the need to ensure that regional and national health authorities around the world had the capacity to diagnose the virus. This was being done so that “if H5N1 did come across to humans, with human-to-human transmission”, the world would be “in a position to immediately respond”, with equitable access to vaccines, therapeutics and diagnostics.

Due to the constantly evolving nature of influenza viruses, and the large outbreaks among animal populations, WHO continues to stress the importance of global surveillance to detect and monitor virological, epidemiological, and clinical changes associated with emerging or circulating influenza viruses that may affect human (or animal) health, and of timely virus sharing for risk assessment. The diversity of zoonotic influenza viruses that have caused human infections is alarming and necessitates strengthened surveillance in both animal and human populations, thorough investigation of every zoonotic infection, and pandemic preparedness planning. There are no approved vaccines for preventing influenza A(H5) in humans. Given the observed extent and frequency of avian influenza cases in wild birds and some wild mammals, the public should avoid contact with animals that are sick or dead from unknown causes and should report the occurrence to the authorities. Close analysis of the epidemiological situation, further characterization of the most recent viruses found in humans and poultry, and serological investigations, are critical to assess risk and to adjust risk management measures in a timely manner.

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Volume: 04 Issue No: 05

SEED PRODUCTION TECHNOLOGY IN TOMATO

Article ID: AG-V04-I05-57

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Introduction

Tomato is a crop of warm and humid climate and It is extensively cultivated all over the world around tropical belt. It is mainly grown for its edible fruits. It is very good source of ascorbic acid and lycopene. It is grown mainly for fresh market and to a little extent for processing. Increased attention is now being rendered to production of tomato. Production of tomato can further be increased if improved cultural practices are combined with good quality seeds. The quality seed production technique in tomato is being discussed in this chapter.

Climate and soil requirements

It is a warm season crop. It does not perform well at temperature 35°C and above as well as below 15°C. It is best suited in the dry season under day temperatures of 21-25°C and night temperatures of 15- 20°C. The plants cannot withstand frost and high humidity. It requires a low to medium rainfall. Bright sunshine at the time of fruit set helps to develop dark red coloured fruits. Temperature below 10°C adversely affects plant tissues thereby slowing down physiological activities. For fruit set, the temperature range of 20-24°C/ 15-17°C (Day/night) is desirable. During ripening the colour of tomato depends upon the temperature. A temperature range of 20-24°C is best for red colour (lycopene) development with optimum temperature at 21°C.

The selection of land is the first and foremost task for a seed producer. The seed production plot must be selected carefully. A fertile and healthy seed plot will certainly produce quality seed. The field selected for seed production must not have been sown with tomato in the previous season. This is done to avoid volunteer plants that cause admixture. Fields continuously cultivated with tomato may harbour root rot to wilt pathogen. Hence, such fields must be avoided wherever possible. Following crop rotation will help to reduce endemic pathogen. Soil with neutral pH must be selected. Loam or clay loam soils are best suited. Higher organic matter will lead to production of vigorous seed.

Floral biology

Tomato is a self-fertilizing crop but a certain degree of natural cross pollination (mainly due to bees) takes place, varying from 0.5-4%. Base of anthers connected with bottom part of petals, facilitating easy emasculation. Anthesis starts at 6.00 a.m. and anther dehiscence takes place between 7 a.m. and 10 a.m., depending upon temperature, humidity and sunshine. The pollen grains remain viable for 2- 4 days; the stigma becomes receptive 15-20 hours before anthesis and until 5 days after anthesis at an optimum temperature of 18-25°C. Generally flowers open after the self-pollination has occurred (chasmogamy). A certain degree of cross-pollination is accomplished mainly by honey bees when the stigma protrudes beyond the anther cone. The optimum temperature for pollination is around 21°C.

Method of seed production: Seed to Seed.

Stages of seed production

Breeder seed - Foundation Seed I - Foundation Seed II - Certified Seed

Season

November – March ; June – July

Varieties:

Indeterminate varieties

Pusa Ruby, Solan Gola, Yaswant (A-2), Sioux, Marglobe, Naveen, Ptom-9301, Shalimar- 1, Shalimar-2. Angurlata, Solan Bajr, Solan Sagun, Arka Vikas. Arita Saurbh.

Determinate varieties

Roma (EC-13513), Rupali, MTH-15, Ptom-18, VL-1, VL-2, HS 101, HS 102, HS 110, Pusa Early Dwarf, Pusa Sheetal, Floradade, Arka Meghli, CO 1, CO 2, CO 3 (Marutham), PKM 1, Py1, Hybrids COTH-1, Pant Hybrid-2, Pant Hybrid-10, Kt-4. Pusa Hybrid-l-4, Arka Shreshta, Arka Vardan, Arka Abhijit, Navell 1 &2 (Sandoz), Rupali, Sonali, MTH 6, COTH 2, TNAU Tomato Hybrid CO 3, Tomato Hybrid CO 4.

Isolation requirement

For Seed production of tomato, varieties require minimum of 50 M for foundation seed and 25 M for certified seed. For hybrid seed production, it requires minimum of 200 M for foundation (parental line increase) and 100 M for certified hybrid seeds.

Seed rate

For i) Varieties - 300- 400 g/ha ii) For F1 hybrid - Male parent 25 g/ha; Female parent 100 g/ha.

Pre-sowing seed treatment

- Seed fortification with 1000 ppm gelatin or 2 % KNO3 or 200 ppm salicylic acid (soaking in double the volume for 12 h) followed by coating with carbendazim (2 g / kg) + imidachlopride (6 g / kg) + polymer (20 g / kg of seed in 40 ml of water). (or)
- Coating with white red polykote (6 g / kg of seed) + *Pseudomonas fluorescens* (10 g/ kg), *Trichoderma viride* (4 g / kg) + DAP (4 g / kg) + MN mixture (20 g / kg). (or)
- Soak the seeds in 50 per cent coconut water for 12 h.

Nursery

FYM or compost @ 3- 4 kg/m2 is to be applied to the beds. Pre-sowing treatment of nursery beds with Furadan 3G @15g/100 sq.m is very important because at this seeding stage, plants become very much susceptible to virus attack. Well drained sandy loam soil is the best for raising the seedlings. If the nursery soil is heavy, sand @ 2 kg/sqm and if the soil is light farm yard manure or compost @ 2.5 kg/sqm need to be added to raise good seedlings. Well decomposed farm yard manure or compost can supply the macro and micronutrients in the growing medium and also it can be used as organic mulch. To control the Damping off disease, Diathane M-45 or Difolaton @ 0.25% should be sprayed and covered with polythene sheet at 7-10 days interval. 10 nursery beds of 3.0m length and 1.0 m wide are required to produce sufficient seedlings for one hectare.

Sow the seeds in raised nursery bed of 20 cm height, in rows of 5 cm gap and covered with sand. Apply 2 kg of DAP 10days before pulling out of seedling.

Transplanting

25-30 days old, healthy seedlings of 10-15 cm height with 3-4 leaves are ideal for transplanting. Transplanting should be done preferably at evening time. Spacing is 60 x 45 cm (90 x 60 cm for female parent and 60 x 45 cm for male parent of hybrids).

Spacing

Determinate varieties	: 45-60 cm × 30-45cm
Indeterminate varieties	: 60-120cm × 45-75 cm

CO 1	: 60 x 60 cm
PKM 1	: 75 x 60 cm
CO 2	: 80 x 75 cm
Pusa Ruby	: 80 x 70 cm
CO 3	: 60 x 30 cm

Fertilizers

At the time of field preparation, well- decomposed FYM @ 25 t/ha is given and NPK @ 100:100:100 kg/ha is to be applied during transplanting. Top dressing with N@ 75kg/ha is applied at two splits, at 15-20 and 40-45 days of transplanting.

Foliar application

- Foliar applicationis recomended for enhanced fruit emergence
- Napthalin Acitic Acid (NAA) @ 20 pm at 65 and 75 days after transplanting

Irrigation

Tomatoes have extensive deep root systems. In deep soils, tomato roots have been found 2 meters below the soil surface although most roots are found in the top 60 cm of soil. However, it is still recommended that water be applied consistently, particularly during fruit development. On sandy soil, application of one inch of water per week is recommended. Drip irrigation may be also used with organic mulch as well. Watering is done at 7 and 14 days interval respectively during summer and winter. Critical stages of irrigation are flowering and fruit development stage.

Weed management

Weeding during the initial stages of plant growth is very necessary. Manual weeding is mostly preferred. Weeding at 45 days after transplanting is very critical. The plants require frequent shallow hoeing especially during the first four weeks after transplanting to facilitate soil aeration for proper root development. Pendimethalin @ 1.0 kg/ ha can be used to control weeds.

Rouging

The roguing should be done based on the plant characters (determinate / indeterminate), leaf, branching and spreading characters and also based on fruit size, shape and colour. The plants affected by early blight, leaf spot and mosaic (TMV) diseases should be removed from the seed production field.

Stages of rouging.

Stages of rouging	Characters to be observed
Pre-flowering stage (or) vegetative stage	Plant height, number of branches, leaf and stem colour and pigmentation
Fruiting stage	Fruit shape, colour and size
After harvest	Fruit shape, colour and size

Field Inspection

A minimum of three inspections should be done, the first before flowering, the second during flowering and fruiting stage and the third at mature fruit stage and prior to harvesting.

Harvesting

Tomato harvesting has to be done in 8 to 10 pickings. Fruits on turning red- ripe stage and with medium to large size are found to be good for quality seeds. The seeds from the above pickings are normally possessing high vigour and germination. The fruits from in between 2-7 harvest should be used for seed extraction.

Seed extraction and processing

The acid method of seed extraction is the best method for tomato seed extraction. In this method, the fruits are to be crushed into pulp and taken in a plastic containers (or) cement tank. And then add 30 ml of commercial Hydrochloric acid per kg of pulp, stir well and allow it for ½ hour. In between this duration the pulp may be stirred well for one or two times. This facilitates the separation of seed and pulp. After ½ hour, the seeds will settle down at the bottom and then the floating fraction is to be removed. The collected seeds should be washed with water for three or four times.

- While following acid method we must use only plastic or stainless steel containers or cement tank.
- Care must be taken to avoid the usage of iron or zinc containers, which will affect the viability potential of the seeds and as well damage to the containers due to chemical reaction with acid.
- For large scale seed extraction we can use the tomato seed extractor developed by Tamil Nadu Agricultural University.

- The seeds extracted by this machine may again be treated with commercial Hydrochloric acid @ 2-3 ml/kg seed with equal volume of water for 3-5 minutes with constant stirring. And then seed should be washed with water for to four times.
- It is easy to dry the seeds extracted by acid method and also remove the fungus growth over the seed coat, thus seeds possess golden yellow colour and high vigour.
- The seed extracted by fermentation method posses poor vigour and off colour due to fungal activity.

Comparison of different seed extraction methods

	Fermentation	**Acid**	**Alkali**
Method	Mix fruit pulp with water - 24 - 48 h	HCl @10ml / Kg of pulp - 20-30 minutes	Washing soda @ 900mg/4 l of water- equal volume – overnight soak
Salient features	• Low cost. • Unskilled labour. • More Time taken • Low Seed recovery (0.5 to 0.6 % • Dull seed colour. •Seed borne pathogens	• Cost is more. • Skilled labour • Lesser Time • High seed recovery (0.8 to 1 %) • Bright colour market value higher. • Seed borne pathogen – removed • Improper washing leads to injury to seeds	• Recovery 0.7 to 0.8 per cent • Luster of the seeds will be lost. • Improper washing leads to injury to seeds

Drying and grading

Seeds are to be dried in the shade. It should never be dried in hot sun. The safe moisture content of the seed for grading is 8 to 9 per cent. Seeds can be graded using 6/64'' round perforated sieve.

Seed standards

Factor	Standards for each class	
	Foundation Seed	**Certified Seed**
Pure seed (min) (%)	**98**	**98**
Inert matter (max)	**2**	**2**
Other crop seeds (max)	**5 /kg**	**10 /kg**
Weed seeds (max)	**None**	**None**
Germination (%) (min.)	**70**	**70**
Moisture (%) (max.)	**8**	**8**
Moisture (%) in VP containers (max.)	**6**	**6**

Seed yield

Seed yield from OP varieties is150 kg/ha. In field production one thumb rule is that the seed weight is 1 per cent of the fruit weight, e.g. 1 ton of fruit will produce 1 kg of seed.

Storage

The seeds dried to safe moisture content after treating either with captan or thiram @ 2 g/kg can be stored for 15 months in moisture vapour pervious containers, while it can be stored in moisture vapour proof containers for 30 months.

Volume: 04 Issue No: 05

OZONE PROTECTANTS: A CHALLENGING APPROACH TO FOOD SECURITY

Article ID: AG-VO4-I05-58

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Abstract

Tropospheric Ozone, a ubiquitous inorganic molecule, poses a dual challenge in the context of food security. It emerges as a significant threat to agriculture by impeding crop growth and productivity. This paper examines the formation of ozone in the atmosphere and its detrimental impacts on crops, elucidating the mechanisms through which ozone disrupts physiological processes and leads to yield losses across various regions. In response to these challenges, the paper explores the efficacy of ozone protectants, including organic and inorganic compounds, plant extracts, and phytohormones in enhancing plant resilience and mitigating oxidative damage caused by ozone exposure. It also underscores the need for further research to optimize application methods, as well as to promote awareness and adoption among farmers. Ultimately, the integration of ozone protectants into agricultural practices offers a promising avenue for safeguarding crop productivity, fostering sustainable farming, and ensuring food security in the face of environmental challenges.

Keywords: Tropospheric ozone, Ascorbic acid, Abscisic acid, Neem oil, Panchagavya

Introduction

Ozone is a trioxygen inorganic molecule that always falls into serious discussion of good or bad. It is present both in the atmosphere (Stratospheric ozone) as well as at the ground level (Tropospheric ozone). In such case, stratospheric ozone is considered as good ozone which protects the life on Earth from harmful ultraviolet rays emitted by the sun. Contrastingly primary pollutants emitted by human activities react with sunlight to form tropospheric ozone or bad ozone which is a secondary ozone pollutant. Tropospheric ozone is a potent short-lived greenhouse gas next to CO_2 and CH_4 also an oxidant (important criteria air pollutant) and is becoming a threat to agriculture by affecting growth and productivity.

1.Ozone formation

In the stratosphere, ozone is created naturally in two stages. First, an oxygen molecule splits into two separate oxygen atoms when exposed to ultraviolet sunlight. The formation of an ozone molecule occurs in the second step, wherein each atom collides with another oxygen molecule through binding. The formation of ozone in the stratospheric is depicted in Fig. 1. Tropospheric ozone is formed from anthropogenic activities such as vehicular emission, industrial activities, fossil fuel combustion etc., which emit non-methane volatile organic compounds (NMVOCs), Carbon monoxide (CO), and Methane (CH_4) along with nitrogen oxides (NO_X) together in the presence of sunlight.

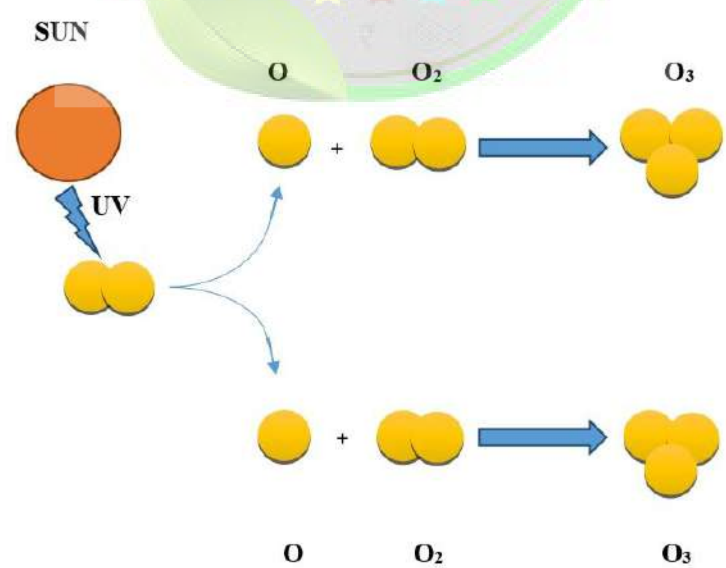

Fig. 1. Formation of ozone in the Stratosphere

2.Tropospheric Ozone impacts on crops

During gas exchange, ozone enters the plant system and causes the formation of reactive oxygen species (ROS), such as O_2, OH, and H_2O_2, which forms an oxidative burst in the apoplast. Necrotic symptoms are the result of lipid peroxidation and cell death caused by this oxidative burst inside the plant system. Ozone affects the leaf stomatal conductance, photosynthetic rate, chlorophyll content, and RuBisCO activity. Severe effects of O_3 on crops have been documented in several regions of the world in recent decades. Numerous investigations have documented the impact of O_3 stress on agricultural and horticultural crops, as well as forest trees. Some of the crop yield responses to ozone effects are listed in Table 1.

Table 1. Impact of tropospheric ozone on crop yield with their location

<table>
<tr><th>S.No.</th><th>Crops</th><th>Yield loss</th><th>Location</th></tr>
<tr><td>1.</td><td>Soybean</td><td>8.5-14 %</td><td rowspan="3">Global</td></tr>
<tr><td>2.</td><td>Wheat</td><td>3.9-15 %</td></tr>
<tr><td>3.</td><td>Maize</td><td>2.2-5.5 %</td></tr>
<tr><td>4.</td><td>Mustard</td><td>22.74-26.15 %</td><td rowspan="2">New Delhi</td></tr>
<tr><td>5.</td><td>Maize</td><td>13-20 %</td></tr>
<tr><td>6.</td><td>Wheat</td><td>~12 %</td><td rowspan="2">India</td></tr>
<tr><td>7.</td><td>Rice</td><td>~ 22 %</td></tr>
<tr><td>8.</td><td>Sunflower</td><td>13.33-18.6 %</td><td>Uttar Pradesh</td></tr>
<tr><td>9.</td><td>Cotton</td><td>50 %</td><td>Punjab and Haryana</td></tr>
<tr><td>10.</td><td>Potato</td><td>4.58-25.5 %</td><td>Tamil Nadu</td></tr>
<tr><td>11.</td><td>Rice</td><td>30.52 %</td><td>Germany</td></tr>
<tr><td>12.</td><td>Chickpea</td><td>22.11 %</td><td>New Delhi</td></tr>
<tr><td>13.</td><td>Jute</td><td>14 %</td><td>West Bengal</td></tr>
</table>

3.Ozone protectant mechanism to protect crops

Several strategies are involved in alleviating the ozone effects on crops. An effective way of scavenging the ozone stress on crops is by external application of organic or inorganic chemical protectants/ antioxidants/ antiozonants/ plant hormones. Some notable organic ozone protectants are panchagavya, neem oil and other plant extracts and inorganic ozone protectants are ethylenediurea, ascorbic acid, abscisic acid etc.,

4.Ozone protectants

One of the options for protecting crops from ground-level ozone is exogenous foliar application of ozone protectants during certain interval or at critical stages of crop. Ozone protectants may be organic or inorganic, phytohormones or growth regulator or plant extracts or chemical or fungicides or pesticides or herbicides or

Ethylenediurea (EDU)

EDU (N-[2-(2-oxo-1-imidazolidinyl) ethyl]-N'-phenylurea) or synthetic chemical, is recommended as the most studied and useful substance to assess the differences in crop responses to O_3 damage. Several researchers applied EDU as foliar spray, soil drench, and stem injection, where foliar spray and soil drench were the most widely used application methods. The EDU application against O_3 damage was first tested in bean plants. Since then, in India, EDU has been applied to several crops, such as wheat, black gram, and rice, to categorise cultivars to O_3 stress. Though the EDU is used as ozone protectant in several crops but its actual mode of application is still unknown. The foliar spray of EDU helps in mediated by suppressing reactive oxygen species and alleviates the ozone stress on crops. EDU helps in cell proliferation in the apoplastic pathway and induces antioxidant defense mechanism. As per studies the concentration of EDU applied as ozone protectants varied with crops as wheat (300-500ppm), rice (300ppm), sesame (500 ppm), mung bean (500 ppm) and maize (200 ppm).

Ascorbic acid

Ascorbic acid (Vitamin C) plays an important role in decreasing the ozone impacts in crops. In plants, ascorbic acid is the most prevalent antioxidant that targets reactive oxygen species (ROS) such as H_2O_2 and O_2^- in the apoplast, thereby averting damage caused by O_3. Few studies reported that ascorbic acid (0.1%) has played a vital role as an ozone protectant on different crops (rice, wheat, soybean, cauliflower, turnip, *Arabidopsis thaliana*, garlic, and groundnut). Under elevated O_3 environments the ascorbic acid enhances the wheat yield by 23-26%. Its application raised the amounts of micronutrients (Cu, Fe, Zn, and Mn), protein, and carbohydrates in wheat grains in addition to the levels of endogenous leaf ascorbic acid.

Abscisic acid also aids in stomatal aperture reduction during droughts, which may also lower O_3 intake.

Panchagavya and Neem oil

Panchagavya is prepared in a unique way using both water (cow milk, cow urine, curd, cow dung, tender coconut water) and fat (ghee, milk with fat) products. These products may contain polar and non-polar natural antioxidants that Panchagavya produces and are necessary for the intracellular and intercellular leaf parts to scavenge oxidative stress of elevated ozone. In addition, Panchagavya exhibits antioxidant capability in experiments involving total phenols, FRAP, and DPPH assays. Neem oil at 0.1% and Panchagavya at 3% were investigated as potential ozone protectors in garlic, cauliflower, turnip, and other shola forest plants and tree species. Neem oil has the highest percentage of antioxidant activity when compared to the total phenol content in ethanol extract. Additionally, it produces a higher quantity of free radicals, which have the ability to block the maximum percentage of DPPH radicals.

Conclusion

In conclusion, the use of ozone protectants such as ascorbic acid, neem oil, panchagavya, and ethylenediurea represents a promising approach to mitigate the adverse effects of ozone on agricultural crops. These protectants offer effective mechanisms to enhance plant resilience, boost immune response, and minimize oxidative stress caused by ozone exposure. However, further research is needed to optimize application methods, dosage, and compatibility with different crop varieties and environmental conditions. Additionally, promoting awareness and facilitating the adoption of these ozone protectants among farmers is essential for maximizing their benefits and ensuring widespread implementation. Integration of ozone protectants into agricultural practices holds promise for mitigating ozone-induced crop damage, fostering sustainable farming, and ensuring food security in the face of environmental challenges.

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Volume: 04 Issue No: 05

HOW TO GIVE AN EFFECTIVE PRESENTATION?

Article ID: AG-V04-I05-59

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Introduction

A presentation is a means of communication which can be adapted to various speaking situations, such as talking to a group, addressing a meeting or briefing a team. Various methods can be used to capture the attention of the audience hence engaging the audience and interacting with them becomes essential for efficiently delivering the speaker's point of view. There are certain main techniques for giving presentation which are discussed as under:-

1. **Choosing easy topic for presentation-** Choosing the topic of your presentation is undoubtedly one of the most important parts of presentation creation. If you're a student looking for presentation topics, check the list of topics that are easy to understand. In case you're a business professional and don't have the luxury of picking out your presentation topic, that's okay. You can find a unique angle, such as focusing on a specific problem/aspect on that topic. Even if it doesn't seem to be an exciting topic, you can still make your presentation engaging with the right eye-catching presentation visuals.
2. **Knowing fully your topic from inside and besides knowing your audience -** The knowledge about the nature of the audience is required in order to understand what approach you have to follow while giving the presentation. After that ask the audience what it wants and expects to hear from you. When the time comes to give your presentation, you need to be confident in yourself and your abilities in order to win your audience's trust. You can achieve this is by knowing all the details of your topic. In this way, you'll feel prepared for any question and know just how to answer it. You can do in-

depth research on any topic by reading related material online or in the library. But if you want to walk the extra mile, you can even get in touch with some of your audience in advance and ask them what they like to see in your presentation.

3. **Use audience friendly techniques and language -** Now, not only do you need to know your topic well, but you also need to know and study your future audience just as well. Because by knowing audience's interests, attention span and main points, one will be able to connect them through presentation. Moreover, you will be in a better position to solve their problems and add value to their lives. For example, an advanced data-driven presentation full of technical jargon might not be the best idea if you're presenting to someone who is new to your field and unfamiliar with complicated terms. It might end up confusing them instead of leaving a strong impact. So you need to be able to speak their language and meet them on their level. Your presentation would likely to be more successful if you simplify the pictures, graphs, info graphics, and even short videos that truly make effective presentation and help you to connect with your audience. Start with the basics before jumping into the data and technicalities.
4. **Impactful structure of presentation-** Starting your presentation with a powerful statement, unusual fact or an interesting question will make the audience engage in your presentation instantly. To create a compelling speech with impactful results, you'll need three key things in your outline viz : **an attractive introduction, a strong body and a conclusion** that drives your main points home because starting with a strong introduction can make your audience sit up in their seats and listen to you. Some interesting ways to start presentation include asking a thought-provoking question, listing the benefits and shocking the audience with a fact or statistic. For strong central part/ body of your presentation, you need to unravel your opening statement, give evidence by including all of your facts and statistics and include supporting arguments to prove your statements and to educate your audience on the topic. Similarly, **an** actionable conclusion is equally important to ensure that you loop back to your original opening statement and give your audience actionable steps to take in order to reach the solution you have to offer them.
5. **Rehearse and try to use practical examples -** Don't rush to tell your presentation just once you've made it. Instead, try to first rehearse your presentation in front of a mirror. Also one way to add context to your presentation content is to include a lot of practical

field examples. Telling audience/people what a certain piece of information meant for them in their everyday life can leave a much stronger impact than simply telling them the information .The relatable examples can make the presentation easier to understand.

6. **10/20/30 rule of presentation -** Your presentation should have no more than 10 slides. The time needed for the presentation should be no more than 20 minutes The font you are using for presentation text (if there is any on slides) is no less than 30 point. This will result in clean and pleasing slides to look at and you won't risk losing your crowd's attention due to overstimulation.
7. **Use storytelling as tool to relate people-** People are more inclined to remember stories that touch them rather than statistics simply listed out on slides. To make your presentation the most effective, you can use personal story or suspense. For example, instead of simply presenting the numbers, you can give some context by introducing the problem and explaining what the statistics mean and to whom these are affecting.
8. **Purpose and voice** - For every presentation you create, you need to have an end goal and purpose in mind. The goal of every presentation can be summed up within one of the following purposes:

- To inform
- To entertain
- To inspire
- To persuade

Your purpose maybe a combination of the above four because the idea of pinpointing your presentation's purpose is to facilitate in creating your presentation's subject matter outline and structure more easily. Speech is the most common method of presentation hence, when you are presenting, it's important not only **WHAT you say**, but also **HOW do you say it.**

9. **Check all the facts and information** - If you want your audience to trust you, then make sure you're getting all of your information from credible sources so that anyone can check the facts/data.
10. **Relax-** feel comfortable before presentation and practice deep breathing to keep yourself relaxed.

In addition, there are some other factors pertaining to body language which are quite useful in our effective presentation.

Body language- Body language refers to the unspoken elements of communication or the non-verbal signals that we consciously or subconsciously use for revealing our true feelings and emotions. According to a study, just 7 percent of a message is conveyed verbally while 93 percent of it is shared via non-verbal signals. According to DR Mehrabian's Communication Model, the body language involving feelings and attitude is more crucial than the choice of words and tone of voice for effective communication.

Through powerful body language, a person can motivate his/her subordinates, successfully carry out his/her business deals and meetings and maintain good relationship with the stakeholders through using direct eye contact, firm handshake, nodding the head and monitoring the voice etc. However, the speaker should avoid excessive use of the word 'But', locked ankles, arms crossed over the chest, fidgeting with hand or arm accessories hand placed on the cheek, head in hands, talking too fast, closed off body language and not maintaining eye contact with audience to make his/her effective presentation.

Conclusion

Hence for effective presentation, one should properly organize subject matter, know the nature of audience, feel confident, maintain eye contact with audience and use proper body language.

Volume: 04 Issue No: 05

SUCCESS STORY ON TUBERLET PRODUCTION FROM TPS (TPS VAR. HPS II/ 67) TO MITIGATE THE SHORTAGE OF SEED TUBER IN NORTH TRIPURA DISTRICT, TRIPURA

Article ID: AG-VO4-I05-60

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Introduction

North Tripura situated with her geographic coordination of Latitude $23^{0}39'$ to $24^{0}30'$ N, Longitude $91^{0}45'$ to $92^{0}29'$ N and altitude of 12.80 from MSL. North Tripura district in her land use pattern comprising of geographical area of 210616 ha mostly with tilla and Uplands. North Tripura due to its geographical isolation was suffering from availability of potato seed tuber at reasonable price during the late eighties. No state in Eastern India was producing certified seed tuber because of unfavourable agro-climatic condition. As a result the state had to remain dependent upon North Indian seed tuber producing states by spending a huge amount in transportation, thus making the quality seed tuber available at higher price to a limited number of farmers making the potato production a costly venture.

Horticulture Research Complex Nagicherra under the State Department of Agriculture has taken up studies in collaboration with International Potato Centre (C.I.P.), South West and Central Asia Region, New Delhi to find out cheap and alternative way in solving the issue particularly for the marginal farmers of the state. Initially, a large number of True Potato Seed families were evaluated at Horticulture Research Complex for ware potato as well as seedling tuber production, which was presented in different regional workshops. On being encouraged from the results a sincere thought was put into for standardization of commercial production of True Potato Seed in Tripura. A large number of trials were laid into and the method was standardized at Horticulture Research Complex itself. North Eastern Council came forward to extend financial help in establishing the required infrastructure for commercial production of

Hybrid True Potato Seed in the state. Thereafter there was no looking back. During the period from 1995-96 to 2009-10, it is estimated that more than 2.8 ton Hybrid True Potato Seed was produced at Horticulture Research Complex, Nagicherra worth more than 4.628 crore rupees, a part of the produce was exported to other states as well as abroad. This has not only saved huge amount of public money but also helped the marginal farmers of the state to realise a significant increase in production, thus making the state as possessing the highest yield (t/h) in the whole NE India, which is nearer to the national average.

INITIAL STATUS / PRACTICE OF FARMER BEFORE KVK INTERVENTION:-

1. Conventional potato cultivation
2. Non practice of TPS technology though its our State pride on TPS cultivation and seed production
3. Unavailability of potato seed tubers & Import from outside state
4. Requirement and Demand for seed tuber was high and unaffordable
5. Not many cold storage facility
6. Less resistance to pests and diseases.


Conventional potato cultivation plot before KVK intervention and less income due to high seed tuber cost involvement imported from outside state (West Bengal)

HOW FARMERS APPROACHED KVK

Progressive farmers normally cultivate potatoes but unaware regarding TPS to Tuberlet production technology. farmers approached to KVK came to KVK North Tripura during 2012-2013 and he was trained on TPS technology by Double Row Method and letter stages he did TPS to tuberlet cultivation by Double Row Method for the first time trial basis during 2012 and got huge success and production. Recently more than 100 nos of farmers following him for the new practice in the entire village and also nearby villages which reduces the shortage of Seed tuber for the next year with huge quantity of Tuberlet to Govt Supply through THCL.

KVK INTERVENTION & EXTENSION TOOL :- OFT/ FLDs, Training, Market Linkage with THCL (Tripura Horticultural Corporation ltd) among growers for procurement or sale of Tuberlet @ Rs 25/- kg

Methodology - Potato cultivation is common in North Tripura by the commercial varieties and also by the TPS but availability of the seed tuber is a big problem every year. State Govt is procuring huge quantity of seed tuber every year from the neighboring states like WB, UP and Bihar.

KVK North Tripura is undertaken several FLDs to popularize the TPS technology among the farmers in the district since last 5 (Five) years. TPS cultivation by utilizing seedling is very much common in the district but practice for tuberlets production by TPS by Double Row Method is less popular in the district though this method provides more yield compared to seedling method and Single Row Method.

It was decided by the State Govt. to produce TPS seedling tubers through Co-operative farming mode in cluster approach during the year 2014-15. For which Programme Co-ordinator of the four KVKs in the state declared as implementing agency.

KVKs contribution by OFT/FLDs/ training – For TPS to Tuberlet production

Year	**Tech Dissemination**	**Nos of Villages**	**Area (ha)**	**Avg yield (mt/ha)**
2012-13	OFTs	3	4.0	21.4
2013-14	FLDs	5	8.0	20.7
2014-15	Cluster demonstration (MIDH)	12	15.0	20.3
2015-16 to 2018-19	farmers own interest and Cluster demonstration (MIDH , RKVY, FLDs)	37	52.0	20.5

OUTCOME - Has it made a difference to yield? How?

Answer - Yes.

1. 125 grams of TPS seed or 600 kg of Tuberlet from TPS is sufficient to cover one hectare area instead of planting 2- 2.5 tons of potato seed tubers
2. Being hybrid capable of giving more production
3. Net profit is more as cost of cultivation is less
4. Self dependence for seed tuber for next season

5. Good market linkage.
6. Cost of production of potato using TPS is approximately 55 % less



Adoption of New technology (TPS to Tuberlet) in potato cultivation by farmers

Cost of production (per ha.)	Avg. production (per ha.)
Potato (tuber) (Kufri jyoti, Kufri chandramukhi etc.) (Seed rate – 2000 kg/ha)	**21 mt**
Potato (TPS) by seedling (Seed rate – 125 gm)	22 mt
Potato (TPS Tuberlet) (seed rate – 600 kg/ha)	**25 mt**
Tuberlet production from TPS (Seed rate – 1 kg)	20 mt


Agri Minister, Director (Agri & Horti) visit in his plots



Intercultural operation in my plots of TPS to tuberlet production

Cost variation before after adopting the technology: Qualitative & Quantitative impact

Cost of production (per ha.)	Avg. production (per ha.)	Avg. market price of potato (Rs/ Kg.)	Annual income of potato growers (in Rs.)	B:C ratio
Potato (tuber) (Kufri jyoti, Kufri chandramukhi etc.) (Seed rate – 2000 kg/ha) - 2017	21 mt	Rs 10/ kg	GC- 90238.00 GR– 2,10,000.00	2.33:1
Potato (TPS) by seedling (Seed rate – 125 gm)	22 mt	Rs 9/ kg	GC- 64863.00 GR– 198000.00	3.05:1
Potato (TPS Tuberlet) (seed rate – 600 kg/ha) - 2018	25 mt	Rs 10/kg	GC- 64703.00 GR- 250000.00	3.86:1
Tuberlet production from TPS (Seed rate – 1 kg) - 2018	20 mt	Rs 25/kg	GC- 105000.00 GR – 500000.00	4.76:1

What were the other advantages?

1. Govt supply & 25/- per kg as TPS Tuberlet seed tuber for next season table potato cultivation.
2. Locally cultivation of potato is very less in the district and mostly comes from outside states, which is having more than Rs. 20/- per kg. So my locally production faces very good return.
3. District level market supply (Kumarghat) –better price
4. TPS table potato is Supply at Darchoi BSF fronting HQ Mess –100% chain supply and no loss.
5. Supply in nearby Bangladesh border market area – high demand of TPS



Technical guidance for TPS to Tuberlet production for the growers in their village with Scientists of KVK and State Agriculture Department Crop at maturity ready for harvesting, road side stock for sale , sale to THCL (Tripura Horticulture Corporation limited)

Problem faced by majority- Challenge and problem is difficulty in preparation of rows on beds for TPS sowing with proper seed depth under double row method which need huge farm labour resulting high cost of cultivation. Normally rows making by stick without opening furrows of "V" shapes reduces germination percentage. Weed problem

Methodology- implement having two V shape wooden projections for Double Row Method which facilitates easy sowing of true potato seed (TPS) having proper seed depth. The wooden implement (tool) with 12 cm gap instead of 10 cm gap between row to row. The spacing maintained was 12 cm X 4 cm X 25 cm (Row to row – 12 cm (5 inch), two row to two row – 25 cm (10 inch) and Seed to seed – 0.5 cm (0.20 inch) instead of recommended Spacing = 10 cm X 4 cm X 25 cm.

Advantages of tool- This 1 inch i.e., 2 cm increased in spacing in row to row in his tool *facilitates easy intercultural operations, irrigation and weeding.* tool *makes open furrow for seed sowing* and these furrows are kept opened till seedling height 5 cm. These furrows facilitates accumulation of foggy drops resulted higher germination percentage because germination of tinny seeds is also one of the major problem TPS cultivation as seed depth should be within 0.5 cm. Here permanent two V shapes projections and uniform open furrows in wooden tool resulted low labour requirement and high germination percentage.

Volume: 04 Issue No: 05

NUTRIGENOMICS: DIET IN HUMAN HEALTH

Article ID: AG-VO4-I05-61

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Abstract

Nutrigenomics is one of the emerging fields of food sciences for innovative trends in food sciences. Nutrigenomics has the potential to revolutionize the way one views nutrition and well-being by offering personalized dietary recommendations based on individual genetic profiles. Understanding of the genetics of the human health and diseases is very important to set the diet and nutrition plans. With the advancement in the field of genetics and genomics especially next generation sequencing and molecular markers, nutrigenomics has been gaining much attention in the field of food sciences.

Keywords: Nutrigenomics, diseases, heath

Introduction

Nutritional genetics (also known as nutrigenetics) is a branch of nutrigenomics that studies how genomic variants interact with dietary variables and the consequences of these interactions (Mathers *et al.*, 2017). Diet play an important role on the health of human. However nutrigenomics is the interaction of food-gene interactions, sometimes known as 'inborn errors of metabolism,' which have long been corrected by dietary changes (Bull *et al.*, 2008). Nutrigenomics is a relatively recent science that explains how some foods affect your DNA. What you eat has a direct impact on the genetic messages your body receives. It is significantly change how food interacts with your body, reduce weight, and enhance your health if you can learn the language of your genes and regulate the messages and instructions they provide your body and metabolism."

The study of the impact of nutrition on the genome, proteome, and metabolome is known as nutrigenomics

The genetic variants in dietary metabolism

Variations in our DNA sequence, which are known as genetic variants, or single nucleotide polymorphisms (SNPs), can have an effect on how our bodies process (or break down) various nutrients. Genetic variants are variations in the DNA sequence that occur naturally among individuals. SNPs are the most common type of genetic variant, representing single base pair changes in the DNA. These SNPs can influence how genes function, including those involved in nutrient metabolism, absorption, utilization, and elimination.

Life style associated metabolic diseases

The main factor related with today's lifestyle is unhealthy living habits. It is culminating in diseases with high mortality rates, particularly chronic diseases, which are responsible for the majority of fatalities over the last decade. Lifestyle-related diseases are a set of diseases caused by humankind's long-term exposure to bad diet, lifestyle, and living conditions. Cardiac, renal failure, nutrition-induced malignancies, hypertension, diabetes, chronic bronchitis and other diseases have nearly identical risk factors because they are slow-progressing, non-infectious, and nontransmissible.

Diet is a major factor a ecting the quality of life in humans. In fact, diet habits, such as high consumption of fats and sugars, alcohol abuse and reduced vegetable and fruits intake are major components of risk for non-communicable diseases (NCDs), which are characterized by raised blood cholesterol and glucose, hypertension and obesity. Therefore, an appropriate nutrition pattern is recommended as a protective factor against the risk of heart disease, cancer, diabetes and other NCDs, which represent the primary cause of morbidity and mortality worldwide

According to the WHO research, illness profiles have shifted rapidly from communicable to non-communicable diseases during the last few decades, regardless of area, race, or economic status. Around 60% of deaths globally were due to lifestyle-related chronic diseases, which were twice as common as infectious diseases. Nutrigenetics can be defined as the field of nutritional genomics, which studies (i) the role of specific genetic variants, in the form of single nucleotide polymorphisms (SNPs), in the modulation of the response to dietary components, and (ii) the implications of such interaction, including the influence on health status and predisposition to nutrition-related diseases (Figure 1).

In an animal model, scientists discovered the genes (plasminogen activator inhibitor-1 linked with fat) that were responsible for the change. Changes in lifestyle and environment have an impact on not just human metabolic and physiology processes, but also the intestinal microbiome, which can lead to health issues. The idea that these diseases are only found in rich countries has been debunked, as low- and middle-income countries have more favorable social, economic, and environmental conditions for their development. If this change continues, illness profiles will worsen, especially in developing and underdeveloped countries (Rana *et al*., 2016).

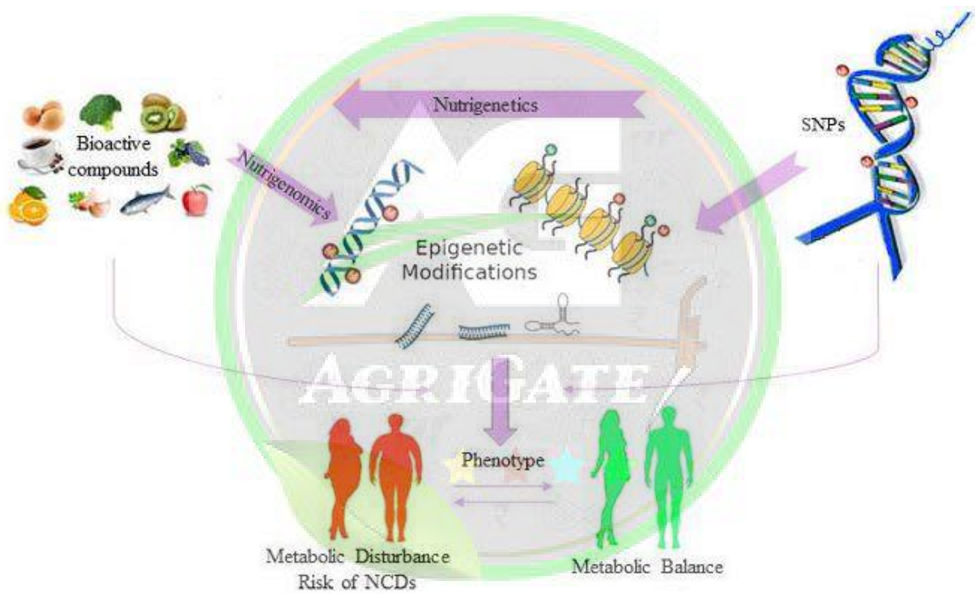

Figure 1. Interactions among genes, diet and human health

Source credit: Franzago *et al*.,2020.

Nutrigenomics and chronic diseases

Nutrition is the act of providing various constituents to the organism. Nutrients play important functions carbohydrates and fats are the source of energy, for the structure of cell protein is the best sources, vitamins and minerals is good for the control of metabolism, allowing the organism to maintain its homeostasis. The primary aim of nutrigenetics is to design effective, personalized nutritional strategies that not only result in body weight loss but also prevent metabolic disturbances (Franzago *et al*., 2020).

Diet plays an important role because the minerals and other bioactive chemicals found in food can either be healthy or cause a variety of disorders. Many chronic disease like phenylketonuria, cancer, diabetes, and dyslipidemias, are among the disorders linked to food consumption. In this approach, a person's health will be determined by the interaction of their genes and their dietary habits. As a result, nutrigenomics, like other omic sciences, aims to better understand the relationship among genes and diet (nutrients) (Afman *et al*., 2006)

Future perspective

As nutrigenomics research expands, the future of personalized nutrition looks quite promising. In the future, nutrigenomics will enable efficient dietary intervention to restore normal homeostasis as well as prohibit diet-related diseases. However, as nutrigenomics advances, ethical considerations related to genetic privacy and counselling have come to the forefront

Conclusion

The advancing discipline of nutrigenomics, which integrates genetic information with nutrition, has made it work to provide individualized meal recommendations based on a person's genetic profile. With the potential to enhance health outcomes, prevent illnesses, and change nutrition, this emerging discipline paves the way for a day when tailored nutrition becomes the norm and wellness is promoted individually. However, it is important to note that nutrigenomics is still a rapidly evolving field, and further research is needed to fully understand the complex interactions between genetics, nutrition, and health outcomes.

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AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

IMPACT OF MUSHROOM PRODUCTION TECHNIQUES IN NORTH TRIPURA DISTRICT FOR INCOME GENERATION AMONG RURAL YOUTH

Article ID: AG-VO4-I05-62

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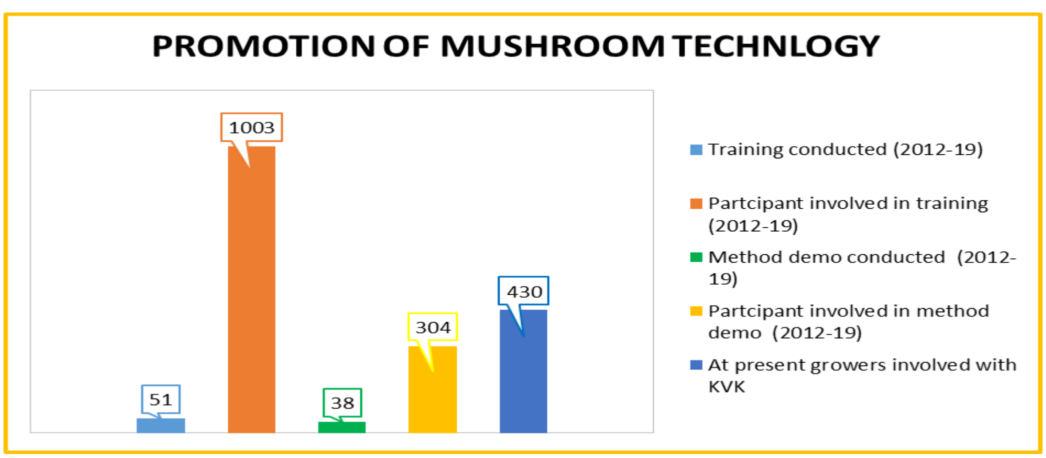
Introduction

Fungi play an important role in the changes that take place around us because of their ubiquity and their astonishingly large numbers. They fulfil many roles beneficial to humans. However, fungi have been relatively poorly collected and studied from most countries, regions, and habitats. This is at least in comparison to plants and larger animals that are considerably easier to collect and identify. One of the large groups of fungi are the Basidiomycota with over 30 000 species. They include many familiar mushrooms and toadstools, bracket fungi, puffballs, earth balls, earth stars, stinkhorns, false truffles, jelly fungi, smuts, rusts and some less familiar forms. In modern times, the cultivation and annual production of mushrooms has steadily increased. The world has witnessed dramatic acceleration in total worldwide cultivated mushroom production and mushroom scientists are making a great effort to bring wild species under domestication to increase production, because growing awareness in the past two decades of the nutritional merits of mushrooms has increased consumption in an era in which people have become more concerned about human nutrition.

Mushroom in general and Pleurotus in particular are an important source of nutrition particularly for the people on cereal-based diet. Edible species of mushroom are low in calories, fats, sodium, carbohydrates and cholesterol, whereas, rich in proteins, minerals, vitamins and fibres. Besides nutritional importance genus Pleurotus is also known for its medicinal value, paper pulp bleeching, cosmetics and industrial use. However, Pleurotus is ranked second to the button mushroom, but low yield level, inconsistency in flush appearance, texture, color and taste affects its adoption as the favorite mushroom for cultivation. The need of the hour is not only to explore other new species but also to improve the existing species through various breeding techniques for higher yield, better quality, texture, color and taste to meet the rising demands of the increasing population. Agriculture has remained be the major force of Indian economy but a fight is still on to meet the ever-increasing demand of nutritional security following secondary agricultural vocation. To meet such challenges, diversification in the agricultural activities which include mushroom production is important to address the problems of quality food, health and environmental sustainability.

In the present diet conscious era, mushrooms are increasingly considered as a future vegetable and their consumer demand has markedly expanded in the recent years owing to its medicinal and nutritional properties. Mushrooms are considered as a potential substitute of muscle protein on account of their high digestibility. In addition to protein, mushroom is an excellent source of vitamin D, minerals such as potassium, iron, copper, zinc and manganese, low in calories, fat free, cholesterol free, gluten free and very low in sodium. From 2010- 2017, the mushroom industry in India has registered an average growth rate of 4.3% per annum. Out of the total mushroom produced, white button mushroom share is 73% followed by oyster mushroom (16%), paddy straw mushroom (7%) and milky mushroom (3%). The white button mushroom (*Agaricus bisporus*) is very popular throughout the world and is the most important mushroom of commercial significance in India.

The state government including KVKs has put emphasis in Mushroom entrepreneurship to make interested citizens of the state financially empowered through various schemes and policies.



Initial status / Practice of farmer before KVK intervention:- less income through paddy farming, less income sources for rural youth, confusion towards scientific mushroom production techniques

KVK Intervention & Extension tool:- Training, group discussion and Method Demonstration since 2012-13, developing market linkage, utilizing waste land and update knowledge on value addition

Targeted group & Commodity :- Rural youth, farm women, / Oyster and Milky mushroom



Training, group discussion, and method demonstration by KVK North Tripura Scientist.

Adoption of improved practice by the growers after KVK intervention:- Oyster Mushroom

Use of quality spawn, scientific method of mushroom bed preparation, grading and packaging of mushroom, harvesting techniques, value-added products from mushroom.

Horizontal Spreading of Technology

Adoption of improved practice by the growers after KVK intervention:- Milky Mushroom Spawn was purchased from Pvt. Sources (BM Enterprise, Koch Bihar, Sarkar Mushroom Seed Centre, Siliguri, Geeta Agro Trading, Agartala, etc..) in higher price due to unavailability in the district. Substrate preparation, Spawning and spawn run and its scientific techniques is guided by KVK North Tripura.

Milky mushroom production by rural youth

Physical/ Financial development (Year round)

Sl.No	Type of Enterprise	Area/ Nos	Production/ annum (Qtl.)	Expenditure (Rs)/ Annum	Income / Annum	Net Profit (Rs./Annum)	B:C Ratio
1.	Production of Oyster Mushroom	2500 Nos p.a.	20	75,000	300000	2,25,000	4.0:1
2.	Production of Milky Mushroom	1200 beds p.a.	12	60,000	216000	1,56,000	3.6:1

Marketing

Farmer's Reaction & Feedback :- Acquired necessary infrastructure to take up milky mushroom and oyster mushroom cultivation on a large scale to upgrade their enterprise. The rate of the spawn is high and they required it locally.

Extent of Diffusion :- Trainees has started their medium and small scale production units and also motivated other youth, farm women (around 300) and mobilized them for taking up entrepreneurship activities on mushroom and also provided employment to others in their enterprises.


Mushroom Stall & processed product, Stall & Selling by grower, Master Trainer at STRY

Follow up action:- Diagnostic field visit by KVK Scientists, linking with the DDA, DDH, District Administration for establishment of Spawn production unit in the District, marketing in cluster & sale to the defense authority, conducting Skill training to the rural youth (STRY), Involvement of Successful entrepreneur and became a role model to other people in the village as well as other villages.

Volume: 04 Issue No: 05

LILIES-HERBACEOUS FLOWERING PLANTS

Article ID: AG-VO4-I05-63

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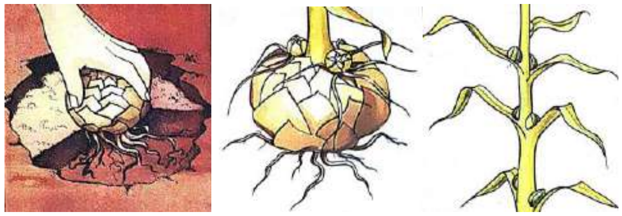
Introduction

Of all the bulbs that beautify the herbaceous department it is arguable that the lilies are the loveliest. They are certainly the most difficult to manage successfully. In nature they are usually found in open scrub, where their lower leaves are shaded, while the flowers emerge in full in sunlight sometime between mid summer and early autumn (June to August). Also, unlike other bulbs, the underground portions of the stems are liable to produce roots. This means that they do best in a fairly open soil with ample compost or leaf mould and that they should be planted fairly deeply, so that there is a good length of stem underground. It is probably best if the top of the bulb is 15 cm below the surface.

Preparing the ground

Since lily bulbs are expensive it is best to take considerable trouble, digging out the soil to a depth of 30 cm, breaking it up well and incorporating compost or leaf mould, leveling out at a depth of about 20cm and putting down a good layer of sharp washed garden sand to improve the drainage immediately around the bulb, and then filling up with the rest of the soil.

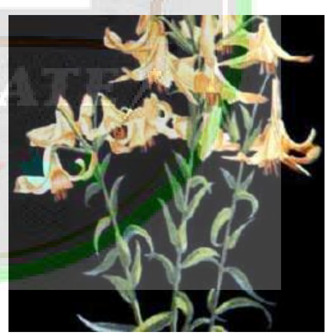
In the garden, lily bulbs scarcely rest at all and there is often ample root growth going on at times when nothing can be seen above ground, so the bulbs should be planted as early as possible, say in late autumn (October), if the bulbs can be procured at that time. The bulbs may have travelled a long way even from as far as Japan- so that the roots will have dried off altogether and the plants may take some time to get going again. It is not unknown for a whole season to pass before any leaves are seen, so don't despair until the second year.



Some varieties to choose

Lilium candidum (Madonna Lily)- pure pearly white and its popular hybrid *L.* x *testaceum* (Nankeen Lily)- pale yellow – are exceptional in that they are more or less evergreen and should be planted in early autumn (August or 1st week in September). Once they have been planted in suitable soil there is little you can do, except wait and hope for the best. If it likes you, the Madonna lily will thrive, but it is a chossy plant and it is not clear quite what it needs, but it seems to do best where the roots are crowded.

Lilium candidum (Madonna Lily) *L.* x *testaceum* (Nankeen Lily)



Virus disease is very common in lilies, although less common with plants that have been raised from seed. It is apparently always present in *L. tigrinium* (Tiger lily)- orange red with black spots- so if you grow that you will probably be wise not to grow any other lily. The lilies that seem easiest to grow are *L. regale*-white, *L.henryi*- orange, and the mid century, Halequin and Bellingham hybrids- mixed colours, followed by *L. umbellatum* (now called *L.*x *hollandicum*) but frequently listed under *L.maculatum*)- in many varieties and different colours.

L. tigrinium (Tiger lily)

L.regale

L.henryi

L.umbellatum

L.x hollandicum

L.maculatum

L.hansonii

L.pardalinum

L.speciosum

Also easy and rewarding to grow are *L.hansonii*- orange- yellow, *L.pardalinum*- orange-red, and *L.speciosum*- pure white. Of the modern lilies raised in recent years that are generally reliable, hardy and free flowering, the following offer a good selection.

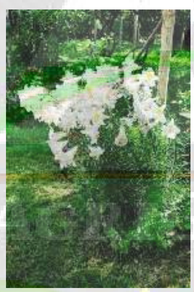
Variety	Colours
Citronella	Golden brown
Connecticut dream Lime light	Yellow
Geisha Girl	Lemon yellow
Connecticut yankee Orange light	Orange
Earlibird	Apricot
Enchantment	Red
Firebright	Currant Red
Golden Splendour	Gold
Green Magic	White & Green

Pink Champagne	Yellow and pink
Redstart	Wine
Red Velvet	Deep maroon
Shuksan	Light orange
Tabasco	Ruby-red
White Princess	Ivory

Increasing your stock

Lilies are very slow to produce offsets, but some come rapidly from seeds, notably *L.regale*; and some produce bulbils on their stems, which can be grown on outdoors in a specially prepared seedbed. Otherwise you have to remove bulb scales, put them upright in a box of sand and peat with only the tip protruding, and keep in a temperature of 15°c until a bulblet forms at the base; this can then be grown on.

L.regale



Volume: 04 Issue No: 05

NATURAL FARMING

Article ID: AG-VO4-I05-64

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Introduction

Natural farming is defined as a chemical free environmental friendly agriculture or alternative/specific land use system and landscapes which are based on integration of rich biological diversity and management practices involving from the ingenious and dynamic adaptataions of a community/population to its environment and the needs and aspirations for sustainable development. It is proved through practices that helps to make efficient use of Panch Bhoota [Land, Water, Air, Energy (Fire) and Space] as biotic and abiotic substances in farming leading to benefit in aspects of environment, society and economy.

Natural farming is a unique production management system based on agro-ecological learnings and principles evolved from five great elements of nature (Land, water, energy, air and space) which promote self-sustainable inclusive growth of individual bio-system, landscape and local communities (Crop, animal, tree, fish and other mixed communities) for sustainable living. It is based on self-evolving agro-ecological principles covering everything from nature, recycling of inputs and closed cycling of natural processes and exclude human synthesized/artificial inputs, tools and other processes which disturbs the nature and local economy.

It is voluntary and not compulsory use of Panch-Maha-Bhoota in farming to mimic nature for stability, support, trust, dignity, creativity and prosperity leading to oneness.

Natural Farming can be defined as "a chemical- free diversified farming system soundly grounded in native indivisible agro-ecology that integrates crops, trees and livestock allowing the optimum and efficient use of five Panch Bhoota [Land, Water, Air, Energy (Fire), and Space] without disturbing but promoting the functional relationship among natural elements of common environment and life opportunities for sustainable health and wellbeing of living ecological system.

Principles of Natural Farming

1. Principles of (Improved) Resource Efficiency
2. Principle of Resilience
3. Principle of Social equality/responsibility
4. Principle of Self sustainability/no dependency

10 Principles of Agro-Ecology

The 10 Elements of Agroecology framework was launched at the Second FAO International Symposium on Agroecology held in **April 2018** and continues to evolve.

In October 2018, the 10 Elements of Agroecology were supported by the FAO Committee on Agriculture (COAG) at its 26th Session as a guide to one of the ways to promote sustainable agriculture and food systems.

1. **Diversity:** Diversification is key to agro-ecological transitions to ensure food security and nutrition while conserving, protecting and enhancing natural resources.
2. **Co-creation and sharing of knowledge:** Agricultural innovations respond better to local challenges when they are co-created through participatory processes.
3. **Synergies:** Building synergies enhances key functions across food systems, supporting production and multiple ecosystem services.
4. **Efficiency:** Innovative agro-ecological practices produce more using less external resources.
5. **Recycling:** More recycling means agricultural production with lower economic and environmental costs

6. Resilience: Enhanced resilience of people, communities and ecosystems is key to sustainable food and agricultural systems.

7. Human and social values: Protecting and improving rural livelihoods, equity and social well-being is essential for sustainable food and agricultural systems.

8. Culture and food traditions: By supporting healthy, diversified and culturally appropriate diets, agroecology contributes to food security and nutrition while maintaining the health of ecosystems.

9. Responsible governance: Sustainable food and agriculture requires responsible and effective governance mechanisms at different scales - from local to national to global.

10. Circular and Solidarity economy: Circular and Solidarity economics that reconnect producers and consumers provide innovative solution for living within our planetary boundaries while ensuring the social foundation for inclusive and sustainable development.

Components of Natural Farming

- **Enrichment of soil:** Abandon use of chemicals, use natural elements and manures, adopt crop rotation and multiple cropping, avoid excessive tilling and keep soil covered with green cover or biological mulch.
- **Management of temperature:** Keep soil covered, plant trees and bushes on bund
- **Conservation of soil and rain water:** Dig percolation tanks, maintain contour bunds in sloppy land & adopt contour row cultivation, dig farm ponds, maintain low height plantation on bunds.
- **Harvesting of sun energy:** Maintain green stand throughout the year through combination of different crops and plantation schedules.
- **Self-reliance in inputs:** Develop your own seed, on-farm production of compost, vermicompost, vermiwash, liquid manures and botanical extracts through natural processes.

- **Maintenance of life forms:**

Develop habitat for sustenance of life forms, never use pesticides and create enough diversity.

- **Integration of animals:**

Animals are important components of natural landscape and not only provide animal products but also provide enough dung and urine for use in soil and promote biological processes.

- **Use of renewable energy:**

  Use solar energy, bio-gas and other eco-friendly machines complementary for high resource efficiency.

- **Protection from biotic and abiotic stress:** Use precautionary measures, agronomic, biological, mechanical and nature based solutions by understanding biotic and abiotic cycles.

Comparing conventional, organic and ZBNF production systems:

Characteristic	Industrial Approach	Agrarian Approach	
	Conventional	Organic	Subash Palekar's ZBNF
Seeds	HYV, Hybrids and GMO	HYV and Hybrids	Preferably indigenous and local adapted varieties
Crops & Cropping system	Predominantly Monocultures	Diversified cropping systems	Polycultures with 8 to 20 crops including agroforestry
Tillage	Deep tillage	Deep tillage and Conservation tillage	Reduced tillage
Seed treatment	Fungicides, Insecticides & Biocontrol agents	Biocontrol agents	Beejamrita
Nutrient management	Integrated nutrient management: Synthetic fertilizers, Organic and Green manures, Biofertilizers and Legume crops	Organic & Green manures, enriched compost, Non-edible oil cakes, Biofertilizers, Legume crops, Biodynamic formulations and Effective microbial cultures	Jiwamrita and Legume crops
Weed management	Integrated – Cultural, Mechanical, Biological and Herbicides	Cultural and Mechanical, Soil solarization, Stale seedbed etc	No specific recommendation?
Plant Protection	Integrated Pest & Disease management – Cultural, Mechanical, Biological and Chemical	Biopesticides, Neem based formulations, plant-based extracts, pest repellent crops; Yellow / blue sticky traps, Light traps, Pheromone traps, and Inter-cultivation practices	Brahmastra, Neemastra, Agniastra, Cow dung + urine, Sour butter milk etc.
Irrigation scheduling	Climate, Soil and Plant based methods; Use of Sensors, Mobile Apps., Satellite imaging etc	Fixed interval and variable depth and Critical growth stages	Irrigation at noon hours (*Whapahasa*) without any scientific basis
Irrigation method	Surface, Sprinkler and drip irrigation	Surface, Sprinkler and drip irrigation	Alternate furrow
Water use	Medium to high	Medium to high	No scientific evidence

Comparison among chemical, organic and natural farming

Sr. No.	Farming practices	Specific inputs uses	Merits	Demerits
1	Organic Farming	• Farm Yard Manure (FYM) • Vermicomposting • Bio-fertilizers • Panchagavya • HYV/Hybrid seeds • Biological pest and diseases management	• Chemical free • Eco friendly • Assured market for contract farmers • Premium price	• Huge quantity of FYM • Yield reduction during conversion period • Stringent procedure • Expensive for consumer
2	Natural Farming	• Indigenous cow centric • Jeevamritha and	• Regular and better farm income from intercrop	• Need of indigenous cow dung and urine • Possibility of lower

		FYM • Ghanajeevamritha • Beejamritha • Mulching • Inter/mixed/poly crops • Local cultivars seeds • Home made materials (Kasayams) for pests and diseases controlAgneyastra, Neemastra etc	• Lower production cost • Less use of FYM/Inputs • Improved family health-non-use of pesticides and food diversity • Improved soil health • Chemical free produce	yield • Cumbersome practices • More farm engagement • No established market certification
3	Chemical farming	• Synthetic fertilizers • Farm Yard Manure • Chemical pesticides, herbicides • HYV/Hybrid seeds • Heavy irrigation • Intensive tillage and farm mechanization • Mono-cropping system	• High yield potential • Convenience in farming • Less price for customers • Easy input availability • Well established market	• Rising cost of production • Health hazard for farmers and consumers both • Unsustainable system • Loss of biodiversity • Pests resurgence

Subhash Palekar's Approach of ZBNF/NF The main aims of Zero Budget Natural Farming/natural farming are to improve soil physical, chemical and biological properties by adding microbe inoculants and organic matter. It includes the addition of microbial cultures to enhance decomposition and nutrient recycling, integration of crops, trees and livestock (mainly cows of native breeds), use of local seeds, effective spacing of crops, agronomic measures to conserve water, intensive mulching, extensive intercropping and crop rotations. Mulching has positive effect on SOC content due to enhanced soil and water conservation, lower average and maximum soil temperatures under mulch than in unmulched soil surface, return of biomass to the soil, increase in soil biodiversity, and strengthening of the nutrient cycling mechanisms (Lal and Kimble, 2000).

Components of ZBNF/NF According to Subhash Palekar, the ZBNF/NF has following 4 essential components Sr. No. Components Description 1 Jeevamritha Ensuring soil fertility through cow urine, cow dung, undisturbed soil, pulses flour & jaggery concoction 2 Beejamritha Seed treatment with cow dung, urine and lime based formulations 3 Acchadana - Mulching Using polycropping and different mulches with trees, crop biomass to conserve soil moisture & adding organic carbon 4 Whaspa Water vapour condensation through activating available.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

CERTIFICATION AND QUALITY MANAGEMENT OF TISSUE CULTURED PLANTS

Article ID: AG-VO4-I05-65

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Introduction

Tissue culture raised plants have become increasingly popular in recent times, primarily because of their ability to produce healthier and superior quality plants. The process of tissue culture involves the propagation of plants by growing plant cells or tissues under sterile conditions in a laboratory. This process allows for the production of uniform plants that are free from pests, diseases, and genetic variations. However, the success of tissue culture-raised plants depends on the implementation of proper quality management practices and certification programs.

NCS-TCP:

Government of India established (**NCS-TCP**) the "National Certification System for Tissue Culture raised Plants" authorizing (DBT) Department of Biotechnology, Ministry of Science and Technology as the certification agency for ensuring production and distribution of quality tissue culture planting materials under the "Seeds act 1966" on March 10, 2008. India is the first country to establish such set up. NCS-TCP is unique, dynamic and comprehensive system which is one of its kind in the world.

Objectives:

- To certify or recognize the production and distribution of disease free and genetically similar quality (true to type) tissue culture plants to provide high quality planting material to the farming community for better returns.

- To commercialize indigenous R&D efforts
- To make plant tissue culture technology a viable commercial proposition for industries and small entrepreneurs.
- To enhance income generation and employment opportunities.

Services offered under NCS-TCP:

- To approve Accreditation of Test Laboratories (ATL).
- To recognize Tissue Culture Production Facilities.
- Certification of Tissue Culture raised plants (certification agency).
- Capacity building/ providing trainings for Tissue Culture facilities

NCS-TCP operational structure:

NCS-TCP is functioning under DBT and governed by Apellate Authority. In addition there is an apex committee formed by higher officials. They give suggestions, advice and details on how to operate Certification process.

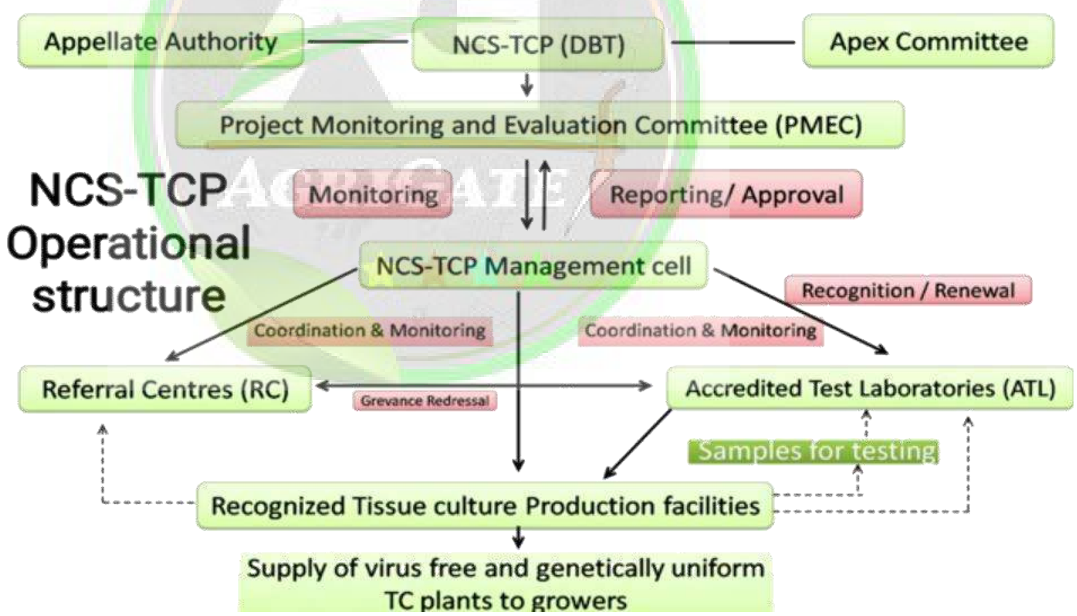

Fig 1. NCS-TCP operational structure

Components/ bodies of NCS-TCP:

1. TCCA (Tissue Culture Certification Agency)

Tissue Culture Certification Agency authorized under section 8 of the 'Seeds Act 1966' is responsible for developing standard tests, production protocols/ guidelines and manuals.

2. NMC (NCS-TCP management cell)

NMC has been established by the Tissue Culture agency at Biotech Consortium India limited (BCIL), New Delhi. Activity of NMC is constantly monitored by Project Monitoring and Evaluation Committee (PMEC). NMC do advisory services to DBT for new initiative of Standard Operating Protocol/ procedure (SOP) guidelines and management of information relevant to certification and governance throughout India. They also assist DBT in accreditation of test laboratories for Virus diagnosis and Genetic fidelity or uniformity testing of tissue culture raised plants.

3. RC/RL (Referral Centres/ Laboratory)

It is an official laboratory for the performance of confirmatory tests in the event of dispute of test results. Referral laboratories develop and validates standard protocols and diagnostic reagents. They always maintains referral material for virus indexing and provide training of technical personal working at Accredited Test Laboratories. There are two reference centres available in India namely

- Referral Centre for Virus Diagnosis – IARI, New Delhi
- Referral Centre for Genetic fidelity and Uniformity – NRCPB, New Delhi.

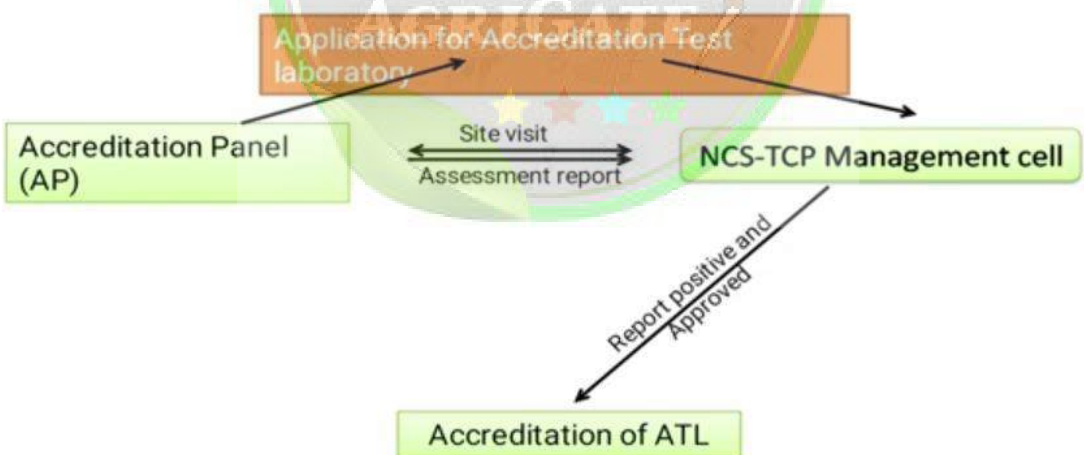

Fig 2. Process to obtain ATL

4. ATL (Accredited Test Laboratories)

Test laboratories are accredited entities, prepare a test report based on tests conducted in uniformity with a standard/ protocols/ guidelines for the purpose of certification. Based on test reports, each ATL is authorized to issue the certificates of quality for the Tissue Culture raised plants on behalf of TCCA. There are 4 Accredited Test Laboratories available in India namely,

- UAS – University of Agricultural Science, Bangalore
- VSI - Vasantdada Sugar Institute, Pune
- IISR - Indian Institute of Sugarcane Research, Lucknow
- CPRI – Central Potato Research Institute, Shimla

Guidelines for testing of Mother plants/ Stock culture:

All mother plans or stock cultures must be indexed for all the viruses. If number of plants is small in a sample, individual mother plants or stock should be tested; if number of plants in sample is large, batches consisting of minimum of 10 mother plant or stocks cultures are taken. Tissue Culture Production Facilities must maintain record of individual mother plants or stock of each batch. Virus testing can be done by ATL or by any government institute having facilities and expertise for virus testing.

Operational guidelines for ATLs:

- For **Genetic Fidelity**: Rs. 1500.00 per 10 samples of same species.
- For **Virus Indexing**: A minimum fee of Rs. 1000.00 for 10 samples of the same species for a maximum of 5 viruses. (Tests for additional viruses will be charged @ Rs. 100.00 per virus).

Recognized Tissue Culture Production Facility (TCPF):

Commercial tissue production facility with minimum production capacity of 0.5 million plants/ annum may get recognition based on their compliance with NCS-TCP guidelines which is assessed by Accreditation Panel, at that time including hardening facility needs to be operational. Time taken to issue certification by the ATL will take 30 working days from the time of complete application. In case of non-conformities verification visit would be organized within 30 working days after formal communication from TLs of their corrective actions. Recognition of TCPF is granted for a period of two years, thereafter it will be reassessed for renewable of recognition. TCPF should adopt standard operating procedures (SOP) and maintain all relevant records. Currently there are more than 90 TCPF recognized under the system this includes almost all the leading companies.

Crops under NCS-TCP:

Guidelines and Tissue Culture standards for Potato, Banana, Sugarcane, Apple, Citrus, Vanilla, Bamboo and Black pepper have been notified by Ministry of Agriculture and have been approved by Central Seed Certification Board.

Tissue Culture standards for other crops like *Anthurium*, Teak, Strawberry, *Lillium*, cardamom, *Jatropha*, Carnation, Fig, Grape, Turmeric, Ginger and Archives are under development.

Labeling of tissue culture raised plants:

Once the Tissue Culture Production Facility is recognized they become eligible to get their tissue culture raised planting material certified from Accredited Test Laboratories (ATLs). The certified batches of tissue culture raised plants are provided with certification labels with bar code, which is of 12 CM * 6 CM in size with olive green upper right half diagonal and orange bottom right half diagonal. The container should also have printed on the kind, variety and name of facility produced the propagates. This bar code provides end users to track back history of plants from where the tissue culture raised planting material are derived.

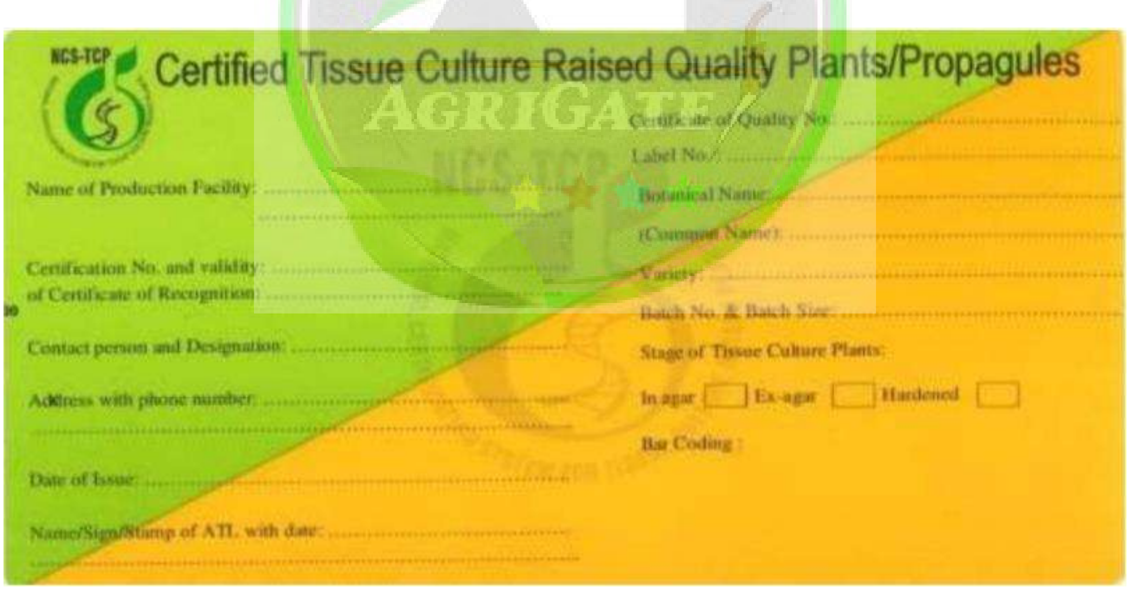

Fig 3. Label for Tissue Culture Raised Plants

Conditions for use of logo:

NCS -TCP logo shall be used in all certificates and all certified products. The logo shall not be displayed on vehicles buildings and flags. ATLs upon suspension/ withdrawal of its accreditation shall discontinue use of logo.

Fig 4. NCS-TCP logo

Conclusion

The success of tissue culture-raised plants depends on proper quality management practices and certification programs. Therefore, it is crucial for tissue culture facilities to adopt and adhere to quality management protocols and obtain the required certifications. This will ensure that the plants produced are of high quality and meet the market's expected standards.

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Volume: 04 Issue No: 05

DELIGHTFUL GRASS FOR DRYLAND AREAS

Article ID: AG-VO4-I05-66

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Introduction

Deenanath grass botanically called *Pennisetum pedicellatum* (2n: 72) belonging to the Poaceae family, is widespread in Sudanian and Guinean Savannahs of Africa though sparse in littoral areas, where it is a common agricultural weed, present on cultivated fields, also managed grasslands as well as extensively grazed savannahs. It is a weed in tropical uplands and croplands following disturbance or forest clearing, but is less common within forests and plantations, performing poorly under dense shade. In India, it is cultivated in Karnataka, Maharashtra, Andhra Pradesh, Bihar, Chattisgarh, Jharkhand, Odisha and West Bengal. Dinanath grass is widely used as green fodder for animal feed, as hay and silage making and also providing good quality forage for maintaining nutritional security in animals' health during lean situations. Besides, as a forage crop, it is also used as an ornamental, soil erosion control, and bio-energy crop and improves the physical and chemical properties of the soil. Apart from animal feed, it is also used to reverse land degradation, rehabilitate degraded land, and to improve the physical and chemical properties of soil.

In India, it is found growing in the natural grasslands on poor and marginal soils of Bihar, Odisha, West Bengal, Madhya Pradesh, and Uttar Pradesh. *Pennisetum pedicellatum* as hay, and indicated its use as a basal diet for sheep with better performance than natural pasture hay-based diets. The grass has the potential to be used as a source of some important nutrients (47.16 %

carbohydrate, 19.3 % crude fiber, 7.7 % crude protein, 22.7 % ash) in alleviating potassium, phosphorus, and calcium deficiencies in animals

Origin and Distribution

Pennisetum pedicellatum is native to tropical Africa, from Mauritania and Senegal to Ethiopia and Kenya. Nigeria grass is native to West Africa and was first introduced to India from where it has spread to South East Asia and Northern Australia. It is now widespread within 20°N and 20°S. It is mainly found on disturbed land, road edges, and recent fallows, in areas where annual rainfall ranges from 600 mm to 1500 mm with a rainy season of 4-6 months and where average day temperatures are about 30-35°C. It thrives on a wide range of soils (including degraded sandy or ferruginous soils) provided they are well drained. It is susceptible to waterlogging and frost but has some drought tolerance

BOTANICAL DESCRIPTION OF DEENANATH GRASS

It is a tall, annual, bunch of grass, up to 1.3 m high, branched from the base and often fastigiately branched above. Leaves linear, acuminate, rounded at base, sparsely hairy or glabrous; sheaths glabrous or sparsely hairy. Spikes cylindric, dense, pink or purple. Spikelets solitary and pedicelled or in groups of 2-6. lower glume is very small, and oblong. Lower lemma long, truncate, often 3-toothed, and with minute bristles or cilia at the tip. Upper floret readily disarticulating; upper lemma broadly lanceolate. Anthers not penicillate. Cross pollination due to andromonoecious conditions and wind pollination. Fibrous root system. The culm is cylindrical and glabrous. It is small to medium robust, 1 to 3 mm wide, greenish, and often tinged with purple at the base. The knots are glabrous and light in color. The leaves are hairy, 5-25 cm long and 4-15 mm wide, arranged in two rows; light to dark green in color; flat and hairless. The inflorescence is a very contracted cylindrical panicle, having the appearance of a terminal spike, 5 to 15 cm long and 1 to 2 cm wide.

The rachis is angular, with prominent ribs under the involucres of bristles. Each involucre is formed of more than 10 bristles 0.5 to 10 mm long, some up to 3 cm. The terminal part of the bristles is scabrous, the middle part is feathery and the basal part is woolly with tangled hairs giving the inflorescence a pink color more or less sustained. Inside the involucres are 1 to 5 spikelets, at least one of which is carried by a pedicel 0.5 to 3 mm long. The spikelets are ellipsoid spindle-shaped, 3.5 to 6 mm long. They are composed of 2 flowers; the inferior is male or sterile, and the superior is fertile. The lower glume is lanceolate and measures half the length of the spikelet. The upper glume and the lower lemma are as long as the spikelet. They are trifid at the top. The glumes and the lower lemma are membranous, dotted with fine woolly hairs. The lemma of the upper flower is hard, smooth and shiny. It is 2 to 4 mm long and has 3 dorsal veins. Its edges are partially closed on the palea, of the same nature. At maturity, the entire involucre is detached from the rachis. The fruit is a lanceolate caryopsis 0.02-0.1 in. (0.5–2.5 mm) long. It is dorsally compressed and golden brown in color.

Fig. 1. Deenanath grass- *Pennisetum pedicellatum*

Growing conditions

It is mainly found on disturbed land, road edges and recent fallows, in areas where annual rainfall ranges from 600 mm to 1500 mm with a rainy season of 4-6 months and where average day-temperatures are about 30-35°C. It thrives on a wide range of soils (including degraded sandy or ferruginous soils) provided they are well drained. It is susceptible to waterlogging and frost but has some drought tolerance.

Cultivation aspects

All types of soil with good drainage. Does not come up well on heavy clay soil or flooded or waterlogged conditions. Ploughing 2-3 times to obtain good tilth and form beds and channels. As basal fertilizer apply: FYM 25 t/ha NPK 20 : 25: 20 kg/ha. For top dressing: 20 Kg N on 30th day after sowing and 50% of this has to be applied for rainfed crop. Seed rate 2.5 kg/ha. Spacing 35 x 10 cm or solid sowing in lines 30 cm apart. After cultivation Hoeing and weeding on the 30th day after sowing. Irrigation done once in ten days or depending on the soil condition.

After two months from the time of sowing, Deenanath fodder can be cut and fed to livestock after 45 days of the first harvest, another harvest can be made. It gives a yield of 60-80 quintal of fodder every hectare.

Uses of Deenanath grass

1. Deenanath grass is used as a year-round fodder.
2. Due to its rapid growth rate, it is used as a cut and carry fodder by regular harvests, even reaching monthly cuts during the rainy season.
3. Once in a year, just before the dry season, sufficient grass is harvested and stored as hay to feed the livestock until the rains return.
4. Grown as grass strips, or hedgerows, to prevent runoff and soil loss on hill slopes.
5. The culms are woven into mats and also used for thatching.
6. It is used for daubing with clay to make hut-walls
7. A decoction of the whole plant is considered diuretic.
8. It is used as a soil stabilizer.
9. Grown as a cover crop and promote soil formation on coal spoil heaps.

Forage quality of deenanath grass

Green fodder: Deenanath grass is used as green fodder and it is considered to be a very palatable species to cattle, It provides high yields of green herbage ranging from 30 to 109 t/ha, comparing favorably with *Sorghum bicolor* or other *Pennisetum* species. It responds well to fertilizer and can be combined with fodder legumes in mixtures or rotation cropping. Deenanath grass should be cut 4 months after sowing at 8 cm from ground level to obtain the highest yield. It provides huge quantities of good quality green forage and can stand several cuts per year.

Hay and Silage: Once a year, just before the dry season, sufficient grass is harvested and stored as hay to feed the livestock until the rains return. The nutritive value of hay is Dry matter 93%, crude protein 4%, crude fiber 44.2%, Neutral digestible fiber 78.8%, Acid digestible fiber 50.9%, lignin 7.8% and mineral ash 8.6%. The nutritive value of Deenanath grass is Dry matter 32.9%, crude protein 6.7%, crude fiber 36.5%, Neutral digestible fiber 71.6%, Acid digestible fiber 42.5%, lignin 5.9% and mineral ash 15.5%.

Nutritive value of green fodder: Dry matter 26.8%, crude protein 6.5%, crude fiber 40.9%, Neutral digestible fiber 75.8%, Acid digestible fiber 47.4%, lignin 7%, and mineral ash 9.5%. Protien:14.24%, calcium:1.22%, Phosphorus: 0.43%.

Palatability: Deenanath grass pasture was found to be palatable to goats, though less so than Bermuda grass, but its palatability has been reported to be average than other forage grasses.

Pasture: Deenanath grass is used in temporary pastures.

Toxicity: Contains high amounts of phytates and Saponins and low levels of Oxalates.

Advantages of Deenanath grass

1. High biomass production per year.
2. Valuable grazing grass for sheeps
3. Good green fodder for horses
4. Used to recover coal spil heaps affected soils.
5. Very good for short term ley.
6. The grass has good quantity of tannins and alkaloids.

Limitations of Deenanath grass

1. Being an aggressive weed, it invades agricultural lands to the level that its dense growth leads to the abandonment of the whole farm.
2. Nutritive value decreases with the aging of the crop.
3. They have lower vigor and germination, due to which they need specific operations such as defluffing, separation of true seeds, cleaning, and grading by specific machines. In designing a machine for a specific use, physical properties and their behavior with moisture play an important role.

Conclusion

In conclusion, Deenanath grass crop production has the potential to provide valuable resources for livestock, enhance soil quality, and contribute to environmental sustainability in arid and semi-arid regions. However, successful cultivation requires careful management, attention to seed quality, and adaptation to local conditions. To fully realize the benefits of Deenanath grass, farmers should engage in ongoing research and extension activities and consider market opportunities in their region.

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Volume: 04 Issue No: 05

IN VITRO GERMPLASM STORAGE AND CRYOPRESERVATION

Article ID: AG-VO4-I05-67

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Introduction

Plant breeding programmes rely heavily on the germplasm.Preservation of germplasm is a means to assure the availability of genetic materials as the need arises. Most seeds and vegetative organs have a limited storage life, research on germplasm preservation has concentrated on the development of procedures to extend usable lifespans.Since meristem cells are highly cytoplasmic and non-vacuolated, a high percentage of cells can be expected to survive cryopreservation procedures. Meristems are genetically stable and can be regenerated into pathogen-free plants.

Meristems have been identified as excellent material for germplasm preservation of crop species with seed borne viruses also. Biotechnology requires germplasm, as both raw material and a source of natural variation. As a way of shaping and using genetic information, biotechnology has implication for germplasm conservation and use. Germplasm is the sum total all genes and their alleles present in a crop and its related species. The aim of germplasm conservation is to ensure the availability of useful germplasm at any time. This is represented by a collection of various strains and related species of the concerned crop species. Breeding programs rely heavily on locally adapted ancient plant varieties and their wild relatives as sources of germplasm. Further, the continuing search for high yielding varieties of crop plants with resistance to pathogens and pests warrants the availability and maintenance of large collections of germplasm. Also, the modern agricultural practices and other developmental activities have caused a rapid decline in genetic variability, termed as genetic erosion. Due to genetic erosion, it is necessary to conserve germplasm, which could be done either *in situ* or *ex situ*. In situ germplasm conservation is done by protecting areas of diversity, which is generally ideal for wild relatives of crops. Ex situ germplasm conservation is done either in seed banks or field collection.

***INVITRO* GERMPLASM STORAGE**

Ex-situ germplasm conservation includes collection and removal of the target genotype or its part from its natural habitat and maintenance in a restricted location. This conservation strategy tend to halt the natural evolutionary process of the species and conserves it in its original forms. Collection of material requires sampling of genotypes from a target location. The ex-situ germplasam conservation mostly include genebank conservation, which involves germplasm conservation in living state. Gene banks are also known as germplasm banks. *Invitro* storage of germplasm was first suggested in the mid-1970s (Henshaw, 1975; Morel, 1975).The germplasm is stored in the form of seeds, pollen or in vitro cultures, or in the case of a field gene bank, as plants growing in the field. Gene banks are mainly of the following types:

I.Seed Gene Bank

A place where germplasm is conserved in the form of seeds is called seed gene bank. Seeds are very convenient for storage because they occupy smaller space than whole plants. However, seeds of all crops cannot be stored at low temperature in the seed banks.

Fig 1. Seed Gene Bank

The germplasm of only orthodox species (whose seed can be dried to low moisture content without losing variability) can be conserved in seed banks (Figure 1). These germplasm are regularly used for crop breeding programme, germplasm exchange and regenerated at regular interval Seed viability is checked by sampling ever alternate year. In species which are propagated through seeds, it is economical to preserve the seeds. These seeds are dried to water content of 5–8% and then stored at a temperature of –18°C or lower and low humidity.

In the seed banks, there are three types of conservation, viz.

i. Base collection or long term conservation: The germlasm seed materilas kept under long term (50 years or more) at moisture content of 3-7 per cent in hermetically sealed packets at-18 to-20°c. The viability of the material is checked only after a long period.

ii Active collection or medium term conservation: The active collection materials are stored for medium term storage (10-15 years) at 0-2°c at about 8-10 per cent moisture content. These germplasm materials are used for characterization of germplasm. The viability of the collection is checked at regular interval.

iii. Working collection or short term conservation: These germplasm seed materials are stored for short term (3-5 years) at 5-10° C with 8-10 per cent moisture content. These germplasm are regularly used for crop breeding programme, germplasm exchange and regenerated at regular interval.Seed viability is checked by sampling every alternate year.

II.Field gene banks: It also called plant gene banks are areas of land in which germplasm collections of growing plants are assembled. This is also ex-situ conservation of germplasm.

Fig 2. Field gene banks

Those plant species that have recalcitrant seeds or do not produce seeds readily are conserved in field gene bank(Figure 2). In field gene banks, germplasm is maintained in the form of plants as a permanent living collection. Field gene banks are often established to maintain working collections of living plants for experimental purposes.

III.Tissue Gene Banks: Germplasm of asexually propagated species can be conserved in the form of meristem, buds and protocorms. This method is widely used for conservation and propagation of horticultural species. This is an In vitro method of storage of tissues under slow growth conditions with specific light and temperature arrangements in a nutrient media. Regeneration of germplasm is carried out through subculturing after every six months to three years(Figure 3).

Fig 3.Tissue Gene Bank

ADVANTAGES OF *INVITRO* GERMPLASM STORAGE:

Germplasm storage in vitro is crucial for the future development and safety of agriculture. The conservation of plants in vitro has a number of advantages over in vivo conservation.

These are as follows:

i) In vitro culture enables plant species that are in danger of being extinct to be conserved.

ii) In vitro storage of vegetatively propagated plants can result in great savings in storagespace and time.

iii) Sterile plants that cannot be reproduced generatively can be maintained in vitro.

iv) It is possible in vitro to efficiently reduce growth, which decreases the number of subcultures necessary.

v) If a sterile culture is obtained, often with great difficulty, then subculture in vitro is the only safe way of ensuring that it remains sterile. There are two main approaches for in vitro storage of germplasm.

Cryopreservation

Cryopreservation (Gr., Kryos = frost) means "preservation in the frozen state". Cryopreservation is a process where cells, whole tissue or any other propogating substances susceptible to damage caused by chemical reaction or time are preserved by cooling to sub zero temperature. In practice, this is generally meant to be storage at very low temperatures, e.g. over solid carbon dioxide (–79°C), in low temperature deep freezers (–80°C or above), in vapor phase of nitrogen (–150°C) or in liquid nitrogen (–196°C). Generally the plant material is frozen and maintained at the temperature of liquid nitrogen (–196°C). At this temperature, the cells stay in a completely inactive state. The theoretical basis of freeze preservation is the transfer of water present in the cells to the solid state. While pure water becomes ice at 0°C, the cell water needs a much lower temperature because of freezing point depression by salts or organic molecules.

The lowest temperature at which water has been demonstrated to be liquid is –68°C. At these temperatures, all biological processes virtually come to a stop. Low temperature is attained by storing the materials in liquid nitrogen. The freezing process in cryopreservation is carried out in two ways. Firstly, the temperature of the plant material is slowly reduced to a pre-freezing temperature followed by rapid cooling in liquid nitrogen. Secondly, the explant are subjected to virtification a process by which ice formation within the cell is inhibited using cryotectants such as dimethyl sulfoxide (DMSO) and the viability of the plant material is maintained.

The cryopreservation of plant cell culture and seeds and eventual regeneration of plants from them involves the following steps:

APPLICATIONS:

- ✓ **Conservation of genetic material:**Large number of plant species have been successfully maintained by means of cryopreservation of cultured embryos, tissues, cells or protoplasts.
- ✓ **Freeze storage of cell cultures:** A cell line to be maintained has to be sub cultured and transferred periodically and repeatedly over an extended period of time. It also requires much space and manpower. Freeze preservation is an ideal approach to suppress cell division and to avoid the need for periodical sub-culturing.

1.Raising sterile tissue cultures

- The morphological and physiological conditionsof the plant material influence the ability of an explant to survive freezing at –196°C.
- In general, small, richly cytoplasmic, meristematic cells survive bettert han the larger, highly vacuolated cells.
- Cell suspensions have been successfully frozen in number of species. These should be in the late lag phase or exponential phase.
- Callus tissues, particularly among tropical species, are more resistant to freezing damage and have also been used.
- Water content of cells or tissues for cryopreservation should be low.

2. Addition of cryoprotectants and pretreatment

- The orthodox seeds can be successfully stored at –20°C after desiccating to 5–7% moisturein liquid nitrogen.

3. Freezing

- **Rapid freezing:** The plant material is placed in vials and plunged into liquid nitrogen, which has a cooling rate of –300 to –1000°C/min or more. This method is technically simple and easy to handle. The quicker the freezing is done, the smaller the intracellular ice crystals are.
- **Slow freezing:** In this method, the tissue is slowly frozen with a temperature decrease of 0.1–10°C/min from 0°C to –100°C and then transferring to liquid nitrogen. Survival of cells frozen at slow freezing rates of –0.1 to –10°C/min may have some beneficial effects of dehydration, which minimizes the amount of water that freezes intracellularly.
- **Stepwise freezing:** This method combines the advantages of both rapid and slow methods. A slow freezing procedure down to –20 to–40°C, a stop for a period of time (approximately 30 min) and then additional rapid freezing to –196°C is done by plunging in liquid nitrogen. A slow freezing procedure initially to –20 to –40°C permits protective dehydration of the cells. An additional rapid freezing in liquid nitrogen prevents the growing of big ice crystals.

4. Storage

- Storage of frozen material at the correct temperature is as important as freezing. The frozen cells/tissues are immediately kept for storage at temperature ranging from –70°C to –196°C. A liquid nitrogen refrigerator running at –150°C in the vapor phase or –196°C in the liquid phase is ideal for this purpose.
- The temperature should be sufficiently low for long-term storage of cells to stop all metabolic activities and prevent biochemical injury. Long-term storage is best done at –196°C.

5. Thawing

- Thawing is usually carried out by putting the ampoule containing the sample in a warm water bath (35–45°C) for thawing.
- Just at the point of thawing, quickly transfer the tubes to a water bath maintained at room temperature (20–25°C) and continue the swirling action for 15 sec to cool the warm walls of the tubes. Then continue with washing and culture transfer procedures. It is necessary to avoid excessive damage to the fragile thawed tissues or cells by minimizing the amount of handling at pre-growth stage.

6.Determination of survival/viability

- Regrowth of plants from stored tissues or cells is the only realistic test of survival of plant materials.
- Cell viability tests viz. FDA staining, growth measurements by employing parameters like cell number, packed cell volume, dry and fresh weight, mitotic index Other staining methods of triphenyl tetrazolium chloride (TTC) and Evan's blue can be used.
- In TTC method of staining cell survival is estimated by the amount of formazan produced .This reaction results in a pink colour,which denotes the percentage of survival.

7. Plant growth and regeneration

- Addition of certain compounds in the media during regrowth has shown increased surviving ability.
- e.g. GA3 in the medium for freeze preserved shoot tips of tomato, activated charcoal for carrot.

✓ **Maintenance of disease free stocks:** Pathogen-free stocks of rare plant materials could be frozen, revived and propagated when needed. This method would be ideal for international exchange of such materials.

- **Cold acclimation and frost resistance:** Tissue cultures would provide a suitable material for selection of cold resistant mutant cell lines, which could later differentiate into frost resistant plants

Limitations

1. Greater skills in handling and maintenance of cultures is required.
2. Sophisticated facilities are required.
3. Plants may show genetic instability.
4. Cell/tissues get damaged during cryopreservation.
5. Cryopreservation procedures are genotype dependent.
6. Cost of maintenance of large collection is very high.
7. Slow growth cultures are vulnerable to contamination
8. Large storage space is required especially for slow growth cultures.

Conclusion

Biotechnology has made significant contributions to improved conservation and use of plant genetic resources. The rapid progress made in *invitro* culture technology has helped in improving the conservation of genetic resources especially of problem species. Some of the most important contributions have been in the areas of *invitro* collecting and cryopreservation. The field of germplasm conservation will have to address how to best integrate technological advances in the areas of molecular genetics, genomics, cryopreservation and other conservation techniques, and geographic information system to further facilitate conservation and utilization of these resources.

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Volume: 04 Issue No: 05

CONTRIBUTION OF GOATS TO THE DAIRY INDUSTRY OF INDIA

Article ID: AG-VO4-I05-68

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Introduction

India, a land of diverse cultures and traditions, has a long-standing history of dairy farming. While cows are often the focal point of dairy discussions, goats play a significant, albeit less acknowledged, role in the country's dairy industry. In recent years, the contribution of goats to India's dairy sector has gained recognition, showcasing their potential to transform rural livelihoods and enhance nutritional security.

India is the world's top producer of milk, accounting for 24.64% of the world's total production in the 2021–2022 period. Over the course of the last nine years, or between 2014–15 and 2022–23, India's milk output has increased by 58%, reaching 230.58 million tons in 2022–23. Over the previous nine years, the CAGR for milk production has climbed to 5.85%. In 2022–2023 India exported 67,572.99 MT of dairy products to the world, valued at $284.65 million.

The goat is a versatile animal, also known as the poor man's cow because it largely contributes to small and marginal farmers' economies. Goat farming supports the national economy and socio-economic growth of small farmers as well as landless laborers. Goats play an important role in income generation, capital storage, employment generation, and improving household nutrition. The dairy goat market is growing quickly on a global scale. Dairy goats not only produce healthy and nutritious milk products, but they also help smallholders build assets and sustain livelihoods, particularly in places with limited resources. Goats under good management can also help the environment by preventing fires, controlling weeds, preserving biodiversity, and mitigating some of the consequences of climate change. Their eating habits and nutrition choices are mostly to blame for this.

Diversity in Goat Breeds:

India boasts a rich diversity of goat breeds, each adapted to varying climatic conditions and geographic landscapes. There are 39 goat breeds in India, which are spread across various bioclimates and have varying nutritional values. Nonetheless, some goat breeds that are native to the country's north and northwest, such as Beetal, Jamunapari, Jakhrana, Surti, and Zalawadi, are regarded as Indian dairy breeds and can produce 150 to 500 liters of milk annually.

From the sturdy Jamunapari of Uttar Pradesh to the prolific Beetal of Punjab and the resilient Barbari of Rajasthan, these indigenous breeds form the backbone of India's goat farming sector. Their adaptability to harsh environments and ability to thrive on diverse diets make them invaluable assets to farmers across the nation.

Milk Production and Quality:

While goats typically produce less milk compared to cows, their milk is rich in essential nutrients and is easier to digest, making it an ideal choice for infants, elderly individuals, and those with lactose intolerance. Goat milk is also renowned for its therapeutic properties, aiding in the management of various health conditions such as hypertension and gastrointestinal disorders. The growing demand for goat milk and its by-products like cheese and yogurt presents a lucrative opportunity for dairy farmers to diversify their income streams.

Quality of Goat milk

India is the world's top producer of milk, with 230.58 MT (2022-23), up 3.83% from 2021–22. A total of 3.30% of the milk produced in the nation comes from goats. At 8908.9 thousand tonnes, Rajasthan is the leading producer of goat milk in all of India. Total goat milk production in India is 7.59 million tonnes in 2023 and contributes 3.3 % of the country's total milk production. 9.04 % growth in goat milk production from 2022 (6.6 MT). Jamunapari is the most popular breed for commercial goat farming in India

Economic Empowerment:

In rural India, where agriculture remains the primary source of livelihood for millions, goat rearing serves as a sustainable income-generating activity. Goats require minimal investment and space, making them accessible to smallholder farmers with limited resources. The sale of goats, both for meat and milk, provides a steady source of income, particularly during festivals and religious ceremonies when demand surges. Moreover, women in rural communities often play a significant role in goat rearing, empowering them economically and socially.

Ecological Sustainability:

Goats are efficient converters of low-quality forage into high-quality protein, requiring less feed compared to larger livestock species. This inherent efficiency makes them environmentally sustainable, reducing the ecological footprint associated with intensive livestock farming. Furthermore, goats play a vital role in land management by clearing invasive vegetation, preventing wildfires, and improving soil fertility through their grazing patterns. The development of the goat dairy industry will necessitate concentrated efforts to stimulate entrepreneurship and establish as many commercial dairy farms as feasible by enlisting the private sector through suitable legislative support and incentives.

Challenges and Opportunities:

Despite their numerous benefits, goat farming in India faces several challenges, including limited access to veterinary services, inadequate infrastructure, and lack of organized marketing channels. Addressing these challenges requires concerted efforts from policymakers, researchers, and industry stakeholders to promote sustainable goat farming practices, enhance productivity, and ensure fair market prices for farmers.

Novel recombinant vaccines against PPR, Rift Valley fever (RVF), goat pox, and contagious caprine pneumonia are being developed through advances in virology, immunology, and genetics. These vaccines have the potential to manage the primary diseases that restrict the productivity of small ruminants.

Conclusion

In conclusion, the contribution of goats to India's dairy industry cannot be overstated. From providing nutritious milk to empowering rural communities and promoting ecological sustainability, goats play a multifaceted role in the country's agricultural landscape. As India strives towards achieving food security and rural prosperity, recognizing and harnessing the potential of goats in the dairy sector will be instrumental in building a resilient and inclusive agricultural system. With the right support and investment, goats can continue to be the unsung heroes driving positive change in India's dairy industry for generations to come. In addition to being a consistent source of money, goats give tribal residents in the area access to nourishment. The economic advantage of goat production should be increased by scientific and technological research in nutrition, disease control, management, and breeding. Governments have the authority to establish regulations and policies that raise the bar for goat rearing and to set up systems that assist producers.

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AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

MUGA SILK (GOLDEN SILK) - THE FABRIC AND WEAVING GOLDEN DREAMS

Article ID: AG-V04-I05-69

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Introduction

Muga silk is golden silk which is secreted by muga silkworm (*Antherae assamensis* Helfer) the semi domesticated worms which is endemic to Assam. These worms are sericineous insect , having many generation in a year. These worms are polyphagous insects which feeds on many host plant namely primary, secondary, and tertiary out of which its mostly reared on primary host plant som (*Machilus bombycina*), and Soalu (*Litsea polyantha*).

Distribution of Muga silk worms

These worms are distributed across Bramaputra valleys and also found in North Eastern states such as Meghalaya, Nagaland, Arunachal Pradesh, Manipur and south Tripura and in other parts of India, like West Bengal, Sikkim, Uttarpradesh, Pondicherry, Gujarat and Himachal Pradesh.

Production process of Muga Silk

It begins with cultivation of host plant whose leaves are primary food sources for production of Silkworms and require careful attention throughout entire process starting from rearing of silkworms to harvesting of cocoons followed by they undergo a serious process including boiling, reeling and weaving to transform the raw silk in to muga silk fabric.

Features of Muga Silk

It is golden yellow fabric extracted from the cocoons of *Antherae assamensis* Helfer and is one of the most recognizable and seemingly luxurious materials among all textiles of Assam.

Distinctive characteristics of Muga silk

- It is having lustrous golden colour appearance with durability
- It has shimmering and glossy texture
- It has highest tensile strength as compared to other natural fabrics
- It has shine which increase with age and wash
- Has resistant and thermal properties
- Had received Geographical indication tag in the year of 2007
- Had trade mark logo in the year of 2014
- Has humidity absorption quality
- Has long shelf life
- Its body is being amenable to any kind of embroidery

Uses of Muga silk

- It is used in make traditional dresses like mekhela chador, riha, gamosa, kurta, jainsem and saree
- Used in making upholstery items like curtain, cushion covers
- Used in manufacturing of cloths like dress suits , robes and sun dresses
- Also used in aesthetics wherein production of of parachutes, bicycle tires conforter filling and artillery gun powder bag production
- Used in making UV radiation resistant umbrella
- Used in crafting ceremonial dresses and wedding costumes

Table 1. Physical and Mechanical properties of Muga Silk fiber

S.No	Parameters	Value
1.	Length (mm)	2750-4500
2.	Fineness (Den)	5-6
3.	Tenacity (g/d)	2.84
4.	Elongation (%)	28.8
5.	Shrinkage (%)	7.7
6.	Moisture regain (%)	10.2

Table 2.List of Amino acid composition found in Muga Silk fiber

Amino acids composition (mol %)		
S.No	**Amino Acid**	**Muga Silk**
1.	Aspartic acid	4.97
2.	Glutamic acid	1.36
3.	Serine	9.11
4.	Glycine	28.41
5.	Histidine	0.72
6.	Arginine	4.72
7.	Threonine	0.21
8.	Alanine	34.72
9.	Proline	2.18
10.	Tyrosine	5.12
11.	Valine	1.5
12.	Methionine	0.32
13.	Cystine	0.12
14.	Isoleucine	0.51
15.	Leucine	0.71
16.	Phenyl alanine	0.28
17.	Tryptophan	2.18
18.	Lysine	0.24

Advantage of Muga Silk

- It is soft fabric with very smooth surface and gently caresses body
- It is chemical free and made of natural fibers which resemble human hairs
- It has 97% of protein , 3% fat, wax and containing 18 amino acids
- It is most allergen free fabric and repel dust mites and resistant to fungus, mold and few other pollutant
- It is assists in reducing skin moisture loss thereby stimulating skin regeneration and delay sign of aging and alleviates dry, flaky skin problem by trapping moisture in.

Disadvantage of Muga Silk

- Its price is costly and most expensive like gold jewellery in the world
- It is being occasionally wearing
- It is required highly maintenance

Conclusion

The inherent natural golden colour, durability and thermal properties are major factors influencing credibility of muga silk thus it enhancing its export potential. Muga silk should be processed with utmost care without weighing down its natural qualities.

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Volume: 04 Issue No: 05

RURAL AGRICULTURAL WORK EXPERIENCE (RAWE) OF AGRICULTURAL COLLEGE STUDENTS AT MARAKKANAM BLOCK, TINDIVANAM

Article ID: AG-VO4-I05-70

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Abstract

Agricultural education is evolving in a very rapid manner to meet the needs of the society. RAWE (Rural Agriculture Work Experience) was introduced in the Agricultural Universities mainly to bring overall improvement in quality of life of rural families. This programme is offered in final year of the B.Sc. (Hons.) Agriculture degree programme which includes training, demonstration, observation, practice and participation in purposeful activities and to orient agricultural graduates for participation in various rural developmental programme. This pioneer study about RAWE was undertaken to study the perception of RAWE programme by the students and to know the constraints of students for effective conduct of RAWE. The Perception of the students regarding extent of achievement of RAWE is to understand rural institutions, socio economic conditions of farmers, adoption patterns and adoption gaps, farmers' problems, farming systems and farming, improvement in diagnostic skills, provided practical training in crop production, improved communication skills, improved leadership qualities, provided opportunity to work with various Agri based institutions, developed confidence and professional competence to solve field problems. We the final year students of 2020 batch of Agricultural College and Research Institute -Vazhavachanur hereby sharing our knowledge and experience gained by RAWE PROGRAMME .

Keywords : Students, RAWE, VSP, FPO, NGO, Farmers, Agriculture and Rural People

Introduction

People living in rural areas are dependent on agriculture. Development of India cannot be possible without strengthening the socioeconomic condition of rural people. The rural work experience is basic for developing a graduate's competence in functioning as an effective teacher, researcher and extension professional in the transfer of technology to rural families and therefore, this type of practical training and experience of working with people in villages becomes inevitable. Rural Awareness Work Experience Programme (RAWE) is an opportunity to the students to live in rural areas and develop right perspective of rural life. Burnell. RAWE is one of the best means to produce well trained agricultural graduates with broad based knowledge and techniques to meet the emerging challenges Kapri et al. In India, Randhawa Committee of ICAR (1992) recommended the Rural Agriculture Work Experience (RAWE) Programme for imparting quality, practical and productive oriented education for the agriculture degree programme. It provides significant hands on experience in acquiring skills, which are mainly aimed at creating a product or providing a service to those who demand. In fact, RAWE is basic to develop graduate competence as a teacher, researcher and extension specialist.

The Rural Agricultural Work Experience Programme aims to empower students with practical skills and knowledge to contribute to rural development, particularly in the context of food security and hunger Rural agricultural work experience programme is a key component in B.Sc (Hons.) Agriculture. The main aim of the programme is to acquaint the students with the villagers and the farming situation so that they can have practical knowledge about agriculture . The students are given rigorous orientation and familiarization on various issues and problems they can expect in the farmers' field .

RAWE is for 65 days which includes village stay programme (VSP) , tie up with farmer producer organization (FPO), Non- governmental organization related to agricultutre (NGO), attachment with Assistant Director Of Agriculture(ADA) and Industrial Visit

Village Stay Programme

In this programme we have visited various villages in Marakanam block of Villupuram district. We met more than 100 farmers and collected basic details about farming and problems faced by them.In addition to this we also collected basic information about villages from village administrative office , panchayat secretary. During this programme we conducted Participatory rural appraisal techniques (PRA),Group discussion ,demonstration ,awareness ,rally,transfer of technology .

Participatory rural appraisal techniques (PRA)

PRA techniques we conducted in various village are,

- **Social map**
- **Venn diagram**
- **Problem tree**
- **Time line**
- **Crop pyramid**
- **Daily activity clock**
- **Seasonal calendar**
- **Matrix ranking**

Social map

Venn diagram depicting he distance from the village to important resource places

Timeline

Problem tree depicting the various problems faced by the farmer

Daily activity clock

Crop pyramid depicting the crops cultivated

Awareness

We created awareness by conducting rally, by interacting with the people. To attain **100% voting** we conducted rally in Tindivanam town combining with Mr. Saravanan, ADA and Lions club. To celebrate **Earth Day**, we took pledge and made awareness on Plastic vs Planet among the students. We created awareness to the school students about the personal hygiene. On **World malaria day**, awareness is raised to control and to eradicate it. Vaccination schedule for cattle is explained on **World Veterinary Day.** We elucidated about **Pradhan Mantri Fasal Bhima Yojana**, crop insurance scheme to the rural farmers. The usage of pesticide is increased nowadays, to control this we made awareness on **pesticide toxicity.** We saw many parthenium weeds in the villages, so we gave awareness on **parthenium ill-effects and its eradication**

Demonstration

We gave demonstration to the farmer for the purpose of increasing productivity , mitigating the infestation of pest and disease ,to minimize the cost of purchasing chemicals. We have done more than 40 demonstration related to crop production.

In **groundnut** to control Spodoptera litura - poison bait, seed treatment with rhizobium and phosphobacteria , gypsum application, earthing up were demonstrated to farmers. In **paddy**, seed treatment with

bio-control agents , egg floatation method to separate ill filled grains were demonstrated. In **sesame,** seed pelleting was carried out with **arappu (*Albiziz amara*)** powder to promote uniform germination**.** In **banana,** to control root kont nematode – sucker treatment , to avoid sun scorching to the bunches - bunch covering was demonsrated. Besides, denavelling one of the special practices in banana was done. In **Coconut,** bucket trap to control rhinoceros beetle , coconut – butter milk karaisal for supplying nutrients to the young seedlings.

To induce the plant growth and to give protection to plants, various organic pesticide techniques were delivered. **Brahmastra** comprising of various leaves extract; **3G karaisal** a mixture of ginger,chilli,garlic ; calotropis leaf extract, 5 leaves extract, banana karaisal , tobacco extract were demonstrated. In addition to this panchankavya, neem leaf extract, fish amino acid, egg amino acid, tobacco leaf extract, amrit paani was done.

The importance of **soil testing** was explained to the farmers and then we demonstrated the steps to collect the soil samples from the field. The **vermicompost** application is done in the farmers field to enhance the fertility of the soil.

Transfer of technology

Various technologies of Tamilnadu Agricultural University, were transferred to the farmers.

In the villages of Marakkanam block, wild boar is the major problem. Because of this many farmers left the land fallow. So, we demonstrated the use of **Wild boar repellant** released by Agricultural Research Station,Virinjipuram to the farmers. We demonstrated the use of **solar light trap** for controlling nocturnal insects .The usage of **yellow sticky trap** was demonstrated in the farmers' field to avoid the infestation of sucking pest .We explained the use of **blue sticky trap** for controlling thrips .We elucidated the usage of **fruit fly trap in gourds** .The utilization of fish meal trap was demonstrated to the farmers which attracted shoot flies.We transferred the technologies

like expert system in rice and in coconut .We shared the information about Integrated crop management in Groundnut and Sesame and Integrated pest management in Brinjal .We illustrated the Integrated farming system model to the farmers.

The technology of **System of Rice Intensification** was explained to the farmers. In sugarcane, **Sustainable Sugarcane Initiative** (SSI) technology was elucidated.

Farmer Producer Organization

We visited various FPOs during RAWE programme.

A) Nallavur farmer producer company

It is located in Kooteripattu of Mayilam block. They provide technical assistance and financial support to the farmers. In agricultural activities, they provide seeds like Black gram,Paddy, Groundnut. The turnover of the company is Rs.1 crore . They also run seed processing unit and urad dhal processing.

B) Tindivanam Oil Palm And Groundnut Fed Farmer Producer Company Limited

It is located in Kooteripattu of Mayilam block. They own a supermarket in Kooteripattu which sells many products of other FPOs. They are selling the traditional rice varieties under the brand of THINDRIS. The annual turnover of the company is 30 lakhs.

C) Thellar Farmer Producer Company Limited

It is located in Tiruvannamalai district. There are 1000 members as shareholders. They run oil extraction unit and cattle feed manufacturing unit. Besides, they run the supermarket. The annual turn over is 75 lakhs .

Industrial visit

Indigo processing plant is the emerging industry in Tindivanam. We visited K.M.A. Exports in Tindivanam. Indigo is used for dying purpose for textiles and for cosmetics. The finished products are exported to Canada,Nepal,France.They make buy back agreements with the farmers.The annual turnover of the industry is Rs. 5 crores.The scheme like PMEGP was utilized to establish the industry.

Assistant Director of Agriculture (ADA)

We met Mr. Saravanan sir who is Assistant Director of Agriculture, explained various schemes and its benefits to farmers.The scheme which is focussed on a large scale is Kalaignar All Village Integrated Agricultural Development Programme (KAVIADP).

We met Mr. Shankar who is Agriculture Engineer of Marakkanam block. He explained various machineries and implements in agriculture. We came to know about the rents of various machineries offered by the Agricultural Engineering Department. The machineries for post harvesting processing are provided to the farmers under various schemes by providing various subsidies.

We met Mr. Karl Marx, Assistant Director of Horticulture in Marakkanam block. We learnt about the various horticultural schemes. The procedures for availing mobile vending carts were explained. The activities in the Coconut crossing centre, Chettiyapakkam were explained. Here, Tall × Dwarf seedlings are crossed and the quality seedlings are supplied to the farmers.

Conclusion

Hereby, we conclude our knowledge gained through RAWE Program. We gained lot of experience through this program. We sincerely thank our course teachers Dr. P. Sumathi, Professor and Head (Agricultural Extension),Dr. M. Kavaskar, Associate Professor (Agricultural Extension) and our group facilitators Dr. K. Ananthi , Assistant Professor (Crop physiology) , Dr. D. Dhanasekaran , Assistant Professor (Horticulture), Dr. Shibi Sebastian (Agricultural Extension) We convey our heart full thanks to all who helped us to complete this RAWE program.

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AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

PRODUCTION OF SOMATIC HYBRIDS AND CYBRIDS

Article ID: AG-VO4-I05-71

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Introduction

Somatic hybridization is an important tool of plant breeding and crop improvements through the production of inter-specific and inter-generic hybrids. The technique involves the fusion of protoplasts of two different genomes followed by the selection of desired somatic hybrid cells and regeneration of hybrid plants (Evans DA and Bravo JE, 1988). It is an efficient way to produce hybrids by fusion of two different protoplast from different plants or species or varieties, and hybrids which produced by this way called somatic hybrids. This is a non-conventional genetic procedure involving fusion between isolated protoplasts under in vitro condition and subsequent development of their product to a hybrid plant.

Protoplast fusion provides an efficient mean of gene transfer with desired trait from one species to another and has an increasing impact on crop improvements (Brown DCW and Thorpe TA, 1995). Purified protoplasts once obtained from any two different sources (it can be different tissues, plants, species or different genera), can be fused together to form somatic hybrids. This non-conventional method of genetic recombination involving protoplast fusion under in vitro conditions and subsequent development of their product to a hybrid plant is known as **somatic hybridization**. The aim of somatic hybridization is to improve crop plants, medicinal plant or other types of plants. The purpose of improvement by somatic hybridization is may be to modify species by disease resistance, quality, quantity, or others.

Steps Involved in Somatic Hybridization/Cybridization

The following steps are involved in the somatic hybridization/cybridization:

a) Protoplast isolation
b) Protoplast fusion
c) Selection of hybrid cells
d) Culture of hybrid cells
e) Regeneration of plants from Hybrid tissue
f) Confirmation of Hybridity/Cybridity

A. PROTOPLAST ISOLATION:

Protoplasts are isolated by (i) mechanical and (ii) enzymatic methods.

A1. Mechanical method

In this method, large and highly vacuolated cells of storage tissues such as onion bulb scales, radish root and beet root tissue could be used for isolation. The cells are plasmolysed in an iso-osmotic solution resulting in the withdrawal of contents in the center of cell. Subsequently, the tissue is dissected and deplasmolyzed to release the preformed protoplasts. However, this method is generally not followed because of certain disadvantages which are:

i. It is restricted to certain tissues which have large vacuolated cells.
ii. Yield of protoplasts is generally very low. Protoplasts from less vacuolated and highly meristematic cells do not show good yield.
iii. The method is tedious and laborious.
iv. Viability of protoplasts is low because of the presence of substances released by damaged cells.

The mechanical method is useful when there are side effects of cell wall degrading enzymes.

A2. Enzymatic method

The enzymatic isolation of protoplasts can be performed in two different ways.

(a) Two step or sequential method: The tissue is first treated with a macerozyme or pectinase enyme which separates the cells by degrading the middle lamella. These free cells are then treated with cellulase which releases the protoplasts. In general, the cells are exposed to different enzymes for shorter periods.

(b) One step or simultaneous method: The tissue is subjected to a mixture of enzymes n a one step reaction which includes both macerozyme and cellulase. The one step method is generally used because it is less labor intensive.

During the enzyme treatment, the protoplasts obtained need to be stabilized because the mechanical barrier of cell wall which offered support has been broken. For this reason an osmoticum is added which prevents the protoplasts from bursting.

B. PROTOPLAST FUSION

Freshly isolated protoplasts will fuse if brought into intimate contact and held together for a few minutes. A reproducible and controlled fusion method, using NaNO3 as the fusogen was first reported by Power et al. (1970). Although this method was employed by Carlson et al. (1972) to produce the first somatic hybrid, between *Nicotiana tabacum* and *N. langsdorffii* it suffers from low incidence of fusion. The two most widely used techniques to fuse plant protoplasts are chemical fusion by PEG (polyethylene glycol) and electric stimulation.

B1. PEG-Induced Fusion

Freshly isolated protoplasts from the two selected parents are mixed in appropriate proportions and treated with 15–45 % PEG (1,500–6,000 MW) solution. After 15–30 min, the protoplasts are gradually washed with the culture medium containing a high level of Ca2+ ions (50 mM CaCl2 .2H2O) and pH adjusted to 9–10. Fusion actually occurs during elution with hypotonic washing solution.

PEG is a highly water soluble, nonionic surfactant, with slight negative polarity and forms hydrogen bonds with positively polarized groups of water, protein, carbohydrate and so on. When the PEG molecule chain is large enough it forms bridges between the surfaces of adjacent protoplasts, allowing their agglutination. PEG can also bind Ca2+ in the fusion mixture, and Ca2+ may further form a bridge between the PEG chain and negatively polarized group of the membrane constituents and thus enhance the agglutination. During subsequent elution of the fusion mixture, the PEG molecules that are already bound to the cell membranes are forced away from the plasma membrane. Osmotic shock may also occur on cell membrane by the hypotonic washing solution used. These combined effects can cause disturbance and redistribution of electric charges in the adhering membranes leading to fusion.

C. Mechanism of fusion.

Protoplast fusion consists of three main phases:

a) agglutination, during which the plasma membrane of two or more protoplasts are brought into close proximity,
b) membrane fusion at small localized regions of close adhesion resulting in the formation of cytoplasmic continuities or bridges between protoplasts) and,
c) rounding-off of the fused protoplast due to the expansion of the cytoplasmic bridges forming spherical hetero- or homokaryons.

The fused protoplasts with two nuclei of different parents are called heterokaryons and those with nuclei of the same parent are called homokaryons. The fusion of nuclei in the heterokaryons during culture results into a hybrid cell.

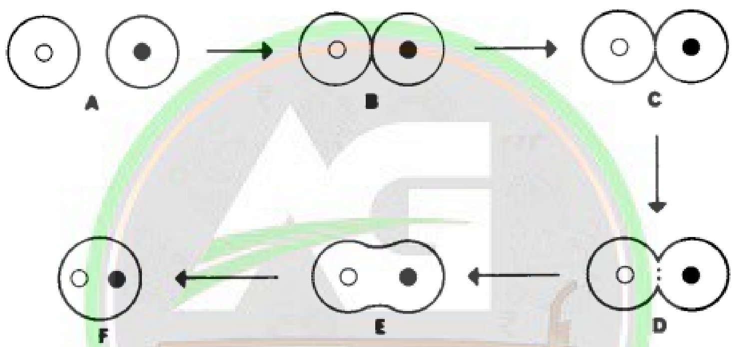

Fig.1. Sequential stages in protoplast fusion. (A) Two separate protoplast, (B) Agglutination of two protoplasts, (C & D) Membrane fusion at localised sites and (E & F) formation of a spherical heterokaryon

C1. Electrofusion

Electrofusion of protoplasts was first demonstrated by Senda et al. (1979). Zimmermann and his co-workers (see Zimmermann and Vienken, 1982) developed this method further, and their work led to the production of an automatic 'Zimmermann Electrofusion System'.

The protoplasts, suspended in the fusion medium of low conductivity (e.g. mannitol solution of appropriate osmolarity) are introduced into the chamber and placed between the two electrodes. A non-uniform high frequency (0.5-1.5 MHz) AC field (10-200 V cm -1) is applied across the protoplasts. As the surface charge on the protoplasts becomes polarized they act as dipoles and migrate along the electric field lines to a region of highest field intensity. If the field intensity is high (ca. 200 V cm -~) the protoplasts may migrate to the electrode with higher electric field but with lower field intensity the aggregation occurs between the electrodes. As the protoplasts have been aligned in chain, one or two short (10-20/~s) DC pulses of high voltage (0.125-1 kV cm -1) are applied which causes reversible membrane breakdown (pore formation) in the contact area of the adjacent protoplasts. The AC field is briefly reapplied to maintain close protoplast contact as fusion begins and then reduced to zero. The fusion process takes about 10 min. Pre-treatment of protoplasts with spermine and the presence of 1 mM CaC12 in the fusion mixture increases the fusion frequency.

D. SELECTION OF FUSION PRODUCTS

In somatic hybridization by electrofusion of protoplasts it may not be difficult to follow the fate of the fusion products because the fusion frequency is very high and sometimes it is possible to achieve one-to-one fusion of desired pairs of protoplasts. However, a chemical fusion treatment results in a heterogeneous mixture of the parental type protoplasts, heterokaryons and a variety of other nuclear-cytoplasmic combinations. The heterokaryons which are the potential source of future hybrids constitute a very small (0.5-10%) proportion of the mixture. Only a fraction of these heterokaryons show nuclear fusion (Pelletier, 1993). Moreover, being novel genetic combinations, several things may happen following fusion treatment which further reduce the number of potential hybrid cell lines to a very low level. It is, therefore, of key importance in somatic hybridization to be able to select the hybrid cells or their products. Numerous different ways of selecting hybrids have been proposed and practised, including morphological basis, complementation of biochemical and genetic traits of the fusing partners, and manual or electronic sorting of heterokaryons/hybrid cells.

Morpho-physiological basis: cultured the whole mixture of protoplasts after fusion treatment and screened the calli or regenerated plants for their hybrid characteristics. However, it is a labour intensive method and may require considerable glasshouse space. Occasionally, the hybrid calli may exhibit heterosis and outgrow the parental cell colonies.

Complementation: In this method complementation of genetic or metabolic deficiencies of the two fusion partners are utilized to select the hybrid component. When protoplasts of two parents, each carrying a non-allelic genetic or metabolic defect are fused it reconstitutes a viable hybrid cell of wild type in which both defects are mutually abolished by complementation, and the hybrid cells are able to grow on minimal medium non-permissive to the growth of the parental cells. For such a complementation it is necessary that the defects are recessive and expressed in cultures (Harms, 1983).

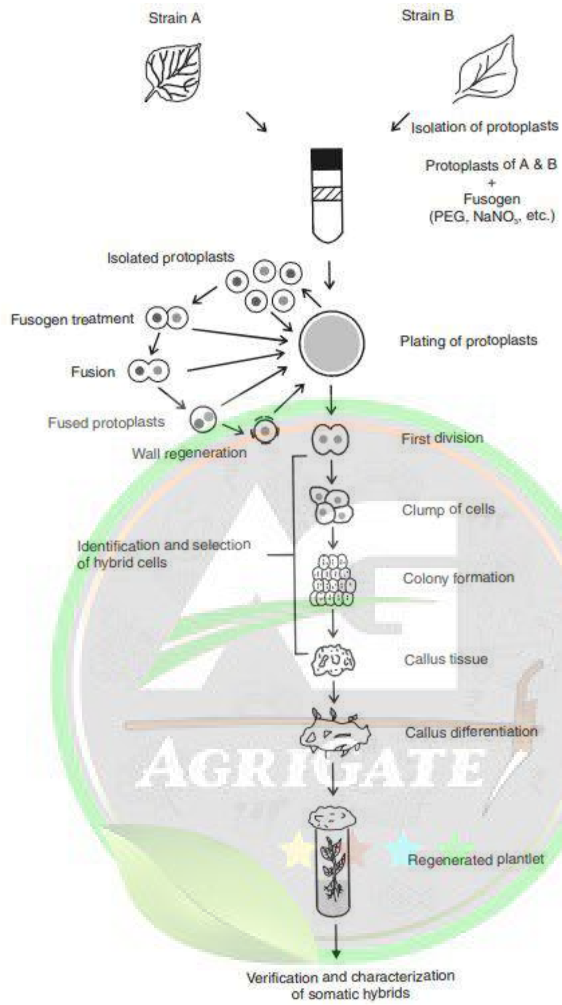

Fig.2 Schematic illustration of protoplast fusion and regeneration of plants

E. PROTOPLAST CULTURE

The density of purified protoplasts is determined using hemocytometer and adjusted to the desired level before culture. A variety of methods have been used to culture freshly isolated protoplasts and after fusion treatment, which are as follows:

Culture Methods

(i) **Agarose Embedded Cultures:** This method is similar to the Bergmann's technique of cell plating, which allows following the development of specific individuals. The type and concentration of the gelling agent may influence protoplast development. Pure, low gelling temperature agarose, such as SeaPlaque (FMC BioProducts, USA) or Sigma type VII and IX are used extensively for protoplast culture. Alginate is a useful gelling agent for protoplasts that are heat sensitive, such as Arabidopsis thaliana. The semisolid medium with embedded protoplasts may be cut into sectors and transferred to liquid culture medium of the same composition in larger plates.

(ii) In Liquid Medium: The protoplasts are suspended in liquid culture medium at the desired plating density and dispensed into culture dishes (3, 5 or 9 cm diameter) as thin layer or microdroplets (50–100 µl). The dishes are sealed with an expandable gas permeable tape, such as Parafilm and Nescofilm.

(iii) Double Layer Method: The protoplasts are suspended in liquid medium and overlaid on a thin layer of gelled medium of the same composition.

(iv) Agarose Droplets or Beads: Embedding the protoplasts in agarose beads or discs improved the plating and regeneration efficiencies in many species (Dons and Colijn Hooymans 1989).

F. PLANT REGENERATION

Plant regeneration from freshly isolated protoplasts or after their fusion occurs via organogenesis or embryogenesis.

G. CONSEQUENCES OF PROTOPLAST FUSION

The hybrid cells formed by the fusion of two unrelated protoplasts combine a set of three genomes from the parents, viz. nuclear genome, mitochondrial (mt) genome, and plastid (pt) genome.

The hybrid cells may give rise to hybrid plants with full nuclear genomes of both the parents (Symmetrical hybrids).However, very often interactions between the genomes of the two parents result in various combinations of nuclear and cytoplasmic genomes The nuclear genome of one of the parents may be partially or completely eliminated during successive cell cycles, before regeneration of plants, leading to asymmetric hybrid or cybrid formation.

a) Symmetrical hybrids : hybrid plants with full nuclear genomes of both the parents
b) asymmetrical hybrids: nuclear genome of one of the parents may be partially or completely eliminated during successive cell cycles.
c) Cybrid: Cybridization refers to combining nuclear genome of one parent with mitochondrial and/or chloroplast genome/s of another parent.

H. CYBRIDIZATION:

Sexual hybridization is a precise mixture of parental nuclear genes but the cytoplasm is derived from the maternal parent only, while in somatic hybrids the cytoplasm is derived from both the parents. However, somatic hybrids can be obtained where nucleus is derived from one parent and cytoplasm is derived from both, thus producing cytoplasmic hybrids, also called as cybrids. Early segregation of nuclei in a fused product can be stimulated and directed so that one protoplast contributes the cytoplasm while the other contributes the nucleus alone or both nucleus and cytoplasm. There are different ways of inactivating, the nucleus of one protoplast can be inactivated. Thus, there will be fusion between protoplasts containing the full complement of nucleus, mitochondria and chloroplasts with functional cytoplasmic component of second parent. The various approaches to achieve this type of fusion are:

(a) By application of lethal dosages of X or gamma irradiation to one parental protoplast population.
(b) By treatment with iodoacetate to metabolically inactivate the protoplasts.
(c) Fusion of normal protoplasts with enucleated protoplasts.
(d) Fusion of cytoplasts with protoplasts
(e) Fusion of a normal protoplast with another in which nuclear division is suppressed.

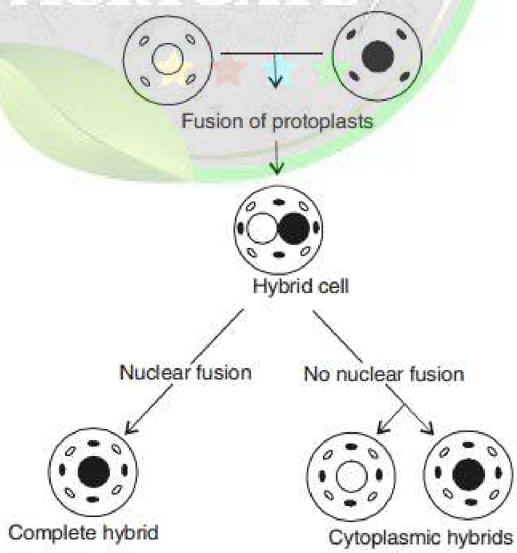

Fig. 3. Schematic illustration of somatic hybridization which can produce complete hybrids (left) and or cytoplasmic hybrids (right)

Cybridization thus opens an exciting avenue to achieve alloplasmic constitution in a single step without the need to perform a series of 8– 12 time-consuming backcrosses. Alloplasmic lines contain nucleus of one parent genome with the cytoplasmic constituents from other parent. Application of cybrids would be the directed transfer of cytoplasmic male sterility or herbicide resistance from a donor to a recipient crop plant species.

3. POTENTIAL OF SOMATIC HYBRIDIZATION

1. Production of novel interspecific and intergeneric crosses between plants that are difficult or impossible to hybridize conventionally. It overcomes sexual incompatibility barriers.
2. Production of autotetraploids: Somatic hybridization can be used as an alternative to obtain tetraploids and, if this is unsuccessful, colchicine treatment can be used.
3. Protoplasts of sexually sterile (haploid, triploid, aneuploid, etc.) plants can be fused to produce fertile diploids and polyploids.
4. Hybridization becomes possible between plants that are still in the juvenile phase.
5. Cybridization has been successfully used to make intergeneric and interspecifc transfer of cytoplasmic traits, such as male sterility and disease and herbicide resistance.

4. PROBLEM AND LIMITATIONS OF SOMATIC HYBRIDIZATION

1. The end products after somatic hybridization are often unbalanced (sterile, misformed, and unstable) and are therefore not viable, especially if the fusion partners are taxonomically far apart.
2. Regeneration products after somatic hybridization are often variable due to somaclonal variation, chromosome elimination, translocation, organelle segregation etc.
3. The genetic stability during protoplast culture is poor.
4. Production of somatic hybrid plants has been limited to a few species.
5. Somatic hybridization of two diploids leads to the formation of an amphidiploid which is generally unfavourable (except when tetraploids are formed intentionally).

CONCLUSION

Somatic hybridization is a tool for the modification and improvement of polygenic traits. Furthermore, the modification of organellar genetic material is possible via somatic hybridization since a mixture of the two fusion partners is obtained in the hybrid cell Production of hybrid plants through the fusion of protoplasts of two different plant species/varieties is called Somatic Hybridization, and such hybrids are called Somatic Hybrids. Therefore, somatic hybridization can be resorted to only when the following two criteria are satisfied: i) Isolation of protoplast in large quantity, and ii) Totipotency of the isolated protoplasts.

In general, Somatic hybridization is an important tool of plant breeding and crop improvements through the production of inter-specific and inter-generic hybrids. It is valuable for plants which is asexual, sterile and that is also beneficial for those plant which has sexual incompatibility with other species.

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AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

BUNCH MANAGEMENT IN BANANA FOR HIGH QUALITY FRUIT PRODUCTION

Article ID: AG-VO4-I05-72

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Introduction

Banana (*Musa paradisiacal* L.) is the largest herbaceous perennial plant belongs to the Musaceae family in the order Zingiberales (Sora and Merga, 2023). It is one of the major fruit crops grown in tropical and subtropical regions of the world, and originated from the tropical region of South-East Asia. Bananas are symbol of prosperity and fertility and the plant is also referred as "Apple of Paradise" or "Kalpataru". There are around 300 varieties of bananas cultivated around the globe. However, there are only 20-25 varieties of bananas are commercially cultivated in different parts of India. Among them Grand naine (AAA) occupied more than 50% cultivated area owing to its high yield, long shelf life and universal acceptance of consumer.

Nutritionally bananas are rich source of potassium (368 mg) and energy 350-550 kilo Joules/100g. Lutein & Dopamine in the bananas act as antioxidants. "Karat" banana belongs to Fei banana group in the island of Micronesia, contains 2230 µg/100 g, 100 times the carotene content of the common Cavendish banana (21 µg/100 g). Ripe fruits of *Musa* cv. Bhimkol could meet 100% RDA of K, Zn, Mn and S for 6 months old infant.

Global banana production increased from 69 million tonnes in 2000-2002 to 155.22 million tons in 2017-2021, with a value of around 40 billion USD (FAOSTAT, 2023). India ranks first in banana production, with 34.52 million tons in an area of 962.6 thousand ha having a productivity of 35.9 t/ha accounting for 19.85% of global output (Ramanandam *et al*., 2023). Among the major banana growing states (A.P, MH, Gujarat, TN, KA, UP etc.,), Andhra Pradesh stands first with 5.68 million tonnes from 1.09 lakh ha. Having 16.5% share. Despite of its higher production, the export of fruits are very much limited owing to non-following of some of the important operations in banana cultivation. External and internal appearance and market quality of bananas are influenced by several factors, including pre-harvest production practices. The external appearance includes key attributes such as colour, shape, size and freedom from defects. The internal attributes such as taste, texture, sweetness, aroma, acidity, flavour, shelf life and presumed nutritional values of the fruit are important in ensuring repeat buys for sustained repeat purchase (Shewfelt, 2009). The physical appearance of the peel is especially important in the highly competitive export markets and in some local supermarkets (Shewfelt, 1999). Buyers in these prime markets require consistent supplies of uniform coloured fruit with blemish-free peels.

Special cultural practices to be followed in banana:

- ✓ Desuckering
- ✓ Mulching
- ✓ Propping
- ✓ Pruning of Leaves
- ✓ Removal of withered styles and perianth
- ✓ Bunch covering
- ✓ Denavelling
- ✓ Banana bunch feeding
- ✓ Bunch/finger thinning
- ✓ Banana bud injection
- ✓ De-fingering
- ✓ Foliar nutrition

- ✓ Peduncle wrapping
- ✓ Bunch sprays

Desuckering

Basically, banana producefour types of suckers as fallows.

- **Sword sucker** (follower) - young sucker, narrow leaves with larger corm size (250 to 350g).
- **Water suckers** - small suckers of superficial origin with broad leaves andsmaller corm size which are unsuitable for followers/propagation and should be removed.
- **Maiden sucker-**A large but non-fruiting ratoon.
- **Peeper-**Avery young sucker bearing scale leaves, appears above the soil.

Removal of surplus and unwanted suckers from banana plant is known as desuckering.When the banana plant grows to a certain size, many suckers, that are derived from axillary buds, sprout from the rhizome (also known as the corm) of the mother plant (6–8 suckers per plant). The suckers consume nutrients; reduce vigour; and delay budding, shooting, and fruiting of the mother plant, which undermines fruit yield and fruit quality (Chundawat and Patel, 1992). Suckers are removed from the mother either by cutting the sucker at ground level or by destroying the heart of the suckers without detaching the sucker from the plant. Desuckering can also be achieved by pouring kerosene oil (5-10ml/sucker)/2, 4-D @ 0.5 per cent into the heart of the sucker. A mixture of KH_2PO_4 (KDP) and paclobutrazol (PBZ) 2:1 ratio can effectively remove banana suckers while improving fruit yield and the quality of the mother plant (Luo *et al.*, 2020).

Fig. 1. Arrows in B indicate growth points that remained fresh and showed normal morphology. Arrows in D indicate growth points that had rotted and disintegrated, with no signs of regrowth.

Mulching

A mulch is a layer of material applied to the surface of soil, which helps in conserving the soil moisture, increasing the number of feeder roots and thereby improving the nutrient and water use efficiency. Further, it suppress weed growth and thereby enhances the banana yield by 30-40%. The disease severity (internal corm discoloration), was reduced from 90% to 37% when *Eucalyptus cloeziana* leaves used as mulch which contain very high concentration of tasmanone which is the primary oil constituent of Eucalyptus leaves (Ryan and Paul, 2021). 100 µ polythene mulches and weed mats can also be used as mulch material for banana cultivation.

Propping:

Propping is a cultural practice carried out on banana plants to provide additional support for the plant when it carries heavy loads (fruits) during bunching.Tall varieties viz. Karpura Chakkerakeli (AAB), Tella Chakkerakeli (AAA), Mortaman (AAB), Kovvur Bontha (ABB), Godavari Bontha (ABB) etc., which produce heavy bunches need propping. While, the short statured cultivars like Kaveri Kalki (ABB), Dwarf Cavendish (AAA), TBM-9 (AAA), Phule pride (AAA) etc., does not required propping. Bamboo poles are commonly used for propping which has effective life of 3-4 years.Eucalyptus or Casuarina poles can also be used as an alternative to bamboo but their economic life is only 1 to 2 years. Coir or polythene rope can also be used for propping.

A. Propping with bamboo poles **B.** Mulching with Polyethylene

Pruning of leaves (Trashing):

The process of removal of undesirable material from the banana plant like dried, diseased and decayed leaves is known as trashing. This operation helps to prevent senescent leaves from hanging over suckers, reduce disease spread and prevents fruit scarring.Ensure there should be at least 12 to 13 healthy leaves remaining on the plant at shooting to bunch development stage. Proper care need to be taken while trashing and avoid severe leaf removal or damage for better bunch weight, yield and quality fruits.

Removal of withered styles and perianth:

In some varieties the styles are persistent and hence they remain in the bunch till maturity. They can be easily removed by a light brushing movement of the hand a few days after flowering and if it is delayed, it is difficult to remove and later they become brown and shrivelled. This operation eliminates the removal of infection by saprophyte fungi especially to avoid the finger tip disease.

A.Trashing **B.**Styles and Perianth removal

Bunch covering:

Skirting of banana bunches during the pre-harvest stage helps to mitigate damage associated with physiological disorders arising from seasonal temperature changes, insect and pest infestation.Also helps to create better microclimate for fruit development, protects the fruit from sunburn, hot wind and dust.It is mostly practiced in Cavendish group and Nendran bananas to get attractive fruit colour. The research results indicates when the bunches were covered with transparent polyethylene sleeves of 2% (cool season) or 4% (summer season) ventilation immediately after opening of the last hand - increased yield by 15-20 %, early bunch maturity by 15-20 days, reduce the blemished fruits by 15-20% with attractive fruit colour in all the commercial varieties viz., Karpura Chakkerakeli, Tella Chakkerakeli, Robusta, Kovvur Bontha and KBS-1 over that of uncovered bunches. Now a days 17 GSM white U.V. resistant non-woven fabric materialsare popularly using as bunch skirting material. 1000 m. role is sufficient for one acre banana.

Banana bunches covered with white transparent polythene covers and blue covers

Denavelling:

The part of the inflorescence which consists of male flowers only, is termed as male budor navel.The process of removal of male bud after completion of female phase is termed as 'denavelling'. This checks the movement of photosynthates into the unwanted sink and promotes better fruit development.In bananacv.KarpuraChakkarakeli (AAB)denavelling12-15 days after last hand openingresulted in increasedfruit size (length and girth), mean bunch weight (0.9kg) and yield (7.5%).

Banana bunch feeding:

This ICAR-IIHR technology enhances the bunch yield and fruit size. The technique involves blending of 7.5g Urea + 7.5 g SOP dissolved in 100 ml water in 500 g of fresh cow dung and applying the slurry to the de-navelled stalk-end soon after fruit set. The technology is cost effective as the cost involved is about Rs. 2/- per bunch while the improvement is of 4-5 Kg of 'Robusta' and 2-3 Kg of 'Ney Poovan' Banana Bunch.

Banana bud injection:

The banana flower thrips, *Thrips hawaiiensis* (Thysanoptera: Thripidae), is one of the most common flower-dwelling thrips worldwide (Mound, 2005) which live and breed in the male buds in large numbers leading to fruit damage (brown freckling) resulting unattractive poor quality fruits. Hence, it is quite difficult to control this thrips mainly due to its rapid population increase during the flowering season (Fu *et al*. 2019). Systemic insecticides can be rapidly absorbed by the plant and translocated throughout its tissue, making plant tissues toxic to the target pests in an efficient and environment friendly way. Among systemic insecticides, the imidacloprid is the most promising and has been widely used in injection systems, as it has high efficacy against numerous pests. To overcome this problem, bud injection with imidacloprid 17.8 SL (imidacloprid 0.3ml in 500ml of water) @ 1ml/bud injected at 1/2 or 3/4th emerged inflorescence at upright position 6 to 8 inches below the bud tip at an angle of 40 degrees. The mean per cent infestation was reduced by about 10% in plant and ratoon crops in banana cv. KarpuraChakkerakeli (AAB).

A. Control **B.** Bud injection imidacloprid 17.8 SL

Bunch thinning & De-fingering:

One to two small bottom hands should be removed from the bunch in order to facilitate uniform bunch development, while defingering is the practice of removing deformed or excess fingers to obtain the good shape of the banana hand.

Peduncle wrapping:

The peduncle is the main - nutrient, photosynthate, water conducting bridge between the developing bunch and the plant. During bunch maturation period, due to bright sunshine, there are possibilities of scorching injury on peduncle. This will pave way for secondary infection by any fungi or bacteria. Once the peduncle gets affected, the nutrient, photosynthate and water flow from plant to developing bunch will be arrested and it will lead to immature ripening or immature falling of the bunches. So during peak summer, banana bunch peduncle exposed to scorching sun should be wrapped with flag leaf or banana leaf trashes.

Sun burn on peduncle

Foliar nutrition:

Foliar application of nutrients provides quick and effective augmentation of nutrients and may prevent hidden hunger when properly timed. In banana particularly at reproductive stage, high nutrient availability is important to support plant requirements until harvest, since large quantities of photosynthetic are beginning to move from the source to the sink (developing fruit bunches).Any limitation in the supply of nutrients at this stage will negatively affect bunch size and fruit quality. However, it has not been wise to apply fertilizers basally at finger development stage, since the uptake is slow and low.

Research at Dr. YSRHU-HRS, Kovvur revealed that, foliar spray of $ZnSO_4$ (0.2%) + H_3BO_3 (0.2%) + $FeSO_4$ (0.2%) recorded higher yield (40 t/ha) in banana cv. Martaman. The fruits had longer shelf life of 6 days and were with higher total sugars and lower percentage of lumps.

Foliar spray of IIHR-Arka banana special or NRCB-banana Shakti also increasing the productivity by 15-20% and quality attributes TSS of fruit by 2.4 ^{o}Brix and decreases the acidity of fruit by 0.03% in Ney Poovan banana leading to improvement in fruit taste, sweetness, flavour and aroma.

Banana bunch sprays:

Among all the nutrients, banana requires high potassium for proper finger filling and bunch development. Foliar spraying of Pottasium nitrate (13-0-45) @ 5g/litre of water along with 0.5ml gum/surfactant at five days after last hand opening followed by spraying with SOP (sulphate of potash; 0-0-50)@10g/lit at 15th day improves the finger quality and bunch yield. Similarly spraying with Potassium di hydrogen orthophospate @ 5g/lit along with 0.5ml gum/surfactant during winter season at 7-10days interval will help to overcome the pre-mature ripening of fruits.

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Volume: 04 Issue No: 05

ROLE OF FARM MECHANISATION IN MODERN AGRICULTURE

Article ID: AG-V04-I05-73

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Introduction

The progress of agriculture through the centuries has been dependent to a large degree on the innovation of scientists and technologists and on the efforts of farmers to make the land more productive. Mechanization is one technological input which helps in increasing the productivity of other factors of production such as land, labour and water; Optimizing the use of inputs like seeds, fertilizers and chemicals etc, and Reducing field, transport.

Farm mechanization has been defined as the process of development and introduction of mechanized assistance of all forms and at any level of technological sophistication in agricultural production in order to reduce human drudgery, improve timeliness and efficiency of various farm operations, bring more land under cultivation, preserve the quality of produce, improve living condition and markedly advance the economic growth of the rural sector. Farm mechanization is an important element of modernization of agriculture. Farm Productivity is positively correlated with the availability of farm power coupled with efficient farm implements and their judicious utilization.

Agricultural mechanization not only enables efficient utilization of various inputs such as seeds, fertilizers, plant protection chemicals and water for irrigation but also it helps in poverty alleviation by making farming an attractive enterprise.Traditionally humans and animals were used for field operations and processing activities. As a result of introduction of mechanical powers, the process of farm mechanization began. Adoption of agricultural tools/machinery and other implements provide technology to facilitate agriculture by efficient utilization of inputs, besides reducing drudgery.

Even farmers with small holdings utilize selected improved farm equipments on custom hiring basis to improve productivity and thus, ultimate increase in quantum of production. Such use of improved farm implements and equipments is preferred with a view to reduce cost of production also. Nearly 50% of production costs for fruit are for hired labour. Intensive horticultural crops require much more skilled labour than broad scale agriculture

Impact of Farm Mechanization on the Agriculture

(i) Farm mechanization led to increase in inputs on account of higher average cropping intensity and larger area and increased productivity of farm labour.

(ii) Farm mechanization increased agricultural production and profitability on account of timeliness of operation, better quality of work done and more efficient utilization of inputs.

(iii) Farm mechanization increases on- farm human labour marginally, whereas the increase in off- farm labour such as industrial production of tractors and ancillaries was much more.

(iv) Farm mechanization displaced animal power to the extent of 50 to 100% but resulted in lesser time for farm work.

Impact of Farm Mechanization on farmers

The effects of the farm mechanization on the farmers are in the form of new seed, fertilizer technology, new cultural techniques of farming, modern farming implements and changes in the timing of operations.Mechanization affects the coat structure of agricultural production by:

- Saving labour (manual and bullock)
- Easing jobs
- Increasing yield
- Saving land
- Facilitating the opening up of new land
- Conserving natural resources

CHALLENGES FOR FARM MECHANIZATION

Unlike other agricultural sectors, farm mechanization sector in India has a far more complex structural composition. It is facing various challenges related to farm machinery and equipment. These challenges pose a serious impediment to the growth of the industry and agriculture. The key challenges faced by the farm mechanization in India are as follows.

- The average farm size in India is small (1.08 ha) as compared to the European Union (14 ha) and the United States (170 ha). Therefore, there will be little mechanization unless machines appropriate for small holdings are made available. Due to small size of land holdings, it is difficult for the farmers to own machinery. As a result, the benefits of mechanization are enjoyed by only a section of the farmers who have large farm holdings.
- Mechanizing small and non-contiguous group of small farms is against "economies of scale" especially for operations like land preparation and harvesting. With continued shrinkage in average farm size, more farms will fall into the adverse category thereby making individual ownership of agricultural machinery progressively more uneconomical.
- The major constraint of increasing agricultural production and productivity is the inadequacy of farm power and machinery with the farmers. The average farm power availability needs to be increased to minimum 2.5 kW/ha to assure timeliness and quality in field operations, undertake heavy field operations like sub-soiling, chiseling, deep ploughing and summer ploughing.
- Matching equipment for tractors, power tillers and other prime movers are either not available or farmers make inappropriate selection in the absence of proper guidance, resulting in fuel wastage and high cost of production.
- Almost 90 % of tractors are sold in India with the assistance of some financial institution. Sale of farm machinery is driven by factors like financial support, limit of funding (in terms of percentage of the cost), funding/financing institution and the applicant"s profile (deciding the credibility of the loanee).
- The high cost and energy efficient farm machinery are capital intensive and majority of Indian farmers are not able to acquire these assets due to shortage of capital with them
- Cropping pattern decides the extent of mechanization required for timely operations and achieving optimum results. The scope of mechanization increases with intensive cropping

pattern. Price realized by the crop is also an important factor, as it indicates the cash in hand for the farmer.

- Hill agriculture, which covers about 20 % of cultivated land, has little access to mechanization. This situation has to be improved by developing and promoting package of technology for mechanization of hill agriculture to achieve higher productivity.
- There are wide technology gaps in meeting the needs of various cropping systems and regions. The Indian farmers have limited access to the latest equipment and technology. Further, there is little feedback from the farmers for product improvement and product acceptance.
- The quality of farm implements and machinery manufactured by small scale industries in the country is generally not of desired standard resulting in poor-quality work, longer down time, low output and high operational cost. The quality of equipment has to be improved.
- The after sales service of farm machinery is the other concern in India as the majority of farmers are cost conscious. There are inadequate service centers for proper upkeep of the machinery.

Advantages of Farm mechanisation

1. **Increase in the cultivable area:**

   The use of machines like tractor and bulldozers will enable the farmers to bring more areas under cultivation. A large area of barren land can be cultivated more easily.

2. **Irrigation Facility**

   In poor countries the canal irrigation facilities are inadequate. The installation of more tube-wells will relieve the cultivators from uncertainty of water supply which will increase the production.

3. **Transportation Facility**

   Tractor and trolly is also used for transferring the agriculture product from one place to another. A huge amount of product is wasted due to non availability of transport.

4. **Reduction of Cost**

   The use of machinery decreased the cost of production and due to this income of the farmer increases. It also improves the quality of production.

5. **Saving of time**

   The use of machinery saves the time of the farmers which can be utilized for other purpose. Many acre land can be cultivated with tractor in few hours.

6. **Increase in Efficiency**

   The use of machinery increases the efficiency of the worker and rises the out put per worker. So the income and efficiency of workers improves.

7. **Water-logging solution:**

   In poor countries every year thousands acre land is destroyed by the water logging. We can remove the water-logging through installation of tube-wells.

8. **No dependence upon animal power:**

   The use of machinery reduces the dependence upon animal power which is costly and slow. There is always a fear of animal death when it is over burden.

9. **Relief to Farmer :-**

   The use of machinery has relieved the farmer from hard work and has increased the production of agriculture sector. Before the use of machinery ploughing and thrashing was a hard job.

Disadvantages of Farm Mechanization:

1. **Increase in Unemployment**

   In the poor countries the rate of unemployment is already high. So the use of machinery in agriculture has increased the rate of unemployment in the country. It is useful in those countries where labour is not available or labour is costly.

2. **Not Suitable for Small Holding**

   The use of machinery is not profitable for small holdings. The majority of the farmers in underdeveloped countries is the owner of small holdings. For instance, owner of a 5 acre land can not purchase tractor.

3. **Costly Machinery**

   In the poor countries farmer is unable to purchase the expensive machinery due to poverty. While labour is cheap in the poor country. Costly machinery increases the cost of production.

4. **Lack of Technical Knowledge**

   In the underdeveloped countries majority of farmers are uneducated and they cannot handle the machines. So misuse of machinery causes a great loss to the farmer.

5. **Lack of Foreign Exchange**

   Foreign exchange is required to make payments for imported machinery. There is a shortage of foreign exchange in poor countries. So it becomes difficult to import the machinery.

6. **Preparing Facilities**

   In most of developing countries maintenance and repairing facilities are not available in the rural areas. The break down of the machinery will cause delay in agricultural operation.

7. **Lack of Energy Resources :-**

   Oil, Gas, and Electricity are the main source of energy. These are essential for the farm mechanization but there is shortage of these resources in the most of underdeveloped countries. Prices of oil are increasing day by day.

8. **Lack of Capital** :-

   In the developing countries farmers are very poor and they are unable to purchase the tractor and heavy machinery.

9. **Lack of Credit Facilities :-**

   In the poor countries, the credit facilities are inadequate so the farm mechanization can not be adopted.

Conclusion

Keeping in view the above facts we conclude that farm mechanization increases the agriculture productivity. It increases the income, saving and investment of the farmers. In the other word we can say that farm mechanization is very useful for the development of agriculture sector. Now in the today modern world every country has also realized importance of farm mechanization and has encouraged the import of machinery.

Volume: 04 Issue No: 05

PALM OIL CULTIVATION AND ITS ISSUES ON ENVIRONMENTAL HEALTH

Article ID: AG-VO4-I05-74

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Introduction

Oil palm *Elaeis guineensis* is one of the world's most rapidly increasing crops. Oil palm is grown across more than 13.5 million hactre of tropical, high-rainfall, low lying areas, a zone naturally occupied by moist tropical forest, the most biologically diverse terrestrial ecosystem on Earth (Corely *et al.*2003). Oil palm has replaced large areas of forest in Southeast Asia, but land cover change statistics alone do not allow an assessment of where it has driven forest clearance and where it ha s simply followed it. Environmental groups and industry representatives debate the extent to which oil palm has contributed to deforestation (Henson *et al.*2003, Buckland,2005). Oil palm is controversial due to its social and environmental impacts and opportunities. Loss of natural habitats, reduction in woody biomass and peatland drainage that occur during site preparation are the main direct environmental impacts from oil palm development (Sheil et al.2009). Such conversion typically reduces biodiversity and water quality and increase greenhouse gas emissions, and when fire is used, smoke and haze (Meijaard et al.2018; Dislich et al.2017).

The efficiency of its production, low cost and stability of the oil make it the most attractive and widely used vegetable oil in the world. It is ubiquitous in global products, including food , cosmetics, detergents, plastics, industrial chemicals and biofuels. The oil palm yields more oil per land area than any other tropical or temperate oil crops (Sheil,2009), but there are severe environmental and social consequences of the rapidly expanding industry, particularly for those countries producing the product.

Bio-physical Suitability for Palm Oil

Climate: Palm oil trees grow in warm and wet conditions. Mainly four climatic factors are crucial for palm oil cultivation: the average annual temperature, the average temperature of the coldest month of the year, the annual precipitation and the number of months which receives less than 100mm of precipitation (Corley and Tinker,2008).

Soil: Constraining soil factors for palm oil cultivation can be either chemical (nutrient deficiencies) or physical (low water holding capacity) in nature. Optimal conditions are provided by finely structured soils with high clay content, though fairly good yields can also be achieved on loam and silt-dominated soils. Palm oil is also very sensitive to insufficiencies in water provision which are frequent on sand-dominated soils.

Topography: Steep slopes restrict palm oil cultivation in different ways. They increase planting, maintenance and harvesting costs, and shallow soils mean weak anchorage of the plants and surface runoff of fertilizers.

Applications of Palm Oil

Food based applications: Cooking oil, substitute for butter, vegetable ghee, margarine, confectionary and bakery fats, ice cream, coffee creamers, emulsifiers, vitamin E suppliments among others.

Non-food based applications: Cosmetics, soaps and detergents. Oleo chemical industry as a base material for laundry detergents, household cleaners and cosmetics.

According to USDA estimates, 75% of the global palm oil consumption is for food purposes, while 22% is for industrial/non-food purposes. The remaining though currently of marginal quantity, is used for biodiesel.

Issues on Environmental Health

Deforestation: Substantial tracts of tropical forests are cleared to make space for large plantations to service an ever increasing demand for palm oil. A remote sensing assessment found that oil palm plantations covered at least 19.5 Mha globally in 2019, of which an estimated 67.2% were industrial-scale plantings and the reminder smallholders (Descals et al.2020). The overall contribution of oil palm expansion to deforestation varies widely and depends in part on assessment scope and methods. Many studies reported that land use or land cover change involving oil palm. In Malaysian Borneo, oil palm was an important contributor to overall deforestation (Gaveau et al.2014).

Biodiversity Loss: Concerns about biodiversity loss are directly related to the loss of natural forests. In particular, orangutan habitats have been threatened by palm oil production. In 1900, there were around 315,000 orangutans in Indonesia and Malaysia. Today, fewer than 50,000 exist in the wild, split into small groups. The palm oil industry is the biggest threat to orangutans, with the species like to be driven to extinction within 12 years unless the devastation of their natural habitat is halted. A related problem has been that fragmentation of natural forest habitats and encroachment by palm oil development which has been resulted in serious human-wildlife conflicts.

Climate Change: Oil palm plantations, and the production of oil palm can also be sources of Methane and Nitrous Oxide, both potent greenhouse gases that contribute further to climate change, although the former is sometimes used as biogas, reducing net greenhouse gas release (Horsons et al.2014). Other emissions associated with oil palm development include elevated isoprene production by palm trees, which influences atmospheric chemistry, cloud cover and rainfall, although how this affects the environment remains unclear (Hewitt et al.2009). Forest use and land use conversion to oil palm impact the local and regional climate, although the extent of these impacts remains debated.

Direct impacts on Species: Oil palm plantations contain lower species diversity and abundance for most taxonomic groups when compared to natural forest. The IUCN(International Union for Conservation of Nature) Red list Threatened Species documents many species for which oil palm is a reported threat, significantly more than for other oil crops. This is also involves the introduction and spread of invasive species including the oil palm itself, as well as non-native cover crops and nitrogen fixing plants.

Use of Pesticides and Fertilizers: Misuse of pesticides and fertilizers is frequently cited as a negative impact of oil palm cultivation. In general, pesticide use is low compared to many other crops, but some chemicals used, pose significant risks to operators and smallholders and the environment. Fertilizers, pesticides and other chemicals used on plantations also impact water quality and aquatic habitats (Mayer et al.2007). Streams flowing through plantations tend to be warmer, shallower, sandier, more turbid, and to have reduced abundance of aquatic species such as dragonflies than stream in forested areas (Luke et al.2017).

Consumption of Oil Palm in India

Oil palm has dominated Indian imports since the last two decades, for its logistical advantages, contractual flexibility and consumer acceptance change in comsumption patterns, availibility, pricing and policy changes. India is the largest importer of oil palm which is also lowest priced oil. Oil palm contributes to around 74% of the total edible oils that are imported into the country.

Almost 90% of the oil palm imported and produced domestically is used for edible purposes, while the remaining is used for industrial/non-edible purposes. Oil palm is now the single largest consumed vegetable oil in India.

Mitigation Measures

Government, environmental and social organizations, scientists, producers,financial institutions, buyers and consumers together have the capacity to soften the impact of palm oil production on biodiversity. Although the best strategies for impact mitigation will differ within and between countries, there are several emerging opportunities. Governmental and non-governmental organizations can work to develop national strategies for land allocation that integrate maps of conservation priorities and agricultural suitablility. Such strategies give no assurance that impacts are being minimised unless they are integrated into land use allocation and coupled with effective regulatory systems. Producers must be given access to information that will allow them to locate new plantations in areas where they will cause the least ecological damage. There is considerable scope for more widespread use of comprehensive Environmental Impact Assessments of proposed plantations including Life Cycle Analysis to indentify and reduce impacts.

Future of Palm Oil

Demand for agricultural commodities is growing. Meeting the growing demand for palm oil, while adhering to new zero deforestation policies and consumer pressure to be more sustainable, will likely require a combination approaches including increasing yields in existing production areas especially those managed by smallholders and planting in deforested areas and degraded open ecosystems such as man-made pastures.

The extent to which biofuel demand by international markets will drive oil palm expansion remains unclear. There is resistance from environmental non-governmental organization and governments, including the European Union, the second largest importer after

India, to the use of palm oil as a biofuel to replace fossil fuels and meet climate change mitigation goals. Such resistence is related to the high CO_2 emissions from oil palm-driven deforestation and associated peatland development.

Conclusion

For biodiversity, oil palm plantations are poor substitute for native tropical forests. They support few species of conservation importance and affect biodiversity in adjacent habitats through fragmentation, edge effect and pollution. The efforts of some producers to reduce their environmental impacts, especially by avoiding forest conversion must be commended. However, unless governments in producer countries become better at controlling logging, protecting forests and ensuring that crops are planted only in appropriate areas, the impacts of oil palm expansion on biodiversity will be substantial.

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Volume: 04 Issue No: 05

ROVING SURVEY OF TOPSOVIRUS TRANSMITTED BY THRIPS, *THRIPS, PARVISPINUS* IN CHILLI OF DHARMAPURI DISTRICT IN TAMIL NADU

Article ID: AG-VO4-I05-75

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Introduction

Chilli or red pepper (Capsicum annuum L.) is an important spice crop as well as a vegetable crop grown all over India. It is grown for the demand of its pungent fruits, both green and ripe (dried form) to add pungency to the food. As a condiment, it has become indispensable in every Indian home. It is also used for medicinal purpose, chutneys and pickles (Das, 2013; Saleh et al., 2018) . India is the world's largest producer, consumer and exporter of chilies and it's cultivated in an area of 7.67 lakh hectares and the production is estimated to be 12.34 lakh tones (Priyadarshini et al., 2018) and in Tamil Nadu, an area covered by chilli is 2160 hectares with a production of 21350 tones during 2016-17 (NHB, 2017).

Methodology

Roving survey will be conducted in chilli crop at fortnightly interval during the Rabi season during 2023-2024 in Pennagaram and Palacode block of Dharmapuri District. Four villages will be selected in each block for monitoring the pest population and viral disease from 10 Days after transplanting to harvesting stage of chilli crop. Fixe plot survey was also conducted in Pennagaram block during 2023-2024. Daily weather data of temperature (maximum and minimum), relative humidity (morning and evening), rainfall, wind speed, bright sunshine hours and evaporation rates will be recorded in the metrological observatory located within the experimental site of KVK, Dharmapuri.

Results

Palacode block: The thrips and mite population was ranged viz., 0.20 to 3.00 nos/leaves and 0.00 to 1.70 nos/leaves. The mean population of thrips and mite *viz.*, 1.63 nos/leaves and 0.68 nos/leaves in village of Onnappagoundanahalli, Tirumalvadi, Kadamadai and Alamarathampatti at Palacode block of Dharmapuri District. During the survey, the virus incidence was ranged from 3.5 to 9.0 percent. The highest disease incidence of 9.0% in Somanahalli village and lowest incidence of 3.0 % in Elumichanahalli were recorded in Palacode block (Table 1).

Block	**Months**	**Villages**	**Thrip/leaves**	**Mite/leaves**	**Virus incidence (%)**
Palacode	Sep	Somanalli	0.50	0.20	0.0
		Elumichanahalli	**0.20**	0.40	0.0
		Kattampatti	0.70	0.60	0.0
		Indamangalam	2.00	0.30	3.5
	Oct	Somanalli	1.00	0.30	0.0
		Elumichanahalli	1.70	1.20	0.0
		Kattampatti	0.60	0.50	0.0
		Indamangalam	2.30	**1.70**	4.50
	Nov	Somanalli	1.00	1.40	0.0
		Elumichanahalli	2.00	0.30	3.0
		Kattampatti	2.50	1.20	4.50
		Indamangalam	1.90	0.80	0.0
	Dec	Somanalli	**3.00**	1.40	9.0
		Elumichanahalli	2.20	0.60	4.0
		Kattampatti	2.50	0.70	4.0
		Indamangalam	1.40	0.90	0.0
	Jan	Somanalli	1.10	0.80	0.0
		Elumichanahalli	2.00	0.20	4.50
		Kattampatti	1.80	0.00	**0.0**
		Indamangalam	2.10	0.10	**3.5**
Mean			**1.63**	**0.68**	**2.05**

Pennagaram Block: The thrips and mite population was ranged viz., 0.80 to 3.50 nos/leaves and 0.11 to 1.80 nos/leaves. The mean population of thrips and mite viz., 1.88 nos/leaves and 0.74 nos/leaves in village of Onnappagoundanahalli, Tirumalvadi, Kadamadai and Alamarathampatti at Pennagaram block of Dharmapuri District (Table 2). During the survey, the virus incidence was ranged from 2.0 to 9.5 percent. The highest disease incidence of 9.5% in Alamarathampattivillage and lowest incidence of 2.0 % in Onnappagoundanahallivillage were recorded in Pennagaram block (Table 1).

Roving survey on Topsoviurs transmitted by Chill Thrips in Dharmapuri District

Thrips attack on leaves

Thrips on flowers

Topsovirus infected

Roving survey by Scientists

Mite incidence in leaves

Survey on Chilli thrips in leaves

Conclusion

Mean population of thrips, mite and topsovirus in chilli crops 1.63/leaves, 0.68/leaves and 2.05 per cent in Palacode and Pennagaram block of Dharmapuri District. Based this result, precausion will be taken to control the chilli thrips in Chill growing area.

Strategies for following management practice thrips in chilli

The main objective should be to evade further spread of this thrips to other chilli growing areas of i by complete destruction of the infested plants in the specific areas and management.

- Use healthy and pest free seedlings for planting.
- Constant exhaustive monitoring and inspection for its infestation in new areas through surveys in chilli growing areas.
- Collection and destruction of severely infested plants and weeds
- Nipping and destruction of infested top/apical shoots
- Erection of blue sticky traps @ 25-30 per acre for mass trapping adults
- Spraying of NSKE 5% or Neem oil 3% @ 2 ml/L, Pongamia oil @ 3 ml/L, *Vitex negundo* extract @ 50-80 ml/L, etc. or *Beauveria bassiana* @ 4.00 g or ml/L or fipronil 5 % SC @1.5 ml/L or spinetoram 11.7 SC @ 1.0 ml/L

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AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

CITRUS LIMETTA (MOSAMBI): EXPLORING THE CITRUS ELEGANCE

Article ID: AG-VO4-I05-76

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Abstract

Citrus fruits, renowned for their vibrant flavors and nutritional richness, occupy a prominent place in global agriculture and culinary traditions. *Citrus limetta*, known as sweet lime or sweet lemon, holds a distinguished position within the citrus family, captivating enthusiasts worldwide with its distinct flavor, adaptable utility, and cultural resonance. Continued exploration and innovation in citrus cultivation, processing, and utilization are essential for maximizing their potential to promote human health, environmental sustainability, and economic development. Despite their nutritional and economic importance, citrus fruits face challenges such as diseases, pests, and environmental pressures, necessitating sustainable agricultural practices and research efforts to ensure their continued viability. This article endeavors to illuminate the multifaceted essence of *Citrus limetta*, elucidating its botanical intricacies, culinary versatility, nutritional advantages, and global relevance.

Keywords: Citrus fruit, *Citrus limetta*, mosambi peel, nutritional properties, health benefits

Introduction

Citrus limetta, commonly known as Sweet Lemon or Sweet Lime, is a citrus fruit that belongs to the Rutaceae family. It is a medium to large fruit with a round to oval shape, a slightly flattened base, and a distinct nipple on one end. The peel of Citrus limetta is thin, taut, and semi-smooth, with prominent sunken oil glands that give it a textured feel. Inside, the flesh is divided by thin white membranes into 9 to 10 segments, and it is pale yellow, tender, aqueous, and pulpy (**Fig.1**). The fruit can be seedless or contain a few cream-colored seeds. Sweet Lemons emit a sweet, honeyed scent when sliced or scratched and have a mild, floral, sweet, and subtly tangy flavor due to their low acidity (Khan *et al*., 2016). Sweet Lemons, like Citrus limetta, are available year-round and are not true lemons but a natural hybrid between two citrus species. They have been cultivated for centuries in Asia and have spread to regions like the Mediterranean, Middle East, India, California, and Mexico. In Iran, Pakistan, and India, Sweet Lemons are known by various names such as Limu Shirin, Musami, Mosambi, Mausambi, Mitha Nimboo, or Musambi.

Fig.1 *Citrus limetta*, Standout citrus variety

Notable varieties of Sweet Lemons include Millsweet, Moroccan limetta, and the Ponderosa Sweet lemon (Hamid et al., 2024). Traditionally, Sweet Lemons have been used in medicinal beverages for their unique flavor and properties. The fruit is rich in vitamin C and other minerals, such as folate, biotin, calcium, and potassium, making it a valuable source of nutrients. Phytochemical analysis of Citrus limetta has identified the presence of various bioactive compounds, including tannins, alkaloids, flavonoids, glycosides, anthraquinones, phenolic, terpenes, saponins, and essential oils. The primary constituent of *Citrus limetta* is d-limonene, a bioactive compound that offers pharmacokinetic and pharmacodynamic properties (Panwar et al.,2023)

Botanical features and Classification of *Citrus limetta*:

Citrus limetta, commonly known as sweet lime or sweet lemon, belongs to the Rutaceae family, encompassing a wide range of citrus species (**Table 1**). Citrus limetta is a small tree that can grow up to 8 meters in height with irregular branches and relatively smooth, brownish-grey bark. The tree has numerous thorns and produces rounded and oval leaves that are more rounded than those of an orange tree. The blossoms and new leaves are bright purple. The fruit of Citrus limetta is medium-sized, round, and has a distinctively flattened blossom end with a prominent nipple surrounded by a deep areolar furrow. The rind of the fruit is slightly bumpy, pitted with sunken oil glands, and turns yellowish-orange at maturity. The fruit's flesh is pale yellow, low-seeded, and low in acidity, giving the juice a sweet taste (Topi, 2020).

Table 1 Classification of *Citrus limetta*

Division	**Magnoliophyta**
Class	Magnoliopsida
Order	Sapindales
Family	Rutaceae
Genus	Citrus
Species	limetta

***Citrus limetta* production in India:**

India is one of the leading producers of *Citrus limetta*. India's diverse agro-climatic conditions allow for year-round production of sweet lime in different regions, ensuring a steady supply of this popular citrus fruit to domestic markets and fulfilling export demands. The exact production figures may vary from year to year based on factors such as weather conditions, pest infestations, and market dynamics. The production of *Citrus limetta* in India has been described in **Fig.2**.

1. **Nutritional Profile of *Citrus limetta*:**

   Incorporating *Citrus limetta* into your diet can provide a range of health benefits due to its rich nutritional profile, including improved immunity, antioxidant protection, hydration, and support for overall health and well-being (Al-Snafi, 2016). Certainly! Let's delve deeper into the nutritional properties of Citrus limetta, also known as sweet lime or sweet lemon:

   - ✓ **Vitamin C:** Citrus limetta is particularly rich in vitamin C, an essential nutrient that acts as a powerful antioxidant in the body. Vitamin C supports immune function, helps in collagen synthesis for healthy skin, aids in iron absorption, and has anti-inflammatory properties. Sweet lime is often consumed to boost immunity and ward off common colds and infections.

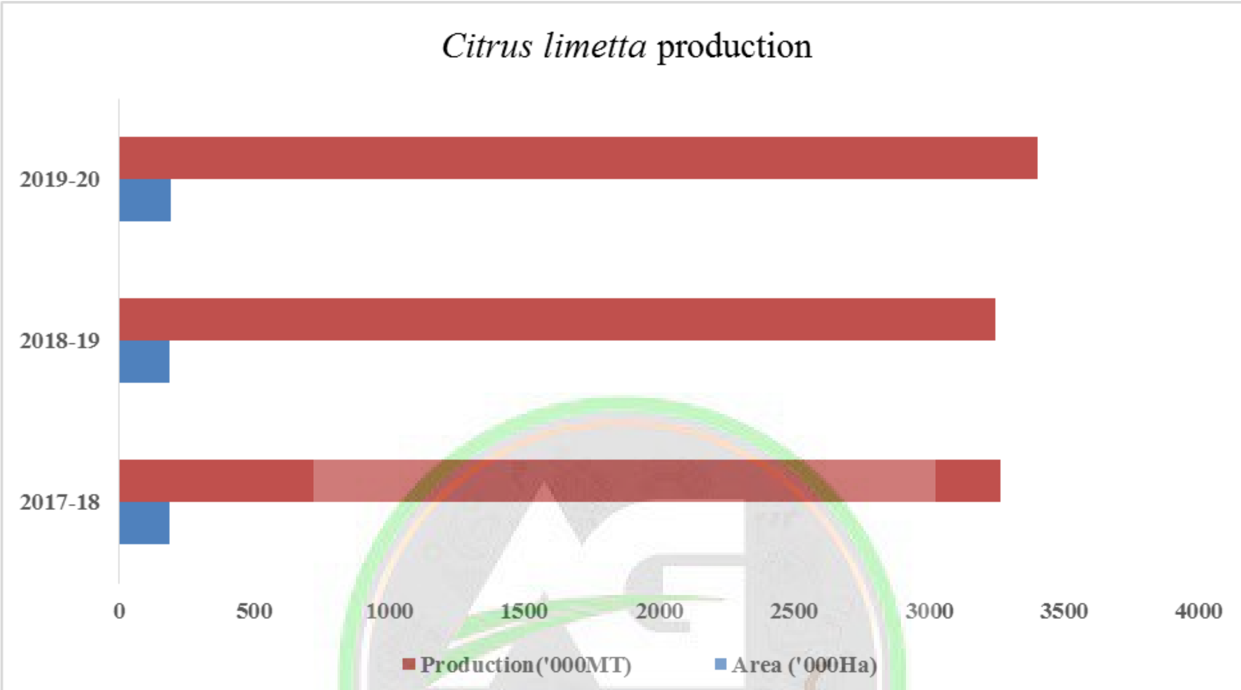

Fig.2 Sweet Lime production during the respective period in India (NHB), (MT-Million Tonnes, Ha-Hectare)

- ✓ **Antioxidants:** In addition to vitamin C, sweet lime contains various antioxidants such as flavonoids, limonoids, and carotenoids. These compounds help neutralize harmful free radicals in the body, reducing oxidative stress and lowering the risk of chronic diseases such as heart disease, cancer, and neurodegenerative disorders.
- ✓ **Dietary Fiber:** While sweet lime is not particularly high in fiber compared to some other fruits, it still provides a small amount of dietary fiber. Fiber is essential for digestive health, promoting regular bowel movements, preventing constipation, and supporting the growth of beneficial gut bacteria.
- ✓ **Hydration:** Like other citrus fruits, sweet lime has a high water content, making it hydrating and refreshing. Adequate hydration is crucial for maintaining overall health and well-being, supporting bodily functions such as temperature regulation, nutrient transport, and waste elimination.

- ✓ **Potassium:** Sweet lime contains potassium, an electrolyte that plays a vital role in regulating blood pressure, muscle function, and nerve signaling. Adequate potassium intake is associated with a reduced risk of stroke, kidney stones, and osteoporosis.
- ✓ **Low in Calories and Fat:** Sweet lime is relatively low in calories and fat, making it a suitable option for those watching their calorie and fat intake. It can be included in weight management diets as a nutritious and satisfying snack or addition to meals.
- ✓ **Vitamin B Complex:** Sweet lime contains various B vitamins, including thiamine (B1), riboflavin (B2), niacin (B3), pyridoxine (B6), and folate (B9). These vitamins play crucial roles in energy metabolism, nerve function, red blood cell production, and DNA synthesis.
- ✓ **Trace Minerals:** While sweet lime is not a significant source of minerals, it does contain trace amounts of minerals such as calcium, magnesium, phosphorus, and iron, which contribute to overall health and various physiological processes in the body.

2. Culinary uses of citrus fruit: Mosambi.

Citrus limetta, or sweet lime, is a versatile fruit that can be used in various culinary applications. Its sweet and tangy flavor, along with its juiciness and versatility, makes it a popular ingredient in various cuisines around the world as depicted in **Fig.3**. Here are some common ways it can be used in cooking:

- ✓ **Fresh Consumption:** Sweet lime can be enjoyed fresh, either by peeling and eating the segments as a snack or by juicing the fruit to make a refreshing beverage. Its sweet and tangy flavor makes it a popular choice for juicing, either on its own or combined with other fruits like oranges or lemons to make mixed citrus juices.
- ✓ **Salads:** Sweet lime segments can be added to fruit salads or green salads to add a burst of citrusy flavor and juiciness. Its sweetness can balance out the acidity of other fruits or the bitterness of salad greens.
- ✓ **Desserts:** Sweet lime juice or zest can be used in various dessert recipes to add a bright, citrusy flavor. It can be used to make sorbets, granitas, fruit tarts, custards, or citrus-flavored cakes and cupcakes. The zest can also be used to add flavor to frostings, glazes, or whipped creams.
- ✓ **Marinades and Sauces:** Sweet lime juice can be used as a base for marinades or sauces for meat, poultry, seafood, or tofu. Its acidity helps tenderize the protein while imparting

a tangy flavor. Sweet lime juice can be combined with ingredients like olive oil, garlic, herbs, and spices to create flavorful marinades or sauces for grilling, roasting, or sautéing.

- ✓ **Beverages:** Sweet lime juice can be used to make a variety of beverages, including cocktails, mocktails, and flavored waters. It pairs well with other fruits like berries, pineapple, or mango in mixed drinks. Sweet lime juice can also be combined with sparkling water or soda to make a refreshing citrus soda.
- ✓ **Preserves and Marmalades:** Sweet lime can be used to make jams, preserves, or marmalades by cooking the fruit with sugar and water until it thickens into a spreadable consistency. The sweet and tangy flavor of sweet lime makes it an excellent choice for preserving and canning.
- ✓ **Chutneys and Salsas:** Sweet lime can be used to make chutneys or salsas by combining diced sweet lime segments with ingredients like onions, cilantro, chili peppers, and spices. Sweet lime chutney or salsa can be served as a condiment with Indian or Mexican dishes, grilled meats, or seafood.

Fig 3. Culinary uses of *Citrus limetta*

Utilization of Mosambi peel:

The peel of Citrus limetta, like other citrus peels, is rich in essential oils and has a vibrant flavor that can be utilized in various culinary and non-culinary applications (Singh et al.,2020).

Here are some ways to utilize C*itrus limetta* peel:

✓ **Zest:** The zest of *Citrus limetta* peel contains aromatic oils that can add a burst of citrus flavor to dishes. Use a fine grater or zester to remove the colored outer layer of the peel, being careful to avoid the bitter white pith underneath. Citrus zest can be used to flavor baked goods, desserts, salads, marinades, sauces, and beverages.

✓ **Infusions:** *Citrus limetta* peel can be infused into liquids such as water, vinegar, oil, or alcohol to impart its citrusy flavor. Simply steep the peel in the liquid for several days to allow the oils to infuse. Citrus-infused liquids can be used in cooking, salad dressings, cocktails, or homemade cleaning solutions.

✓ **Candied Peel:** *Citrus limetta* peel can be candied by simmering it in a sugar syrup until it becomes translucent and sweet. Candied citrus peel can be used as a garnish for desserts, dipped in chocolate, or chopped and added to baked goods such as cakes, cookies, and fruitcakes.

✓ **Dried Peel:** *Citrus limetta* peel can be dried and used as a flavorful addition to herbal teas or potpourri. Simply spread the peel in a single layer on a baking sheet and allow it to air dry for several days, or use a food dehydrator for faster drying.

✓ **Powdered Peel:** Dried *Citrus limetta* peel can be ground into a fine powder using a spice grinder or mortar and pestle. Citrus powder can be used as a seasoning or flavoring agent in spice blends, rubs, marinades, sauces, or baked goods.

✓ **Natural Cleaner:** The oils present in *Citrus limetta* peel have natural cleaning properties and can be used to make homemade cleaners. Combine citrus peel with white vinegar and water to create an all-purpose cleaner for countertops, sinks, and appliances. The acidic properties of citrus peel can help dissolve grease and grime.

✓ **Aromatherapy:** *Citrus limetta* peel can be used in aromatherapy to uplift the mood and reduce stress. Add dried citrus peel to potpourri blends, sachets, or homemade candles to release its invigorating scent into the air.

Mosambi peel used as a substrate:

The peel of *Citrus limetta* has been explored for its potential use in the production of enzymes due to its rich content of bioactive compounds. Enzymes are biocatalysts that facilitate biochemical reactions and are widely used in various industrial processes, including food processing, pharmaceuticals, and biofuel production. Research suggests that the peel of Mosambi contains enzymes such as pectinase, cellulase, amylase, and protease, among others (**Fig.4**).

These enzymes play crucial roles in breaking down complex molecules into simpler forms, which can be utilized in different applications. The utilization of Mosambi peel in enzyme production underscores its potential as a valuable resource in biotechnological applications, offering opportunities for innovation and sustainability in various industries (Suri *et al*.,2022).

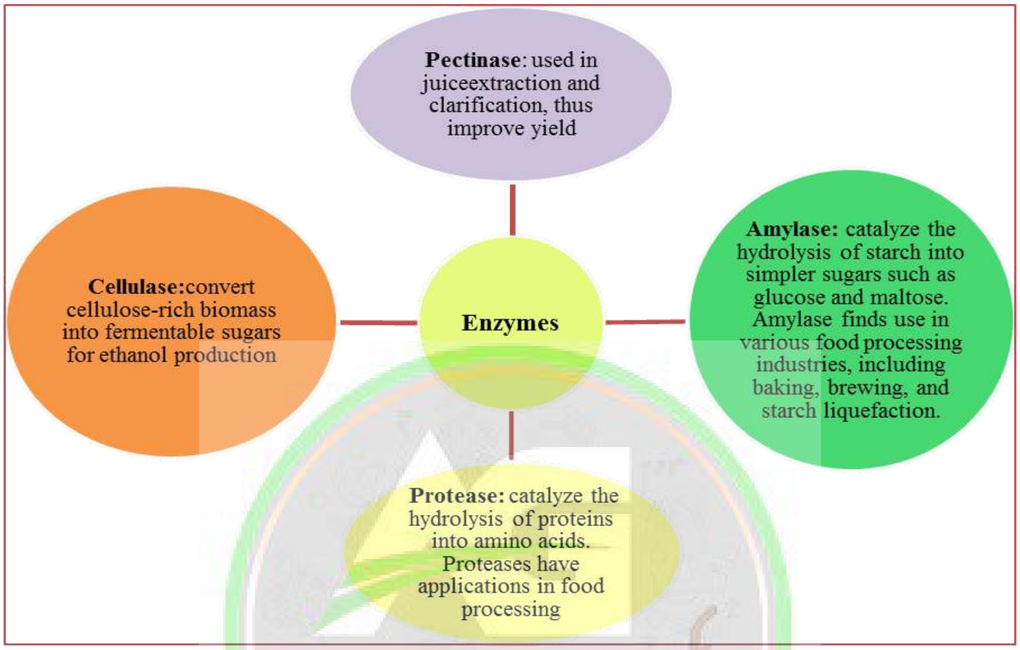

Fig.4 Enzymes production using Mosambi peel as a substrate with their industrial applications

Health benefits of Citrus fruits:

Citrus limetta, commonly known as sweet lime or mosambi, is a citrus fruit with notable nutritional properties. This fruit is low in acidic content and is rich in essential nutrients beneficial for health. A serving of sweet lime provides approximately 50 mg of vitamin C, which accounts for about 22% of the daily dietary requirement. Additionally, sweet lime contains iron, calcium, vitamin B6, and thiamine. It is also a good source of antioxidants, potassium, niacin, riboflavin, phosphorus, and magnesium in small amounts In Ayurveda, sweet lime is recommended for balancing the doshas of vata and pitta while aggravating kapha dosha. It is described as sweet to taste and hard to digest. However, moderation is key to avoiding digestive issues like nausea and vomiting (Lv et al.,2015). These properties make *Citrus limetta* a valuable addition to a balanced and nutritious diet, offering a range of health benefits due to its rich nutritional profile and antioxidant content as shown in **Fig.5.** The health benefits of sweet lime include:

- ✓ **Prevention of Kidney Stones:** Regular consumption of citrus fruits like sweet lime can help decrease the chances of developing kidney stones and aid in naturally flushing them out.
- ✓ **Urinary Tract Infection (UTI) Prevention:** Sweet lime's potassium content can help combat UTIs and improve urinary health.
- ✓ **Heart Health:** Sweet lime consumption can enhance heart performance by reducing high blood pressure and preventing plaque formation in the arteries.
- ✓ **Skin and Hair Health:** The vitamin C in sweet lime promotes collagen production, which helps maintain skin elasticity, reduces signs of aging, and strengthens hair follicles.
- ✓ **Digestive Health:** Sweet lime aids in dealing with digestive issues, stimulates appetite, fights scurvy, and maintains electrolyte balance.
- ✓ **Antioxidant Properties:** The antioxidant-rich nature of sweet lime helps avert the risk of cancer, boosts immunity, and aids in detoxification.

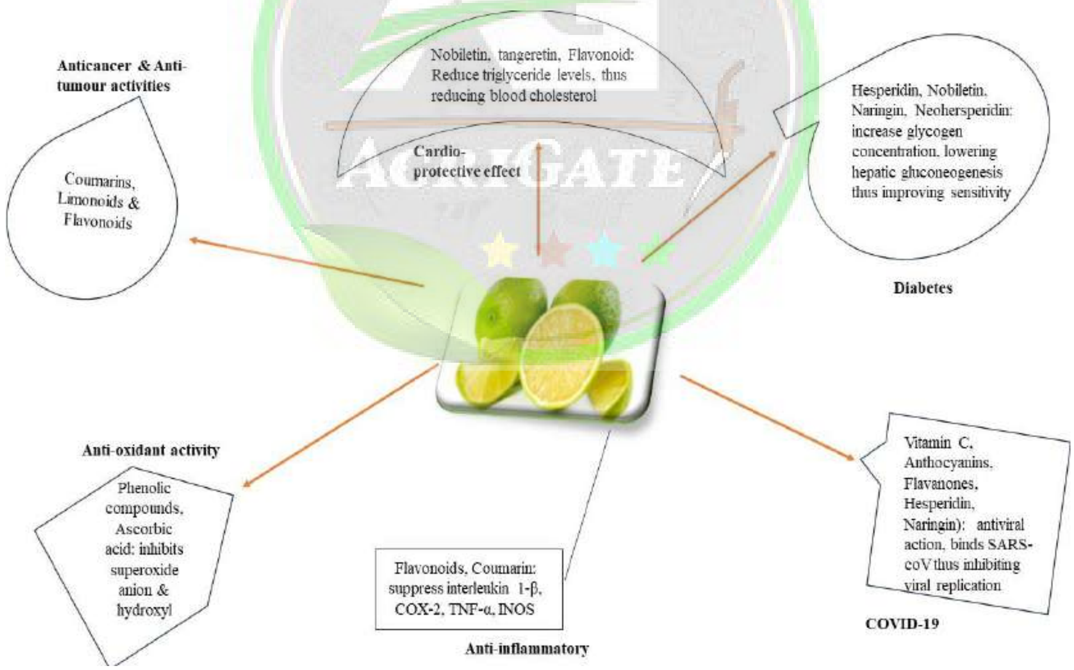

Fig 5. Bioactive compounds present in Citrus limetta and their crucial role in the health world

Conclusion

Mosambi citrus fruit stands out as a delightful combination of flavor, nutrition, and cultural significance. Whether enjoyed fresh, juiced, or incorporated into culinary creations, Mosambi offers a multitude of benefits for both the palate and overall health. Its rich nutritional profile, versatile culinary uses, and cultural significance make it a valuable addition to any diet. So, the next time you crave a refreshing beverage or a zesty dessert, consider reaching for a Mosambi-it's a choice that's as delicious as it is nutritious. Citrus limetta is a valuable fruit that not only delights the taste buds but also offers a range of health benefits and practical applications, making it a beloved addition to kitchens and households around the world. With their unique combination of sweetness and citrusy goodness, sweet limes are a delicious and healthy addition to any diet.

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AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

KVKS GOLDEN JUBILEE TORCH: A VOYAGE OF METAMORPHOSIS IN AGRICULTURE

Article ID: AG-VO4-I05-77

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Introduction

On March 21 this year, KVKs completed 50 years of their establishment. Their voyage since the establishment of first KVK in the country in 1974 has driven agriculture in the country to new heights and bringing in the desired metamorphosis in this sector. The Indian Council of Agricultural Research (ICAR) organized special functions to commemorate the Golden Jubilee Celebration of the establishment of KVKs. On this Occasion Prof. Himanshu Pathak Director General ICAR and Secretary, Department of Agricultural Research and Extension (DARE) in his video message duly acknowledged the role of KVKs in transfer of technologies that resulted in increasing the food grains and horticultural production in the country. Dr. U. S. Gautham in his address highlighted how KVKs have been transformed from a mere training institute to a Single Window Agricultural Knowledge and Capacity Development Centre. Further, to commemorate the Golden Jubilee of KVKs, Secretary DARE and Director General (ICAR) also inaugurated the voyage of the ICAR-KVK Golden Jubilee Torch in Zone-V comprising Odisha, West Bengal and Andaman & Nicobar Islands from ICAR-KVK (A), Nadia. The KVK Golden Jubilee Torch relay symbolizes the spirit of KVK service to the farming community and simultaneously is being carried out in all 11 ATARIs' as a part of the Golden Jubilee celebrations of KVKs.

Education commission

All it started happening when the second education commission (1964-66) headed by Dr. D. S. Kothari recommended for the establishment of agricultural polytechnics to provide vocational education in agriculture to school drop outs and other rural youths. After threadbare deliberations by the representatives of Ministry of Education, Ministry of Agriculture and the Planning Commission (NITI Aayog); the Indian Council of Agricultural Research (ICAR) as a follow up to the recommendations emerging out of the deliberations constituted a committee in 1973 under the chairmanship of Captain Mohan Singh Mehta of Udaipur to work out a comprehensive plan for establishment of such institutes. Captain Mohan Singh Mehta thus came up with the institutional design in the form of Krishi Vigyan Kendra (KVK) and the first KVK was established in the year 1974 in Pondicherry (now Puducherry) under the administrative control of Tamilnadu Agricultural University (TNAU) Madras in Tamilnadu. Since the establishment of first KVK in 1974, these district level institutes are at the forefront of technology dissemination and a vital and integral part of the National Agricultural Research System (NARS) of the country. Their role and contribution in the agricultural sector of the country has been immense. The country at present has 731 KVKs of which 545 districts in the country have one KVK each and there are 93 districts sin the country which have two KVKs.

Cluster Front Line Demonstration (CFLD) programme

The Cluster Front Line Demonstration (CFLD) programme of the KVKs has been instrumental in augmenting pulse production in the country from an average of 17.70MT to 27.80 MT in 2022-23. The Crop Residues Management initiatives in 60 districts of four states have led to a remarkable 52% reduction in crop residue burning incidents contributing significantly to sustainability of the environment. The District Contingency Plans by the KVKs have provided a comprehensive framework for managing weather aberrations, offering vital support to both line departments and the farming community as well. The Integrated Farming System Models across 26 states /UTs including 31 bankable IFS for 22 states have helped increasing net income of farmers by 39% and have improved dietary diversity scores by 8.57%. The adoption of KVK recommended technologies have led to a notable increase of 42% in the productivity housing and health care of the farmers. Each KVK trains around 100 persons annually of which 25% of trainees go for establishment of self employment ventures. 425 KVKs in the country are instrumental in promoting natural farming in the country by organizing awareness and sensitization programmes, demonstrations and capacity building programmes. Kisan Sarthi a digital platform has over 1.74 million registered farmers and has sent more than 5.8 crore advisories. KVKs have embraced drone technology to mechanize farming in the country. A study done by International Food Policy Research Institute (IFPRI) revealed that

KVK interventions have resulted in an additional net farm income of rupees 5752/ha demonstrating their effectiveness in enhancing farmers' livelihood.

With the passage of time KVKs mandate has changed from a single commodity approach to a broad based that now includes not only cereal crops but to other crops like horticultural, medicinal, oilseed, pulses and all other crops that are grown within the concerned district. Besides, KVKs are now training young person to become entrepreneurs, providing farm and weather advisory services, celebration of important days, and in devising technologies that help in drudgery reduction. There is also a lot of reporting work in the KVKs. So a meagre strength of six, finds itself overloaded and difficult to cope with the increasing responsibilities. Also a single KVK in districts having population in crores is not sufficient to cater to the needs of all.

A high powered committee on management of KVKs was set up under chairman ship of Dr. R. S. Paroda. It came up with a slew of recommendations regarding the Krishi Vigyan Kendra. It recommended the change of vision of KVKs to 'Science and technology-led growth leading to enhanced productivity, profitability and sustainability of agriculture', where as the Mission should be 'Farmer-centric growth in agriculture and allied sectors through the application of appropriate technologies in specific agro-eco system perspective'. The new mandate of the KVKs as recommended by Paroda Committee was 'Technology Assessment and Demonstration for its wider Application and Capacity Development' (TADACD). It also called for an additional Krishi Vigyan Kendra in the district be established only based on specific criteria such as large rural population, bigger geographical area, higher net sown area, relative Executive Summary backwardness norms of the district, more Tribal/Scheduled Caste/Scheduled Tribe population, and those in mountainous (above 5000 feet above mean sea level) and difficult/border areas.

National Institute of Labour Economics Research and Development (NILERD)

A third party evaluation of KVKs carried out by National Institute of Labour Economics Research and Development (NILERD), an autonomous institute under NITI Aayog in 2018 came out with findings which reveal that the KVKs all across the country are doing a tremendous job accomplishing and achieving many milestones. The evaluation found that KVKs are playing a proactive role in transferring new technology at field level with beneficial impacts and that these institutes have an edge over other service providers by virtue of having better technical expertise and demonstration abilities. The technologies demonstrated by KVKs were immediately adopted by 40 percent of the farmers and 25 percent adopted them by the next agricultural season. On an average a KVK covers 43 villages and 4300 farmers every year and 80% of villages covered are 10 kilometers away from KVK. The evaluation further said that 96 percent of the farming queries were attended by the KVKs and 42% technologies adopted by farmers resulted in higher productivity and 20 percent resulted in drudgery reduction. About 25% of the persons trained by KVKs started their own self employment ventures.

The Way Forward: In the present era when agriculture is facing challenges like Climate Change, non remunerativeness and farmers are leaving agriculture and youths not interested in it, KVKs have also to redefine their strategies and double their efforts for the welfare of the farming communities. Besides technology transfer and trainings/various skill development initiatives; KVKs have to assist the farmers in becoming successful entrepreneurs. At the grassroots level, the KVKs have to promote the concept of farming as an agribusiness entity through promotion of various startups. The much needed interventions to feed the growing population on a sustainable basis have to come from KVKs. KVKs have to become a comprehensive hub for providing one stop solution of the farming community related to supply of inputs, technical knowledge, weather based agro advisories, market related information, risk coverage and insurance, ensuring remunerative price of the produce by development of appropriate linkages, value addition and processing of the produce, mobilization of the farming community through collective associations like SHGs and Farmer Producer Organizations (FPOs).

Over the years, these institutions have emerged as grass root level institutions on whom the farming community relies without any second thought. They symbolize growth; a growth that is based on the pillars of inclusion, sustainability, profitability and empowerment.

Volume: 04 Issue No: 05

SUB CLINICAL MASTITIS IN DAIRY CATTLE – DIAGNOSTIC IMPLICATIONS

Article ID: AG-V04-I05-78

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Introduction

Mastitis is inflammation of the parenchyma of mammary glands characterized by bacteriological changes in milk, milk production and pathological alteration in glandular tissues. It is one of the leading diseases of dairy cattle that potentially affect farmers' economy due to reduction in milk yield, milk discard after treatment, cost of treatment, and premature culling. Mastitis is categorized as clinical and subclinical mastitis based on signs and changes in milk quality and quantity of affected cows. Diagnosis of subclinical mastitis (SCM) is difficult than clinical mastitis. This paper delves some of the latest diagnostic tools for the detection of sub clinical mastitis.

Economic impacts of subclinical mastitis in dairy cow

Subclinical mastitis has a negative influence on the performance of dairy cows and buffaloes. It has a significant impact on production, nearly 10 - 20% decrease in milk production, as it causes an undesirable effect on the milk constituents, which affects its nutritional value and renders it unfit for processing and consumption (Iraguha et al., 2015). It includes reduced milk production, changes in milk quality and treatment cost. Rathod et al. (2017) estimated the economic losses due to subclinical form of mastitis were approximately in the range of INR 21,677 to INR 88,340 per animal for a lactation period. It has been reported that SCM causes threefold more production losses as compared to clinical mastitis leading to substantial economic losses of 60-70% all due to mastitis.

Etiology of subclinical mastitis in dairy cattle

The foremost causes of SCM in dairy animals are due to many factors such as unhygienic management, nutritional deficiency and several pathogens. The bacterial etiology are Streptococcus agalactia and Staphylococcus aureus, Nocardia spp., Mycoplasma spp. and environmental Streptococci.

Host factors and environmental factors play an essential role in the occurrence of the disease in animals. A wide range of microorganisms can enter the mammary gland through the teat canal and cause disease. Sources of environmental exposure are unhygienic managemental conditions such as contaminated manure, bedding, feeds, dirt, mud and water.

Nutritional factors:

The number of lactations, metabolic stress and protein-energy ratio may affect the immune system and induce the cause of mastitis in animals. Bronzo et al., (2020) opined that immunosuppression can be linked to metabolic disturbance and changes in the modulation of immune system, which may lead to mastitis and reduce milk production.

Diagnosis

Early detection of SCM and identification of the causative agent are crucial for control and treatment. These measures are fundamental in reducing costs, reducing losses in milk yield and milk quality, and increasing the cure rate of the infected animals.

Mammary infection is determined with a cell number above 200,000 cells/mL. In addition, long-term elevated SCC levels suggest that the affected quarters are in a state of chronic inflammation and may interfere with the development of lactating tissues. Somatic cell count (SCC) has been proved to also be affected by parity, milking time, milking frequency, season, and udder infection.

New technologies, such as metabolomics, are emerging as tools for diagnosing and preventing mastitis. Metabolomics evaluates different changes in metabolites in affected cows in order to find effective biomarkers for timely and accurate prevention. Some interesting findings have been highlighted in two studies. This implies gas chromatography–mass spectrometry (GC-MS) on blood, finding as reliable the subclinical mastitis markers valine, serine, tyrosine, and phenylalanine 4–8 weeks pre-partum and valine, isoleucine, serine, and proline 4–8 weeks post-partum..

On-Farm Diagnostic Tools for the detection of Sub Clinical Mastitis

Mammary Ultrasound

Ultrasonography is a non-invasive method for the diagnostics of various physiological and pathological conditions of the reproductive organs of ruminants.

Blood Gas Analysis

Hematobiochemical testing is a useful and reliable indicator of the severity of syndromic conditions and is also a valuable tool in the diagnosis and prognosis of many diseases. Blood gas analysis is already extensively used in the evaluation and management of multiple pathologic condition.

California Mastitis Test

Milk is appropriately collected in the CMT paddle, and an equivalent amount of the reagent (sodium alkyl aryl sulfonate) is added using a horizontal swirling motion for about 10–15 s. Sodium alkyl aryl sulfonate is an anionic surfactant that decreases surface tension, changes the structure and conductivity of cell membrane and nucleus, interferes with the osmotic balance, blocks oxidization, stimulates proteolytic enzymes, and increases milk viscosity. The formation of gel reflects a leucocyte count of 200,000 to 5,000,000, indicative of SCM

Infra-Red Thermography

The physical principal at the basis of the Infra-Red Thermography (IRT) is that a body that has a temperature higher than absolute zero emits electromagnetic radiation in the infrared spectrum. The relationship between the energy emitted by the body surface, the wavelength of this radiation and the temperature of the body is mathematically described. This radiation can be detected through a sensor array and used to build a thermographic image where the intensity, or the color, of each pixel is proportional to the corresponding temperature of the surface observed.

Volume: 04 Issue No: 05

TRADITIONAL RECIPES OF KUMBARKOPPA: A SMALL VILLAGE IN KARNATAKA

Article ID: AG-VO4-I05-79

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Introduction

Foods and recipes that have been passed down through the generations or that have been consumed for a long time are considered traditional foods. Foods and dishes that are considered traditional may have historical precedents in national, regional, or local cuisine.

Importance of traditional foods

Traditional foods reflect culture and, they often provide essential nutrients as well. These foods support general health and wellbeing since they are high in dietary fibre, vitamins, minerals, and antioxidants.

Traditional food specialty

Using age-old culinary techniques that have been handed down through the years, traditional cuisines are frequently produced with fresh, locally sourced ingredients. Consequently, compared to processed or fast foods, they are typically healthier and higher in nutrients.

Customary recipes are associated with a sense of identity and belonging and are frequently firmly anchored in cultural history. They connect people to their roots and save culinary legacies for coming generations by narrating tales of ancestors, rituals, and traditions.

Importance of Traditional recipes

Recipes offer a systematic collection of instructions that walk us through the process of making a particular food. They provide a consistent outline of the necessary components, amounts, methods, and cooking procedures. They guarantee that a dish can be cooked consistently so that the same outcomes may be achieved by multiple people.

About Kumbarkoppa

The village Kumbarkoppa is located in Dharwad Taluk of Dharwad District in the State of Karnataka in India. It is governed by Arwatagi Gram Panchayat. It comes under Dharwad Community Development Block. The nearest town is Alnavar, which is about 8 kilometers away from Kumbarkoppa.

Totally 430 families are residing in Kumbarkoppa village. The village has population of 2073 of which 1053 are males while 1020 are females as per Population Census 2011. The population of children with age 0-6 is 301 which makes up 14.52 % of total population of village. Average Sex Ratio of Kumbarkoppa village is 969 which is lower than Karnataka state average of 973. Child Sex Ratio for the Kumbarkoppa as per census is 1007, higher than Karnataka average of 948. The literacy rate in Kumbarkoppa village was 63.32 percent in 2011, while Karnataka's figure was 75.36 percent. In Kumbarkoppa, the percentage of male literacy is 71.87 percent, while the percentage of female literacy is 54.43 percent. The village has 536 hectares in total, with 419.5 hectares dedicated to forest cover and 103.09 hectares covered by irrigation

About the traditional recipes of Kumbarkoppa village

Under the Nutri Smart Village initiative, Kumbarkoppa village was taken up by the University of Agricultural Sciences, Dharwad, Karnataka's All Indai Coordinated Research Project - Women in Agriculture (family Resource Management). PRA, group discussions with Panchayat members, and Anganwadi/school instructors were held in order to gather the fundamental data of Kumbarkoppa village. Data regarding the socioeconomic standing of one hundred rural households in the village of Kumbarkoppa was gathered. In addition to the socioeconomic status of the rural homes, the traditional recipes of Kumabarkoppa village were gathered through conversations with older women and recorded. These recipes are covered in the section below.

a. Halad Soppu or Tagate Soppu

During the rainy season, this grows in profusion in the village areas. Delightful delicacies like patrode and palya are prepared from its twigs and leaves.

Materials required


Tagate Soppu/ Halad Soppu

Onion

Chili

Turmeric powder

cooking oil

Soaked moong dal

Salt to taste

Method of Preparation

After frying, rinse, and squeeze the leaves.

Add onions, green chilies, and soaked dal to a skillet of heated oil. Once cooked, ten minutes at low heat are required. Add turmeric powder to suit and salt taste.

Nutritional Importance: Rich in iron, vitamins and minerals.

b. Drumstick leaves playa

Materials required


2 cup Drumstick leaves / nugge soppu

2-3 tbsp Moong Dal

3-4 Green Chilli, Slit

2-3 tbsp grated fresh Coconut

1/4 tsp Turmeric

Curry Leaves

1 tsp Mustard seeds

1 broken Red Chilli

1-2 tbsp Cooking oil

Salt to taste

Method of Preparation

Separate the leaves from the stalk and wash it thoroughly. Roughly chop them.

In a kadai, heat the oil, add the mustard seeds and urad dal, and let it sputter. Add the turmeric, moong dal, red chilli, and curry leaves afterwards.

Add the drumstick leaves, green chilli, and salt to taste after sautéing for two to three minutes. Add a little water and sauté for one to two minutes.

After the leaves are cooked, add the grated coconut, stir, and sauté for one to two minutes. Cook and cover the leaves until they are soft.

c. Gouli Soppu

Materials required

Gouli Soppu

Onion

Chili

Turmeric powder

cooking oil

Soaked moong dal

Salt to taste

Method of Preparation

Fry the leaves, wash them in water and squeeze it.

Heat oil in a pan, add onions, green chillies and soaked dal. After cooking, add salt to taste and turmeric powder and cook on low flame for ten minutes.

Nutritional Importance: Rich in iron, vitamins and minerals.

d. Kumbala Sedi/ Pumpkin tender leaves Palya

Materials required

Kumbala Sedi/ Pumpkin tender leaves

Soaked gram

Raw chillies

Onion

Garlic

Turmeric powder

Salt to taste

Oil

Method of preparation

Clean the fragile Kumbala Sedi/pumpkin leaves.

Add the green chilli, garlic, onion, turmeric powder, soaked gramme, and salt to taste to a pan of oil.

Add the finely chopped tender leaves and simmer over low heat.

e. **Haravi Soppu**

Materials required

Haravi Soppu

Raw chillies

Onion

Garlic

Turmeric powder

Salt to taste

Oil

Method of preparation

Clean the haravi soppu.

Add the green chilies, garlic, onion, turmeric powder, and salt to taste to a pan with oil in it.

Add the finely chopped tender leaves and simmer over low heat.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

VERTICAL FARMING IS REVOLUTIONIZING AGRICULTURE AND HORTICULTURE

Article ID: AG-V04-I05-80

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Introduction

Vertical farming represents a revolutionary approach to agriculture, challenging traditional methods by cultivating crops in vertically stacked layers instead of sprawling fields. This innovative farming technique harnesses cutting-edge technology to optimize resource efficiency, maximize crop yields, and mitigate environmental impact. By leveraging controlled indoor environments, hydroponic or aeroponic systems, and advanced automation, vertical farming addresses pressing challenges such as land scarcity, water scarcity, climate change, and food security. As urbanization accelerates and global population increases, vertical farming emerges as a sustainable solution to produce fresh, nutritious food closer to consumers, reducing transportation emissions and preserving natural resources. With its potential to revolutionize food production, vertical farming heralds a new era of agricultural sustainability and resilience in the face of future challenges.

Vertical farming is rapidly transforming traditional agricultural and horticultural practices by offering innovative solutions to address various challenges such as limited land availability, water scarcity, and climate change. This article explores the significant impact of vertical farming on the agriculture and horticulture industries, highlighting its benefits, technologies, and potential for sustainable food production.

Vertical farming offers several significant advantages

Space Efficiency: Vertical farming allows cultivation in vertically stacked layers, maximizing land use. This is particularly valuable in urban areas where space is limited.

Water Conservation: Many vertical farming systems use hydroponics or aeroponics, which require significantly less water compared to traditional soil-based agriculture.

Year-Round Production: Vertical farming can control environmental factors like light, temperature, and humidity, enabling year-round crop production regardless of external conditions.

Reduced Transportation: By locating farms closer to urban centers, vertical farming reduces the need for long-distance transportation of produce, cutting down on carbon emissions and preserving freshness.

Food Security: Vertical farming can be implemented in regions with harsh climates or limited arable land, improving food security by providing a consistent supply of fresh produce locally.

Pesticide-Free Environment: Controlled indoor environments in vertical farms reduce the need for pesticides and herbicides, leading to healthier, chemical-free produce.

Innovation Hub: Vertical farming fosters innovation in agriculture, including advancements in technology, automation, and sustainability practices, which can benefit the broader agricultural sector.

Addressing Urbanization Challenges:

As urbanization continues to expand, the availability of arable land for traditional farming diminishes. Vertical farming utilizes vertical space in urban environments, enabling food production closer to consumers, reducing transportation costs, and mitigating environmental impact.

Maximizing Crop Yield:

Vertical farming optimizes crop yield through controlled environments, leveraging technologies such as hydroponics, aeroponics, and LED lighting. By adjusting factors like temperature, humidity, and light intensity, farmers can cultivate crops year-round, independent of external weather conditions.

Conserving Water Resources:

Traditional farming methods often require substantial water usage, contributing to water scarcity issues. Vertical farming employs hydroponic systems that use significantly less water compared to conventional soil-based agriculture. Additionally, water recycling and closed-loop systems further minimize water wastage.

Reducing Environmental Footprint:

Vertical farming reduces the environmental footprint associated with conventional agriculture by minimizing land use, pesticide and fertilizer usage, and carbon emissions from transportation. Sustainable practices such as renewable energy integration and organic cultivation methods enhance environmental stewardship.

Enhancing Crop Diversity and Quality:

Vertical farming facilitates the cultivation of a wide range of crops, including leafy greens, herbs, fruits, and vegetables, in controlled environments. By optimizing growing conditions, farmers can enhance crop quality, flavor, and nutritional value, meeting consumer demand for fresh, locally-grown produce.

Promoting Food Security and Resilience:

Vertical farming enhances food security by decentralizing food production, reducing dependency on external food sources, and mitigating supply chain disruptions. In regions susceptible to natural disasters or climate extremes, vertical farms offer a resilient solution for consistent food access.

Future Outlook and Challenges:

Despite its numerous benefits, vertical farming faces challenges such as high initial investment costs, energy consumption, and scalability issues. Continued research and technological advancements are essential to optimize efficiency, affordability, and scalability for widespread adoption.

Conclusion

Vertical farming represents a paradigm shift in agriculture and horticulture, offering sustainable solutions to meet the growing global demand for food while addressing environmental, economic, and social challenges. By harnessing innovative technologies and practices, vertical farming has the potential to revolutionize food production, promote food security, and foster a more resilient and sustainable future.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

MINED OUT SOILS

Article ID: AG-V04-I05-81

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Introduction

Mining is the process of extracting useful materials from the earth. Some examples of substances that are mined include coal, gold, or iron ore. Iron ore is the material from which the metal iron is produced. The process of mining dates back to prehistoric times. Prehistoric people first mined flint, which was ideal for tools and weapons since it breaks into shards with sharp edges. The mining of gold and copper also dates back to prehistoric times.

These profitable substances that are mined from the earth are called minerals. A mineral is typically an inorganic substance that has a specific chemical composition and crystal structure. The minerals are valuable in their pure form, but in the earth they are mixed with other, unwanted rocks and minerals. This mix of rock and minerals is usually carried away from the mine together, then later processed and refined to isolate the desired mineral.

Mining and its types

Mining is the extraction of minerals and elements of economic interest from the earth's surface. Mining and subsequent processing of strategic elements can be harmful to the environment.

The two major categories of modern mining include surface mining and underground mining.

In surface mining, the ground is blasted so that ores near Earth's surface can be removed and carried to refineries to extract the minerals. Surface mining can be destructive to the surrounding landscape, leaving huge open pits behind. In underground mining, ores are removed from deep within the earth. Miners blast tunnels into the rock to reach the ore deposits. This process can lead to accidents that trap miners underground.

Harmful effects of Mining

Along with accidents, a career in mining can also be dangerous since it can lead to health problems. Breathing in dust particles produced by mining can lead to lung disease. One of the most common forms is black lung disease, which is caused when coal miners breathe in coal dust. Many other types of mining produce silica dust, which causes a disease similar to black lung disease. These are incurable diseases that cause breathing impairment and can be fatal.

The mining process can also harm the environment in other ways. Mining creates a type of water pollution known as acid mine drainage. First, mining exposes sulfides in the soil. This causes soil pollution. When the rainwater or streams dissolves the sulfides, they form acids. This acidic water damages aquatic plants and animals. Along with acid mine drainage, the disposal of mine waste can also cause severe water pollution from toxic metals. The toxic metals commonly found in mine waste, such as arsenic and mercury, are harmful to the health of people and wildlife if they are released into nearby streams.

How is mining related to soil ?

The sequence of surface mining involves the previous removal of the original soil horizons, to then remove overburden rocks. After extraction, the topographic reconstruction occurs, in which there is the return of the overburden rocks to fill the previous stripped area, and finally, the surface is leveled and topsoil is deposited to finish topographic recomposition, creating an anthropogenic soil . Mining entails the removal of vegetation, soil seed-banks, and topsoil layers, which alters the landscape, changing surface and subsurface hydrology, and causing soil quality deterioration (Martins et al., 2020). Therefore, the ecological restoration of mining areas presents a significant challenge.

Distribution of mine lands

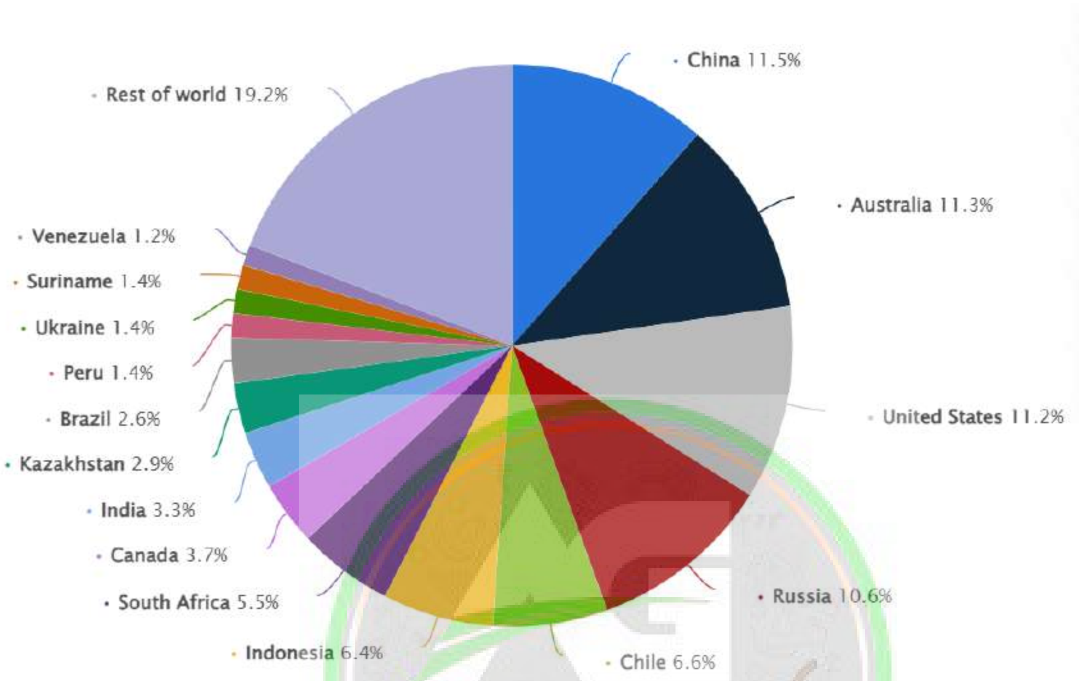


Fig -1: Worldwide distribution of mine lands

Source: Statistica,2023

Fig-2: Areas under mining in Tamil Nadu

Source: mapsofindia.com

Anthropogenic soils

Anthropogenic soils are soils that have been influenced, modified, or created by human activity. They are found worldwide in urban and other human-impacted landscapes. Four distinct types of anthropogenic soils can be distinguished based on geographical setting and historical context:

- ✓ Agricultural
- ✓ Archeological
- ✓ Mine-related
- ✓ Urban.

Mine soils

Mine soils, as the result of the mining and reclamation process, compared to the contiguous native soils, are much younger soils with properties more determined by human-controlled influences rather than by natural processes. Their profile morphology can roughly be described as mainly composed of two layers, a surface layer made by the topsoil (the native soil A horizon) abruptly lying over a overburden layer. After few years of revegetation and exposure to climatic conditions, even in topsoil substitute layers, these young A horizons start to be loosened by root growth and organic matter accumulation and decomposition, developing color darkening and some soil structure. Also, the surface mining may accelerate the soil-forming processes by breaking up the consolidated rocks of the overburden layers allowing air, water, and plant roots to penetrate this layer.

Properties of mine soils

The original soil profiles have been disrupted to a depth of at least 1m, and sometimes partially or completely replaced by earth materials from depth below. These new materials are often less weathered than the original soil. Mine soils inherit their properties from the material used to create them. They have a different distribution of C, N, pH, clay, and microorganisms than natural soils do. This lack structure may decrease infiltration and increase runoff and erosion although properly prepared mine soils have been found to be productive than the natural soils destroyed during mining.

As the soil materials derived from these different horizons exhibit different shares in mechanical mixtures, the resulting mine soil materials may possess very different qualities compared to the original soil. Overall, mine soils tend to be poor. In general, mine soils contain very low levels of organic C, poor nutrient availability (N and P), acidic pH, signs of compaction, poor structure, low water holding capacity, and low biomass productivity, whereby all these properties limit the quality, ability, and function of mine soils as a plant substrate.

- The particle size distribution was dominated in general by silt (41.3 – 51.2%) followed by clay (28.7 – 38.0%) and sand (10.8 – 29.5%).
- The bulk density range rated as productive soils, namely, natural soils typically exhibit a bulk density from 1.1 to 1.5 g cm^{-3} .
- Chemical analysis revealed that the pH values of the mine soils ranged from 4.7 to 5.6.
- In addition to the lower pH of the mine soil, it exhibited higher levels of organic C, total N and available P.
- The organic C and total N levels ranged from 0.66 to 2.09% and 0.08–0.19%, respectively.
- The available P_2O_5 levels ranging from 3.0 to 12.2 mg kg^{-1}.
- The level of potential K_2O reserves, most likely strongly affected by the texture, did not reveal a regular pattern., the levels ranged from 99 to 206 mg kg^{-1}.

Soil Fertility

All newly created minesoils and many older ones will require signicant fertilizer element applications for the establishment and maintenance of any plant community. Minespoils are essentially devoid of nitrogen initially, so the total amount of nitrogen required to sustain plant growth over time must come from initial fertilization and subsequent symbiotic microbial nitrogen xation by legumes. Usually, less than 150 pounds of nitrogen per acre are added as fertilizer when establishing nonforested, postmining land uses such as hayland/pasture, and much of this may be subject to leaching and gaseous losses. When establishing forested post-mining land uses, lower nitrogen fertilization levels are advised

All newly created mine soils and many older ones will require significant fertilizer element applications for the establishment and maintenance of any plant community. Minespoils are essentially devoid of nitrogen initially, so the total amount of nitrogen required to sustain plant growth over time must come from initial fertilization and subsequent symbiotic microbial nitrogen fixation by legumes. Usually, less than 150 pounds of nitrogen per acre are added as fertilizer when establishing nonforested, postmining land uses such as hay land/ pasture, and much of this may be subject to leaching and gaseous losses. When establishing forested postmining land uses, lower nitrogen fertilization levels are advised.

The maintenance of plant-available phosphorus in minesoils over time is hindered by two factors:

(1) fresh mine spoils are generally low in readily plant available (water-soluble) phosphorus; and
(2) as mine soils weather and oxidize, they become enriched in iron oxides that adsorb water-soluble phosphorus, which is then "fixed" into unavailable forms.

The tendency of mine soils to fix phosphorus increases over time . Because organic-bound phosphorus is not subject to phosphorus-fixation, it is critical to establish and build an organic phosphorus reservoir in the soil to supply long-term plant needs through phosphorus mineralization. Large fertilizer applications of phosphorus during reclamation will ensure that sufficient phosphorus will be available over the first several years to support plant growth and to build the organic phosphorus pool.

Mine soil pH and Liming recommendation

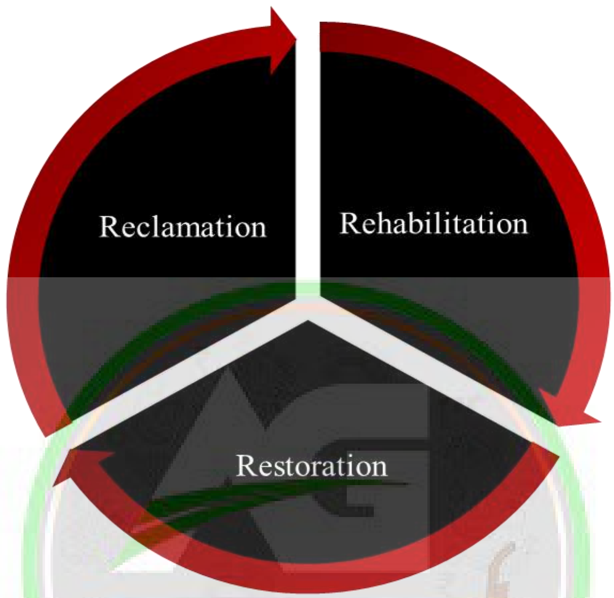
If the soil pH of a weathered mine soil is less than 4.0 and the soluble salts are high, you can be reasonably certain that the soil contains reactive pyrites, and acid base accounting should also be performed as discussed in the next section to determine the appropriate liming rate. If the minesoil has been exposed at the land surface for a sufficient period of time for pyrite oxidation effects to become apparent (if sulfides are present — up to two years), you can assume that the pH, soluble salt, and liming recommendation values given on your soil test are reasonably accurate. If the minesoil material is less than several years old, the full extent of pyrite oxidation might not be evident (e.g., low pH), and acidbase accounting should be performed to accurately estimate liming needs.

In general, minesoils are fairly coarse-textured and low in buffering capacity, so applications of agricultural lime at 1 to 5 tons per acre (depending on initial pH) are usually sufficient to achieve a target pH of 6.5 for 8 typical hayland/pasture forages. Forest species, particularly pines, thrive at lower pH levels, however, and liming is generally not needed unless pyrites are present.

Anthrosols and Technosols

According to the World Reference Base (WRB), anthropogenic soils found in agricultural and archeological settings are classified as Anthrosols, whereas those in mine-related and urban settings are classified as Technosols. Anthrosols are formed by the transformation of natural soil by human additions of organic or inorganic materials over long periods of time, while Technosols are formed in parent materials created and deposited by human activities (e.g., mine spoils, urban fill).

Management of Mined lands



Restoration

Restoration of mine areas is amelioration of physical and chemical characteristics of substrate and ensuring the return of vegetation cover. It also involves identification of specific problems hindering ecosystem redevelopment and intervention to help the recovery of vegetation cover by designing or mimicking natural processes. To achieve a successful restoration, the soil has to be remediated and the vegetation re-established.

Reclamation

Mine reclamation is the process of modifying land that has been mined to ecologically functional or economically usable state. Although the process of mine reclamation occurs once mining is completed, the planning of mine reclamation activities occurs prior to a mine being permitted or started. Mine reclamation creates useful landscapes that meet a variety of goals ranging from the restoration of productive ecosystems to the creation of industrial and municipal resources. Modern mine reclamation reduces the environmental effects of mining. Reclamation is the combined process by which adverse environmental effects of surface mining are minimized and mined lands are returned to a beneficial end use. End uses may be open space, wildlife habitat, agriculture, or residential and commercial development.

In summary, we recommend that the following overburden selection and placement procedures be followed:

1. Select the best substitute overburden strata, basing your judgment on the following parameters: acid-base balance, pH, soluble-salt content, rock type, and overall thickness. Other parameters such as calcium, magnesium, potassium, and phosphorus should enter into the decision but are not as critical.

2. Coordinate the surface mining operations so that the designated strata are separated and hauled to the proper areas for final grading. Exclude excessively stony (more than 80 percent rock fragments) spoils.

3. End-dump the entire final surface using only the designated spoil, with enough spoil to ensure 12 a minimum thickness of 4 feet over any adverse underlying materials.

4. Grade the final surface with a bulldozer, leaving at least a 2 percent grade for drainage of surface water. Exclude all machinery from the area after grading to avoid excessive compaction.

5. Seed and/or mulch the site immediately, when possible, to avoid the formation of surface crusts and begin the development of a soil nutrient and organic matter pool.

Rehabilitation

Rehabilitation comprises the design and construction of landforms as well as the establishment of sustainable ecosystems or alternative vegetation, depending upon desired post-operational land use. Mine site rehabilitation should be designed to meet three key objectives:

- ✓ the long-term stability and sustainability of the landforms, soils and hydrology of the site
- ✓ the partial or full repair of ecosystem capacity to provide habitats for biota and services for people (WA, EPA 2006)
- ✓ the prevention of pollution of the surrounding environment.

Conclusion

Existing minesoils tend to be quite variable in the field, but they can be managed effectively once their chemical and physical properties have been correctly determined. Compaction, low water-holding capacity, and associated rooting restrictions are the major factors limiting the productivity of minesoils in this region. High levels of potential acidity seriously restrict the productivity of some minesoils, but this problem is much more limited in extent than minesoil compaction. Soil testing procedures are useful for comparing overburden materials for use as minesoils, but they cannot be interpreted with the same degree of accuracy as natural soils.

Productive topsoil substitutes can be generated from hard rock overburden in Southwest Virginia, but care must be taken in spoil selection and placement. It is particularly important to reclamation success that controlled overburden placement techniques be used to generate at least 4 feet of loose spoil at the final surface for seeding. The accumulation of soil organic matter and organically complexed nitrogen and phosphorus over time, the maintenance of nitrogen-fixing legumes in the vegetation, and the minimization of phosphorus fixation by soil iron oxides are important factors that control the long-term productivity of minesoils.

Mine soils carefully constructed from topsoil substitute overburden materials can be more productive than many of the natural soils.

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AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

NANO-TECHNOLOGY APPLICATIONS IN MACRO NUTRIENT MANAGEMENT

Article ID: AG-VO4-I05-82

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Abstract

Nanofertilizer technology is cutting-edge, and there is a scarcity of published research in scholarly journals. Conventional fertilizers have nutrient usage efficiency of just 30-35 per cent, 18-20 per cent, and 35-40 per cent for N, P and K, respectively. For the previous few decades, the data has remained steady and study efforts have not yielded positive results. Nano-fertilizers are nutrient transporters made from substrates with nanoscale dimensions ranging from 1 to 100 nm. Nanoparticles have a large surface area and can contain a lot of nutrients and release them slowly and consistently, making it easier for crops to get the nutrients they need without the negative side effects of tailored fertilizer applications.

Introduction

The world's growing population has resulted in rising food demand, which is expected to increase by 70% by 2050. To obtain increased production per unit area, agricultural cropping systems use a lot of fertilizers, insecticides and herbicides. In addition, nutritious agricultural product rich in protein and other vital nutrients for human and animal use is required. Fertilizer is responsible for 35-40% of agricultural productivity. It was reported that in early 1970, just 27 kg NPK ha^{-1} was needed to produce one tonne of grain, however in 2008, 109 kg NPK ha^{-1} was required to attain the same level of production. Because of the increasing issues in agriculture, interest in nanotechnology has grown, with the goal of increasing agricultural yield and resource efficiency. Nanotechnology's products, Nano-particles, can be used across the agriculture production system's value chain. Nanotechnology has made it possible to use nanoscale or nanostructured materials as fertilizer carriers or controlled-release carriers in the development of "smart fertilizers" that cut environmental protection expenditures.

Nanoparticles for fertilizer application

1. Nanoclays (Zeolites, montmorillonite and kaolinite)
2. Hydroxyapatite Nanoparticles (bone mineral)
3. Polymeric Nanoparticles (Chitosan)
4. Carbon-Based Nanomaterials (carbon nanofibers/ nanotubes)
5. Mesoporous Silica
6. Miscellaneous Nanomaterials (metal and metal oxides)

Nano fertilizers in crop nutrition

Plant nutrition can be improved by supplying necessary plant nutrients in the form of nano-fertilizers in two ways:

1. Nanostructured elements are incorporated into a carrier complex, which could be a nanomaterial or not. It is integrated into a matrix such as chitosan, polyacrylic acid, clay, or zeolite through absorption or adsorption.

2. Using nanostructured formulations to provide the needed nutritional elements (either in suspension or encapsulated)

Macronutrients

Nitrogen nanofertiliser

In plant cells, nitrogen is a key component in a variety of structural, genetic, and metabolic molecules. It's a key component of chlorophyll, the molecule that allows plants to convert sunlight into sugars from water and carbon dioxide (*i.e.* photosynthesis). It's also a big part of amino acids, which are the building blocks of proteins. Organic nitrogen molecules, ammonium ions and nitrate ions are the three types of nitrogen available to plants. The majority of nitrogen is not totally available to the plants. This is because negatively charged nitrate has a lower affinity for soil particle surfaces than positively charged nitrate and hence does not readily sorb on soil.

Modified N fertilisers known as "intelligent nano-fertilizers" have been used to increase the degree of N-use efficiency (up to 80%) of crops (Solanki *et al.*, 2015). N-based NFs (for example, porous nano-materials like zeolites, clay or chitosan) could coordinate fertilizer-N release (Abdel-Aziz *et al.*, 2016; Panpatte *et al.*, 2016). Nano-slow zeolite's and consistent release of nitrogen lasts more than 45 days, whereas traditional fertilisers only last 8 days.

Phosphorus

Phosphorus is an essential nutrient in plants since it is a component of several major plant structural compounds and serves as a catalyst in the conversion of many key biochemical reactions. Phosphorus is the most important nutrient in plants because of its role in energy transport and storage. The crop's P usage efficiency ranged from 18 to 20% (Malhi *et al.*, 2002). For systematic and gradual release of P, SMZ and Hydroxyapatite particles were used. Ammonium-charged zeolites (clinoptilolite) increase the solubility of phosphate minerals, increasing the amount of P available for crop absorption (Dwivedi *et al*., 2016).

$$(\text{P-rock}) + (NH_4 - \text{zeolite}) = (\text{Ca zeolite}) + (NH_4) + (H_2PO_4^-)$$

Nano-formulations might release phosphate for up to 40-50 days, but traditional fertilizers only released minerals for 10-12 days (Preetha and Balakrishnan, 2017). P supply from fertilizer-loaded SMZ was still accessible after 1080 hours, whereas KH_2PO_4 was depleted after 264 hours. Soliman *et al.* (2016) investigated the effects of foliar sprays of several sources of P on *Adansonia digitata* and discovered that hydroxyapatite nanoparticles (nHA) significantly increased plant growth metrics, chemical content and anticancer activity of leaves. When *Piriformospora indica*, a newly identified AM-like root-colonizing fungus, was introduced into *Bacopa monnieri*, it displayed growth-promoting capabilities (Prasad *et al*., 2013). CaP NPs in combination with both *Glomus mosseae* and *P. indica* were found to be a more powerful plant growth stimulator by Rane *et al.* (2015). CaP NPs, alone or in combination with *P. indica*, may improve the amount of chlorophyll a and the performance index of treated maize plants.

Potassium

Potassium is required for a variety of plant processes. While potassium isn't found in any plant structures or compounds, it plays a crucial role in the plant's regulatory functions. It's required for nearly all of the mechanisms that keep plants healthier. Potassium is essential for photosynthesis, photosynthate translocation, protein synthesis, ionic balance modulation, plant stomata and water use regulation, plant enzyme activation and many other functions. Natural zeolites contain significant levels of exchangeable K+, which can help plants develop faster.

Selectivity of the ion exchange on zeolite is of order $K^+ > NH_4^+ > Na^+ > Ca^{2+} > Mg^{2+}$

The potassium nitrate release is prolonged by a graphene oxide coating, preventing nutrient loss through leaching (Zaytseva and Neumann, 2016). According to Mazur *et al.* (1986), mixing chemical fertiliser at a rate of 625 kg ha^{-1} with zeolite at a rate of 125 kg ha^{-1} resulted in the highest amount of potassium in the soil because zeolite has the ability to adsorb potassium from chemical fertiliser and prevent leakage. By enhancing nitrogen absorption, foliar spraying different concentrations of nano-K fertiliser on *Cucurbita pepo* resulted in a considerable increase in the number of leaves, fresh and dry weights and product quality (Gerdini, 2016).

Secondary nutrients

Secondary nutrients such as sulphur (S), calcium (Ca), and magnesium (Mg) are required in relatively significant levels for good crop growth. Plants require nearly the same amounts of S and Mg as they do P, however Ca is required in larger proportions by many plant species. Soil sulphur reactions are quite similar to soil nitrogen reactions, which are dominated by organic or microbial fractions. Ca^{2+} and Mg^{2+}, on the other hand, are found in the soil clay fraction and react similarly to K^+. The uptake of Ca and Mg was improved when nano-calcite ($CaCO_3$-40%) was combined with nano SiO_2 (4%), MgO (1%), and Fe_2O_3 (1%).

Higher nutrient use efficiency through nano-fertilizers

The nano-fertilizers have particular features that allow for greater nutrient use efficiency. The following are the most important characteristics:

1. Nano-fertilizers have a bigger surface area, owing to the nanoparticles' small size, which provides more sites to promote the various metabolic processes in the plant system. As a result, more photosynthesis is produced but nutrient elements are consumed less.
2. They are highly soluble in a variety of solvents, including water.
3. Nano-fertilizers have very small particle sizes (less than 100 nm), allowing for greater penetration of nano-particles into the plant system.
4. Nano fertilizer elements have a large surface area and particle size that is smaller than the pores in plant roots and leaves. This promotes nano-fertilizer uptake and nutrient utilization efficiency by increasing penetration into the plant system from treated surfaces.
5. Nano fertilizer's smaller particle size results in a higher specific surface area and number of particles per unit area of fertilizer, resulting in more nutrients.

Conclusion

The use of various nano-fertilizers has a higher impact on increasing agricultural yield, reducing pollution risks to the environment and lowering crop fertilization costs. As a result, nutrient utilization efficiency can be improved by using nano-fertilizers effectively in crop fields. When sprayed at the right doses and concentrations, nano-fertilizers boost crop growth and production. However, surpassing a specific ideal limit might have an inhibitory effect on crop plants, resulting in diminished crop development and output. As a result, optimizing the dosages of various nano fertilizers for various crops is critical. With the optimization of doses for various nano fertilizers and crops, a highly efficient and environmentally friendly production system could be achieved in the near future.

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AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

MILLET: A POWERFUL WEAPON FOR NUTRITIONAL SECURITY

Article ID: AG-V04-I05-83

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Abstract

Millet, a small-grained cereal grass, is a powerful weapon for nutritional security and resource sustainability. It is divided into large and minor millets, with the latter being the most resilient and capable of withstanding harsh weather conditions. Millets are often referred to as "superfoods" or "Nutri cereals" due to their high nutritional content, ability to tolerate climatic change, and efficient use of resources. Millet production is influenced by factors such as urbanization, per capita earnings, low socioeconomic status, reduced grain shelf life, and distribution through the public distribution system. Supply-side factors include farmers being discouraged from producing millet due to industry demand, poor pay, and insufficient infrastructure. Strategies aimed at reversing global trends of declining millet production and consumption and raising consumer knowledge of the dietary and health advantages of millet are needed to ensure its continued importance in food and nutrition security.

Introduction

One of the first crops that humans have ever grown is millet, which requires little irrigation and can withstand harsh weather. A family of small-grained cereal grasses is known as millet. It was divided into two categories: large millets, such as sorghum (cholam), pearl millet (cumbu), and finger millet (ragi), and minor millets, like foxtail millet (thenai), barnyard millet (kudhiraivali), and kodo millet,(varagu), small millet (samai), and proso millet (panivaragu).

Because of their high content of micronutrients, minerals, and B-complex vitamins, they are often referred to as Nutri-grains. According to Bhat *et al.* (2018), they have the potential to treat diabetes, aging, cancer, celiac disease, and cardiovascular disease. It contains a wealth of phytochemicals that are beneficial to health and can be eaten as a functional meal. Even when grown in combination with pulses and vegetables, it might function well. Despite being the world's greatest producer and consumer of millet, accounting for over 40% of the world's consumption, India has never been given priority in national food and agricultural policies (Konapur *et al*., 2014).

Due to their resilience and capacity to flourish in areas with rainy seasons, millets have the potential for both food and nutritional security in India. 60% of India's agricultural land is rainforest. They can withstand harsh climatic elements like drought and unfavorable soil conditions because of their distinct molecular, biochemical, and morpho-physiological characteristics (Bandyopadhyay et al., 2017). Moreover, they might have an advantage because of their small stature, restricted leaf surface area, and shorter lifespan. When it comes to their capacity to tolerate strong light, high temperatures, and dry weather, as well as their potential for C4 photosynthetic activity and efficient use of Nitrogen and water respectively.

When compared to other common grains, millets have a higher nutritional content, can withstand climatic change, use fewer resources, and are frequently referred to as "superfoods" or "Nutri cereals." Millets have traditionally been consumed in larger quantities and are beneficial to diets worldwide, but both their cultivation and consumption are drastically reducing. To provide food and nutrition security, resource sustainability, and economic development, millet may be essential. Therefore, it is essential to develop strategies aimed at reversing the global trends of declining millet production and consumption and raising consumer knowledge of the dietary and health advantages of millet

Nutritional and Health Value of Millets

Millets are an excellent source of nutrients, fibre, and B-complex vitamins. The most macro- and micronutrient-rich millet is pearl millet (Bajra), which includes iron, zinc, magnesium, phosphorus, folic acid, and riboflavin. Ragi, or finger millet, is a remarkable source of calcium. PUFAs (polyunsaturated fatty acids) are abundant in this low-fat diet. The ratio of leucine to

Millets	Moisture (g)	Protein (g)	Ash (g)	Total Fat (g)	Dietary Fibre (g)			CHO (g)	Energy (KJ)
					Total	Insoluble	Soluble		
Bajra	8.97	10.96	1.37	5.43	11.49	9.14	2.34	61.78	1456
Sorghum	9.01	9.97	1.39	1.73	10.22	8.49	1.73	67.78	1398
Ragi	10.89	7.16	2.04	1.92	11.18	9.51	1.67	66.82	1342
Little Millet	14.23	8.92	1.72	2.55	6.39	5.45	2.27	65.55	1449
Kodo Millet	14.23	8.92	1.72	2.55	6.39	4.29	2.11	66.19	1388
Foxtail Millet		12.30		4.30	-			60.09	331
Barnyard dMillet	11.36	6.20	1.34	3.89	7.72	5.42	2.27	65.55	307
Oats	10.47	16.9	2.15	6.9	10	5.8	4.2	66.3	414
Buckwheat	11.35	13.2	2.20	3.4	12.28	9.97	2.21	71.5	343
Quinoa	**10.43**	**13.11**	**2.65**	**5.50**	**14.66**	**10.21**	**4.46**	**53.65**	**1374**

Table 1: Proximate Composition and Dietary Fibre (per 100 g)

Source: Indian Food Composition Tables, NIN– 2017

https://www.kaulige.com/nutritional-information of-millets/

isoleucine is roughly 2, and it is also high in ssential amino acids, such as lysine, threonine, valine, and sulfur-containing amino acids.

Small millets have a high nutritional content and are resistant to drought, which makes them appealing crops for food security and an excellent source of feed and fodder in systems that combine livestock and mixed crops.

Bioavailability of nutrients from millets

Mineral bioavailability is affected by the high fibre content and the presence of some antinutritional elements in millets, such as tannins and phytates. There is evidence from a small number of human studies that millets tend to absorb iron less readily than rice or even wheat. Therefore, lower bioavailability may somewhat offset the benefit of having a higher micronutrient concentration. Further research employing cutting-edge methodologies and diverse cooking procedures is required to investigate the bioavailability of micronutrients, such as minerals and B vitamins, to evaluate their nutritional benefit in reality.

Dietary fibre reduces blood sugar and cholesterol and promotes healthy bowel movements. Millets are high in fibre as well as phytochemicals that are good for health, such as lignans, polyphenols, phytosterols, phytoestrogens, and phytocyanins. These prevent age-related degenerative diseases like cancer, diabetes, and cardiovascular disease (CVD) by functioning as antioxidants, immunological modulators, detoxifying agents, and other things (Rao et al. 2011).

Factors governing millet production

The following demand-side variables affect millet production:

a. Growing urbanization and per capita earnings, which alter consumer preferences and tastes.

b. Low socioeconomic status and ignorance of traditional millet preparation methods.

b. Millet grain shelf life is reduced.

d. A higher proportion of wheat and rice than millets are distributed through the public distribution system (PDS).

The following are the supply-side factors:

a. Farmers are discouraged from producing millet as a result of the absence of industry demand for value-added millet goods.

c. Poor pay and little profit margin.

b. During the Green Revolution, rice and wheat production was encouraged.

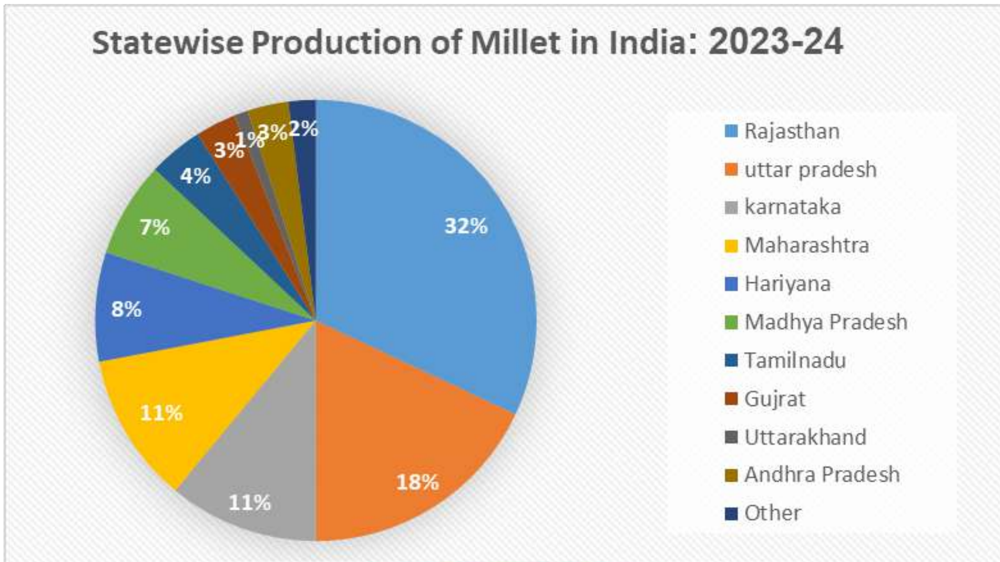
d. Inability to obtain high-quality seeds.

b. Insufficient infrastructure, including milling machinery and processing technology.

Millet production and consumption patterns:

The FAO predicts 33 million hectares of millet will be planted globally in 2020, with India leading the pack at 9.76 million hectares in 2021. India's millet production increased from 28.33 million metric tonnes in 2019 to 30.08 million metric tonnes in 2021. With a 43 percent global market share in 2021, India is the leading producer; the principal crops grown there are finger millet (ragi), pearl millet (bajra), sorghum (jowar), and other minor millets.

Figure :1 State-wise Production of Millets in India: 2023-24



(Source: APEDA 2021-22)

Conclusion

Millet is a drought-tolerant plant that requires little irrigation. More than 40% of the world's millet consumption comes from India, the country that produces and consumes the most of the grain. Due to their rich mineral, B-complex vitamin, and micronutrient content, millets have gained recognition as possible superfoods or "Nutri cereals." B-complex vitamins, fibre, and minerals are all abundant in millet. Due to their high nutritional value and drought resistance, little millets are desirable crops for ensuring food security as well as a great source of feed and fodder in systems that include mixed crops and animals. Growing urbanisation, low socioeconomic position, per capita income, shorter grain shelf life, and a larger share of wheat and rice going through the public distribution system are some of the factors influencing millet production.

Volume: 04 Issue No: 05

EMPOWERING AGRICULTURE: HARNESSING MOBILE TECHNOLOGY FOR PLANT DISEASE DETECTION

Article ID: AG-VO4-I05-84

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Abstract

Plant diseases, caused by pathogens such as viruses, bacteria, and fungi, present significant threats to global food security and economic stability. Traditional methods of disease identification and diagnosis are labor-intensive and often imprecise. However, the emergence of mobile applications equipped with image recognition and artificial intelligence (AI) technologies offers a promising solution. This article explores the advantages of utilizing mobile applications for plant disease detection and management in India, highlighting the accessibility, real-time diagnosis, cost-effectiveness, knowledge sharing, and scalability offered by these tools. By democratizing access to critical agricultural resources and expertise, mobile applications represent a paradigm shift in agricultural innovation, fostering sustainable and resilient food production systems for future generations.

Introduction

Plant diseases caused by various pathogens such as viruses, bacteria, and fungi and pose significant challenges to global food security and economic stability by impeding plant growth and disrupting vital functions. For exmple, diseases like Leaf Blast, Brown Spot and Leaf Blight in rice, Late Blight and Early Blight in potatoes, Early blight in tomates, Rust of coffee and powdery mildew affecting grapes become a great menace and ultimately cause the great yield loss, so early detection of these diseases is crucial to implementing preventive measures and minimizing economic losses.

Traditionally, identifying and diagnosing plant diseases has been a labor-intensive and often imprecise process, requiring manual inspection by experienced pathologist or involve direct consultation with experts who physically examine plants and soil, this approach can be unreliable due to limitations in expertise and practicality or tedious laboratory analysis.

However, as technology has become more accessible, mobile applications have emerged as a cost-effective alternative for disease detection in plants. These apps offer various functionalities, including plant and disease identification, severity estimation, and agricultural solutions. Leveraging image processing, artificial intelligence (AI), machine learning (ML) and deep learning (DL) techniques, these apps analyze plant symptoms and provide insights for stakeholders. Despite claims of effectiveness, the lack of accreditation and standardized evaluation metrics poses challenges for users in selecting suitable apps. Thus, there's a need for thorough analysis and structured studies to assess the functionality and usability of these apps.

MOBILE APPLICATIONS FOR PLANT DISEASE DETECTION

Here are some mobile applications used for plant disease detection and management in India:

Sr. No.	Application Name	App Logo
1.	**Plantix**: Plantix is a popular app that uses image recognition technology to identify plant diseases and nutrient deficiencies. It also provides personalized recommendations for treatment and management.	
2.	**AgriApp**: AgriApp is designed to assist farmers in identifying crop diseases, pests, and nutrient deficiencies. It offers information on organic farming practices, weather updates, and market prices.	AgriApp Connecting Farmers
3.	**Kisan Suvidha**: Developed by the Indian Government, Kisan Suvidha provides information on crop diseases, weather forecasts, market prices, and agricultural advisories. It aims to empower farmers with relevant knowledge and resources.	

4.	**IFFCO Kisan**: This app offers features like crop disease diagnosis, soil health analysis, weather updates, and market information. It also facilitates direct communication between farmers and agricultural experts.	
5.	**AgriBolo**: AgriBolo is an agricultural community platform that allows farmers to seek advice from experts and fellow farmers. It covers various aspects of farming, including plant disease management.	
6.	**CropIn**: CropIn provides farm management solutions, including disease monitoring and advisory services. It helps farmers track crop health, detect diseases early, and take preventive measures.	

Advantages

The utilization of mobile applications for plant disease detection offers a myriad of advantages over conventional methods, heralding a new era of efficiency, accessibility, and precision in agricultural management. This introduction elucidates the rationale behind the adoption of mobile applications as a pivotal tool in the fight against plant diseases. Here, detail about the advantages of mobile apllication for disease detection.

1. Accessibility and Ubiquity:

In an era where smartphones have become ubiquitous, leveraging mobile applications for plant disease detection ensures widespread accessibility to farmers, agronomists, and gardening enthusiasts irrespective of geographical location or technical expertise. With the majority of the global population owning smartphones, harnessing this ubiquitous technology democratizes access to critical agricultural resources and expertise.

2. Real-time Diagnosis:

Mobile applications equipped with image recognition capabilities empower users to capture and analyze images of diseased plants in real-time, enabling swift and accurate diagnosis directly from the field. This real-time feedback mechanism facilitates prompt intervention, allowing growers to implement timely mitigation strategies and prevent the spread of diseases, thereby safeguarding crop yields and ensuring food security.

3. Cost-effectiveness and Efficiency:

By circumventing the need for costly laboratory analyses or reliance on expert consultation, mobile applications offer a cost-effective alternative for plant disease detection. The automation of diagnostic processes through AI-driven algorithms streamlines workflow efficiencies, reducing labor costs and minimizing the economic burden on farmers. Furthermore, the rapid dissemination of information via mobile platforms optimizes resource allocation, fostering sustainable agricultural practices and maximizing productivity.

4. Empowerment through Knowledge Sharing:

Mobile applications serve as invaluable repositories of agricultural knowledge, providing users with comprehensive databases encompassing a myriad of plant diseases, their symptoms, causes, and management strategies. Through interactive interfaces and educational content, these applications empower users with the requisite expertise to make informed decisions regarding disease diagnosis and management, thereby fostering a culture of knowledge sharing and capacity building within the agricultural community.

5. Scalability and Adaptability:

The inherent scalability and adaptability of mobile applications facilitate their seamless integration into diverse agricultural ecosystems, catering to the specific needs and challenges faced by growers across various crop types and geographic regions. Whether deployed in small-scale subsistence farming operations or large commercial agricultural enterprises, mobile applications offer a flexible and scalable solution capable of addressing the dynamic complexities of modern agriculture.

In light of these compelling advantages, the utilization of mobile applications for plant disease detection represents a paradigm shift in agricultural innovation, heralding a future where technology serves as a catalyst for sustainable and resilient food production systems. By harnessing the power of mobile technology, we embark on a journey towards a greener, more prosperous future, where the nexus of agriculture and innovation cultivates prosperity for generations to come.

Conclusion

In conclusion, the adoption of mobile applications for plant disease detection marks a transformative leap forward in agricultural practices, offering a host of advantages that revolutionize the way growers manage their crops. Through the lens of accessibility, real-time diagnosis, cost-effectiveness, knowledge sharing, and scalability, these applications empower farmers with the tools and information needed to combat the ever-present threat of plant diseases.

Volume: 04 Issue No: 05

A MAGICAL SHIFT FROM CORPORATE CAREER TO INNOVATIVE AGRIPRENEUR- SUCCESS STORY OF YOUNG ENTREPRENEUR

Article ID: AG-V04-I05-85

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Introduction

India is witnessing a radical transformation where highly qualified youngsters are giving up cushy jobs to make a difference in rural areas by adopting farming. This is what happened with 25 years old Mr. Suveera Hegde who belongs to a small village Belagundli, Umachagi, Yellapur (U. K.) Karnataka state.

After pursuing B.com (Business & Finance), joined Chartered Accountancy firm at Bangalore to pursue Corporate Career. Soon as per the expansion plan of the firm, came to his native Sirsi to assist the Chartered Accountant who is one of the partner of the Firm to set up office at city Sirsi. Hectic Work Schedules at corporate structure triggered way to Farming interests and started farm visits. Traditional Arecanut and Banana Farm, Barren paddy fields and vacant grasslands at the village made to contribute to the potential revenue generator with pleasant healthy life style.

Lush BlackPepper- Areca-Banana Farm

Though the Initial revenues are very less compared to the earlier occupation, with interest to learn agriculture and its allied activities he contacted local Agriculture Department Office, Yellapur and nearby Krishi Vignana Kendra, Sirsi to procure proper Scientific Knowledge. With the help of ARYA Scheme, learnt cow and goat farming and soon after finishing training brought 5 Goats for getting rich organic manure and generating other commercial aspects at very less investment. Today after 2.5 Years Goat Count is 22(Includes4Male Sold) and self-sufficient organic compost for around 3 Acres of Areca Farm.

Suveer also enrolled with "DAESI" program (1 Year diploma) sponsored by National Institute of Agricultural Extension Management, Hyderabad is a good initiative of ICAR to educate people about the rules that govern agricultural inputs. A training program for input dealers in broad- based agriculture's location-specific crop production technologies related to field issues and concerns. Finally he an act as a para extension to cater the needs of the local farmers.

Apart from agriculture he is also working as Operational and Accounts Head in the Sarvajnendra Farmers Producer Company, Yellapur and Key Advisor for multiple FPO's and NGO's across Karnataka Proprietor of Aghana Associates (Legal Compliance Entity).

Agriculture Department and Local NGO assisted to form Farmers Producer Company which tends to be great Personal and Societal venture started with Rs.10,000 capital from 10 Farmers to Rs.19,00,000+Paid Up Capital with1,000+Farmer Members.Currently its middle of Third Financial Year with Projected Turnover ofRs.60,00,000 with projection of Rs 4-5 Lakh profit

Company Mainly focused on providing skilled laboures to Harvest and Spray and Dehusk the Arecanut with proper tools - equipment's and even with machineries which is procured at 80% Contribution from State Agriculture Department.

From Day 1 Company is profitable and with the unexplainable support from State and Society Company Started Mini Hitachi service and Constructing Own Secondary Processing Unit Facility with Proper Machineries. Our Intention is to make farming hassle free and more rewarding at the same time with community assistance. Company participated in multiple Trade fairs, Conducted several trainings, educational farm visits across states.

Fibre Poll Training for Unemployed Youth

To Our efforts Both Central and State Ministers, Higher Officials of the Department and also Multiple NGO's applauded our work. Suveer Hegde become model farmer to youngsters who are migrating to urban areas in search of private jobs he proved that we can become successful entrepreneurs in agriculture and allied activities. A magical shift from corporate carrer helps him to become Innovative agripreneur

Volume: 04 Issue No: 05

DYNAMICS NATURE OF POTASSIUM IN SOILS

Article ID: AG-V04-I05-86

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Abstract

Potassium is present in soil in different forms. Most important forms of potassium are water soluble and exchangeable K which contribute to available form of K. The distribution of these forms in soil is important in understanding the conditions controlling their availability to growing crops. There is inter -conversion of one form to another under specific soil condition which determines their availability to plants. A large portion of the total K in soil occurs as structural component of soil minerals and is unavailable to plants. Plant can use only the exchangeable K present on the surface of soil particles and the K dissolved in soil water. This often constitute very small fraction of the total K. The dynamics of K in soil depends on the management of equilibrium among various forms which have relationship with physic-chemical properties

Key words: Potassium, soil, forms, exchangeable, non-exchangeable, categorization,

Introduction

Potassium (K) is the third important essential major plant nutrients and second most abundant nutrient in plant photosynthetic tissues after nitrogen. It play vital roles in enzyme activation, water relations, energy relations, translocation of assimilates, photosynthesis, protein & starch synthesis and underpinning agronomic productivity & sustainability (Mengel, 1985). Potassium is required in large amounts for growing crops, but farmers in poor countries often do not fertilize their crops with K due to high costs, which lead to K deficiencies in large areas of farmland across the world (Srinivasarao *et al.*, 2014). Availability of K to plant is controlled by dynamic interactions among its different chemical forms (Wang *et al.*, 2004). The component of dynamic interactions are water soluble K which is taken up directly by plants, exchangeable K held by negatively charged sites of clay particles, non exchangeable K which is a trapped between layers of expanding lattice clay and lattice K, an integral part of the primary minerals (Rao *et al.*, 1997).

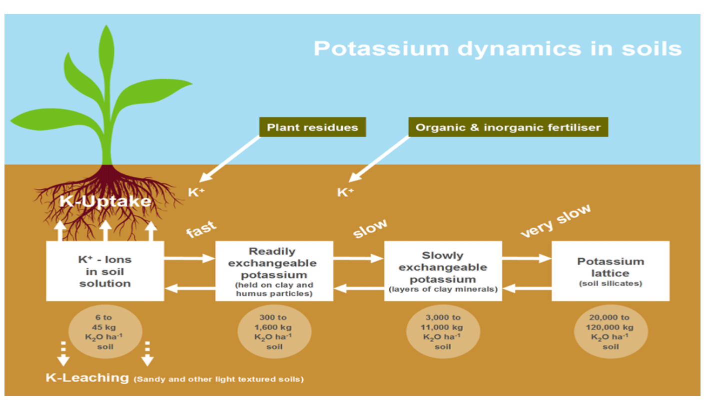
Potassium in Soils its forms and dynamics equilibrium:

Potassium is one of the most abundant elements which constituting about 2.1–2.3% of the earth's crust, K (Zorb *et al*., 2014). Indian soils are generally considered to be rich in potassium and different benchmark soils of India have been reported to range from 0.35 to 4.65% (Sekhon *et al*., 1992). Soil potassium can be classified into four forms i.e. soil solution K, exchangeable K, non-exchangeable K and mineral K Soil solution (Water soluble) K, which is taken up directly by plants; Exchangeable –K, held by negative charges on clay particles and is available to plants; Non-exchangeable (Fixed –K), trapped between layers of expanding lattice clays; and Mineral (Lattice –K), an integral part of primary K bearing minerals. Major portion of soil K exists as part of mineral structure and in a fixed or non exchangeable form (Table-1).

Table-1: Range of different forms of potassium in soil

Forms	Range (ppm)
Mineral-K	5000 to 25,000
Non-exchangeable -K (fixed/difficulty available)	50 to 1750
Exchangeable-K	40 to 400
Solution-K	2-10

Fig.-1: Dynamic equilibrium in different forms of potassium.



Only small fraction exists as water soluble and exchangeable- K in soil (Darunsontaya *et al.*, 2012). All these forms are in equilibrium with each other and there is release from non exchangeable form as the solution and exchangeable K is depleted. The dynamics equilibrium of these forms of potassium is presented in fig-1.

Economic yield and K-uptake in major cropping system of central India

In intensive cropping system, K is recognized as an important limiting factor in crop production. The quantity of K absorbed by plants is as much as or higher than N for most cultivated crops. Demand for K is especially high for certain crops such as tobacco, banana, potato, grapes, onion, sugarcane, soybean etc. Potassium removal by different agricultural production systems is either similar to N or is even higher. It is nearly 4-5 times higher than that of phosphorus, sulphur and magnesium. However, its application rates are much lower than both N and P. The average uptake of major nutrients by crops at 100% NPK treatments of selected intensive cropping system Singh and Wanjari (2013). Data presented in table-2 indicated that in most of the cropping systems, K uptake exceeded N, especially when three crops are taken in a year.

Table 2: Yield and nutrient uptake of important cropping system

Cropping system	Soil type	Yield (t ha^{-1})	Nutrient uptake ($kg\ ha^{-1}\ year^{-1}$)			
			N	P	K	Total
Maize –Wheat-Cowpea (F*)	Inceptisols	6.8 + 0.6	240	45	250	535
Rice – wheat- Jute (F*)	Inceptisols	6.5+1.5	250	50	275	575
Maize –Wheat-Cowpea (F*)	Mollisols	9.5+1.9	260	65	295	620
Rice –rice	Inceptisols	6.2	150	40	175	365
Soybean -wheat	Vertisols	6.3	285	44	225	554
Soybean -wheat	Alfisols	4.2	220	35	170	425
Fingermillet -maize	Alfisols	6.5	210	42	215	467
Fingermillet -maize	Inceptisols	6.5	245	40	270	555
Groundnut - wheat	Alfisols	2.9	106	18	65	189
Sorghum – sunflower hybrids	Vertisols	2.9	89	42	117	248

Potassium management in Indian soil

Potassium availability in soil is most commonly assessed using normal ammonium acetate, which measures the amount of K in the water soluble and exchangeable forms that are easily available to crops. However, there is considerable evidence that the non-exchangeable form of K (Boiling : 1 M HNO_3) also contributes to crop K nutrition. Under intensive cropping, in the absence of K fertilization, initially exchangeable K in soil contributes to plant K nutrition, but with further cropping, exchangeable K reaches a certain minimal level. Thereafter, plant K requirements are met almost entirely from the non- exchangeable form, which in some cases, can account for as much as 90-95% of the total plant K uptake. Categorization of Indian soil (Table-3) based on both exchangeable and non-exchangable- K and suggested K management for each category (Srinivasarao *et al.*, 2010).

Table-3 : Suggested K management in each category of both exchangeable and non-exchangable- K

Category	Ex -K	Non- ex-K	Suggested K management
I	Low (< 50 ppm)	Low (< 300 ppm)	K in fertilization is a must
II	Low	Medium (300-600 ppm)	K fertilization is essential
III	Low	High(>600 ppm)	K adding at critical stages of crops improve yield levels
IV	Medium (50-120 ppm)	Low	Continuous cropping needs K adding at critical stages as non exchangeable K fraction does not contributes to plant K nutrition substantially
V	Medium	Medium	Maintenance doses of K may be required for intensive cropping systems
VI	Medium	High	Crops may not need immediate K addition
VII	High (>120 ppm)	Low	Long term cropping would need K additions after few years
VIII	High	Medium	K applications is not required immediately
IX	High	High	K applications is not required

Conclusions

Considering the contribution of non-exchangeable-K and subsoil-K towards crop nutrition, the current soil test based on exchangeable-K content in surface 0-15 cm soil needs to be suitably modified. Most of the horticultural crops (fruits and vegetables) need K application and special care should be taken when these crops are grown on red, lateritic, light textured and acidic alluvial soils. Most of banana growing regions are low in K and due to high K requirement of banana, regular K application is a must as these soils are low in non-exchangeable K. Alluvial soils of north Indian rice-wheat based cropping system belt are quite rich in non-exchangeable K and total K in surface soils as well as in subsoil, but there are pockets where K mining due to intensive cropping has been done and need K fertilization.

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AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

SOIL FOR FUTURE HANDS: ROLE OF SOIL BIOTA TOWARDS SOIL HEALTH AND AGRICULTURAL SUSTAINABILITY

Article ID: AG-VO4-I05-87

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Abstract

Soil is a natural resource for all forms of life and its dynamic medium helps to cultivate crops and should make it sustainable for future generation. Several factors and organisms plays a positive relation towards soil character which in turn produces crops ultimate towards food production. To achieve better yields, prioritizing soil health is imperative for future food security. Soil is a biological vault consisting of numerous kinds of organisms, serving as a complex part of nature itself. Soil biota plays a prominent role in soil development and soil formation. This article briefly highlights the biological functions and role of soil biota in the soil environment and its sustainability. It aims to provide a better understanding of soil health, function, quality and fertility under sustainability soil management.

Keywords: soil biota; ecosystem; sustainability; organisms.

Introduction

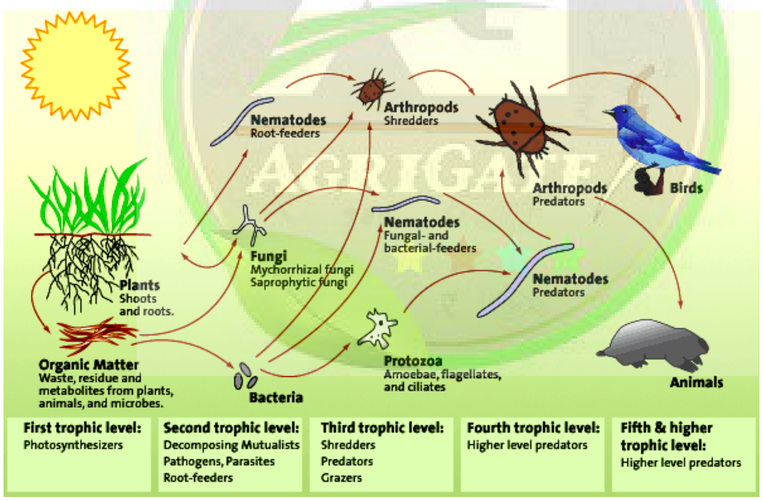
A 'Biological universe' living in a gram of soil. Every arrangements of pore space, soil particles, organic matter will pave way for structural framework of soil through which all the basic functions occurs. Soils are living and highly structured substrate, home to a myriad of organisms, each with a potentially important role in the present and future viability of soils to produce sufficient food, absorb pollutants, maintain hydrological cycles and other ecosystem services.

Soil biota

Soil biota is a broad term which comprises of all the organism that spend a significant portion of their life cycle within a soil profile, or at soil – surface interface. It is also known as soil edaphon or "Soil life". Soil biota, the biologically active powerhouse of soil, include an incredible diversity of organisms. It includes micro-organisms (bacteria, fungi, and algae) and soil "animals" (protozoa, nematodes, mites, springtails, spiders, insects, and earthworms) in soil. They are more diverse than the community of plants and animals on above ground. Soil biota are concentrated in plant litter, the upper few inches of soil, and along roots. Soil organisms interact with one another, with plant roots, and with their environment, forming the soil food web.

Soil food web

The soil food web consists of the community of organisms that live all or part of their lives in the pedosphere and mediate the transfer of nutrients among the living (biotic) and non-living (abiotic) components of the pedosphere through a series of conversions of energy and nutrients as one organism and or substance is consumed by other organism. Relative number and biomass of microbial species at 0 – 6 inches (0-15cm) depth of soil is tabulated below.



Soil food web

Relative number and biomass of microbial species at 0 – 6 inches (0-15cm) depth of soil

Microorganisms	Number / g of soil	Biomass (g/m^2)
Bacteria	10^8-10^9	40-500
Actinomycetes	10^7-10^8	40-500
Fungi	10^5-10^6	100-1500

Algae	10^4-10^5	1-50
Protozoa	10^3-10^4	Varies
Nematodes	10^2-10^3	Varies

Soil organisms

Soil organisms are classifies into two broad term. i.e. Soil flora and soil fauna. Under soil flora, it was classified into micro flora and macro flora. They are, micro flora – Bacteria, fungi, Moulds, yeast, mushroom, Actinomycetes, Streptomyces. Macro flora – Roots of higher plants. Soil fauna includes macro, meso and micro fauna. Macro fauna – mices, moles, earthworms, ant, etc; Meso fauna – Nematodes, arthropods; Micro fauna - Protozoa

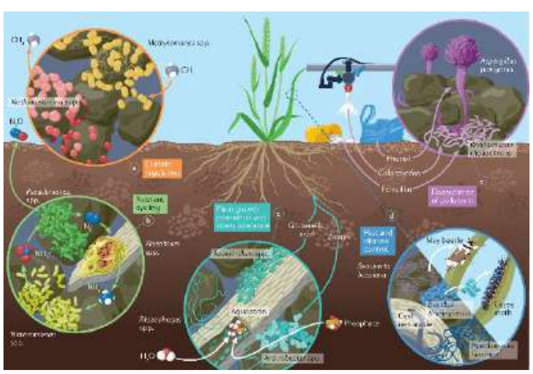
Importance of Soil biota

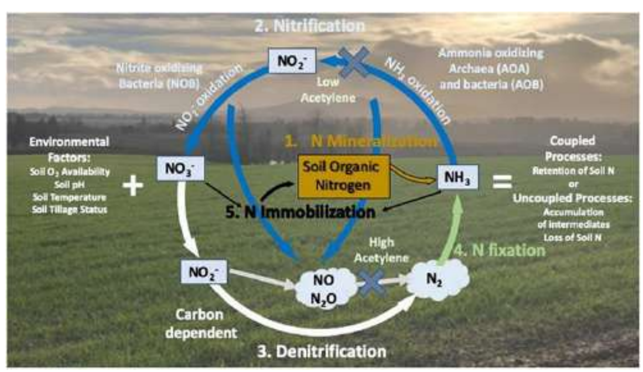
Soil microbes break down organic matter

Microorganisms plays an important role in the decomposition of organic matter. Different types of microbes are specialized to different types of organic matter, between them covering just above everything.

Recycling nutrients

Soil microbes plays a crucial role in returning nutrients to their mineral forms, which plants can take up again. This process is known as mineralization. (Eg. Plant can take nitrogen in the form of Ammonical and nitrate).





Soil organism creates Humus – 'A Black gold'

Soil microbes breaks down all the organic matter under favorable condition like humidity, temperature, oxygen and it releases organic acids and finally converts raw organic matter into fully decomposed material called 'Humus'. Humus is dark brown in colour and contains nutrients which is available to plant. The acids produced in the soil by the micro organism during decomposition will increase the pH of the soil. And so formed humus acts as a cation exchange site through which nutrients transfer and uptake by crops will be taken place in the soil medium.

Maintains soil structure

Angular, prism, blocky are some of the types of soil structure. Keeping soil structure stability is an important phenomenon in plant root nutrient acquisition. The microorganism (Soil biota) present in soil environment will maintain soil structure beneficially by releasing some chemical substance like glycoprotein, gums, polysaccharide which will aggregate (making together) soil particle and make structure more stable thus plant roots hold stronger in soil medium.

Summarized key roles of soil biota in soil environment

Role of soil biota	Key organisms involved (examples)
Maintenance of soil structure	Earthworms, arthropods, soil born fungi, mycorrhizal, plant roots
Regulation of soil hydrological processes	Mostly micro-organisms and plant roots
Gas exchange and carbon sequestration	Mostly micro-organisms
Soil detoxification	Various saprophytic, bacteria, fungi etc.,
Decomposition of organic matter	Mycorrhizal and other fungi, nematodes, bacteria, earthworms, termites

(FAO, 2007)

Conclusion

Maintaining ecological system and soil sustainability and balancing soil health towards future are key role for everyone in earth. Proper understandings of soil biota and their biodiversity in soil environment would provide ways to improve soil health, soil function, soil quality, soil fertility and sustainable soil management activities in agricultural production. Major research on soil biota and biodiversity in India will require long-term effort, and the benefits will be seen in the development of soil quality and soil fertility within a short-term course.

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Volume: 04 Issue No: 05

LEMON GRASS: HEALTH BENEFITS FOR DAILY LIFE

Article ID: AG-V04-I05-88

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Introduction

Lemon grass, popularly known as citronella grass is known by various other colloquial names throughout the world. The members of the Cymbopogon genus produce volatile oils and thus are also known as aromatic grasses. Predominant feature of this grass, is due to the high citral content of its oil. The redolence of the oil enables its use in soaps, detergents, etc. As a good source of citral, it finds an application in the nutrition, perfumery as well as food industries. Lemon grass contains several bioactive compounds that impart medicinal value to it. According to the WHO, herbal medicine is considered an important part of the healthcare industry by more than two-thirds of the population in developing countries. Lemon Grass Oil Essential oils are extracted from flowers, herbs, trees and various other plant materials. These oils contain a mixture of chemical compounds. Apart from being used to manufacture of perfumes, soaps, cosmetics, detergent and health care. Lemon grass oil is also known as citronella oil.

Lemon Grass

Dried Lemon Grass

Lemongrass is a clumped and tall perennial grass that can grow up to 2.5 m in height with green and linear leaf lamina, that is long, glaucous, non-articulate, narrowed at both ends, and able to grow to 50 cm and 1.5 cm in length and width, respectively. Leaves of this grass dried and storedfor making tea, helps to cure many problems of stomach and anesthetic problems.

Health Benefits of Lemongrass

The strong, refreshing flavor of lemongrass is enough reason to try it out in teas and cocktails. But it's even better to know how good it is for your health! Here are some of the health benefits of lemongrass you should know.

May Help Lower Cholesterol

Essential oils in lemongrass possess anti-hyperlipidemic and anti- hypercholesterolemic properties that support healthy cholesterol levels. Lemongrass may assist in sustaining healthy levels of triglycerides and reducing LDL or bad cholesterol. This may help in preventing the accumulation of lipids in the blood vessels and promoting an unobstructed flow of blood in the arteries, thereby preventing various cardiac disorders such as atherosclerosis.

May Detoxify the Body

Detoxification may help in the regulation of various organs of the body, including the liver and kidneys, while also possibly helping to lower the levels of uric acid. The possible diuretic effect of the herb helps in increasing the quantity and frequency of urination, which helps in maintaining digestive health and detoxifying the body.

May Aid in Relieving Stomach Disorders

Lemongrass essential oil has potentially anti- microbial and anti-bacterial properties which help in fighting the infections caused by pathogens. It is beneficial in reducing inflammation and gastrointestinal disorders; it may be helpful to consume to improve digestion and if you suffer from gastric ulcers, constipation, ulcerative colitis, diarrhea, nausea, and stomach ache.

May Relieve Insomnia

Lemongrass tea is a delicious and beneficial beverage that is thought tohelp the body in many ways. This includes improving digestion, lowering blood pressure, boosting the metabolism, strengthening the immune system.

What is Lemongrass Tea?

Lemongrass, scientifically known as *Cymbopogon citratus* is also used as a culinary herb in many parts of the world, primarily in India, Asia, and Australia. Lemongrass oil has certain antifungal and antioxidant qualities and is also used as an insect repellent and preservative.

However, one of the most popular and powerful uses of lemongrass continues to be in tea forms. Stems from lemongrass can be chopped into small pieces and then brewed into powerful tea that possesses a wide range of nutrients, organic compounds, and antioxidants that impact the body. You should always steep the cut pieces for a long time, as this will help release all the nutrients this plant has to offer.

One of the best things about lemongrass is that it is hearty, grows quickly and thrives in warm weather, provided it has enough water and healthy soil. As a perennial plant, it has become a favorite for people who enjoy gardening and want a constant source of delicious lemony tea on hand. A refreshing beverage, lemongrass tea is delightfully healthy.

Lemongrass Tea Health Benefits

Protects Your Heart

The true effectiveness of lemongrass on lowering blood pressure is still being examined by researchers, its many other boons make it a good option to integrate into the diet.

Boosts Metabolism

There are a number of beneficial compounds found in lemongrass tea and its caffeine contents are thought to work together to stimulate your metabolism.

Improves Digestion

For thousands of years, lemongrass has been used in various cultures around the world to soothe stomach issues and improve overall gut health. The tea contains a component called citral that is thought to help digest food more effectively. In local region lemongrass is used as a natural remedy to prevent constipation and other irritation in the bowels.

Boosts Immunity

When you begin to feel ill, it is natural to reach for a warm cup of tea. By increasing your antioxidant levels every day with a cup of lemongrass tea, particularly citral, which is the active ingredient, you can defend against the negative effects of free radicals and ensure prolonged health. The antioxidant content of lemongrass tea will give that extra boost to your immune system that it needs when fighting off an infection.

Reduces Inflammation

Whether you are suffering from arthritis, a sore throat, a headache, or atwisted ankle, the anti-inflammatory effects of lemongrass tea may have an effect all over the body. By reducing inflammation in the tissues and cells of the body, it can effectively ease pain and reduce irritation. This also makes lemongrass tea a good topical application for certain skin issues; you can allow the tea to cool and then apply it with a cloth to the affected area.

Relieves Depression and Anxiety

The people who regularly consumed lemongrass tea did see improvements in their mood swings and anxiety. The natural chemicals in lemongrass tea are sedative in nature, which can help relax the mind and prevent worry and stress from building up.

Induces Sleep

As an add-on to the anxiety and stress fighting characteristics of lemongrass, it isalso an excellent sleep aid. As a sedative substance, it can soothe the body and mind by inducing the release of serotonin and helping you overcome symptoms of insomnia or chronic restlessness. A healthy body begins with a healthy sleep cycle, and lemongrass tea may be your sleep regulator.

Benefits of consuming lemongrass tea

- Antioxidant properties
- Antimicrobial properties
- Anti-inflammatory properties
- Reduced cancer risk
- Improved digestion
- Lowered blood pressure
- Lowered cholesterol levels
- Weight loss

Word of Caution

You should avoid the use of lemongrass if you are pregnant, as the powerful nature of its components can have certain interactions with medicines. Therefore, if you are considering adding lemongrass tea to your daily or weekly health regimen, it is always a good idea to speak with your doctor first, to avoid any complications.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

YEAST IN AGRICULTURE: UNLOCKING ITS POTENTIAL AS A BIO CONTROL AGENT AND BEYOND

Article ID: AG-VO4-I05-89

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Introduction

Yeasts are versatile organisms with wide-ranging applications. They are single-celled belonging to the kingdom Fungi. They are microscopic organisms that play significant roles in various aspects of our lives, ranging from food and beverage production to scientific research. From their role in fermentation and food production to their potential as biocontrol agents and contributions to scientific research, yeasts have a significant impact on various aspects of our lives. Their diverse characteristics and functions continue to be explored and utilized in different fields, making them a fascinating group of organisms.

Yeasts encompass a diverse group of species, with over 1,500 identified so far. The most well-known and extensively studied yeast species is *Saccharomyces cerevisiae*, commonly known as baker's yeast or brewer's yeast. Yeasts are renowned for their ability to undergo fermentation, a metabolic process in which they convert sugars into alcohol and carbon dioxide. This process is widely utilized in the production of bread, beer, wine and other alcoholic beverages. They play a vital role in the food and beverage industry and are used as leavening agents in baking, where they produce carbon dioxide gas, leading to dough rising. In wine making, yeast ferments grape sugars into alcohol, contributing to the production of wine. Similarly, yeasts are crucial in beer and other fermented beverage production. Yeasts, particularly *Saccharomyces cerevisiae*, have been extensively studied in scientific research. Their simple cellular structure and ease of manipulation have made them a model organism for studying various biological processes. Yeasts are also used in biotechnology for the production of enzymes, pharmaceuticals and industrial chemicals. Some yeast strains have been studied for their potential health benefits when used as probiotics. They may aid in digestive health, immune function and nutrient absorption. Probiotic yeast formulations are used in dietary supplements and functional foods.

Yeasts in Agriculture

Yeasts have ecological significance and are found in various natural environments, including soil, plants and aquatic habitats. They contribute to nutrient cycling, decomposition, and the breakdown of organic matter in ecosystems. Yeast plays a significant role in various agricultural processes and has several applications in the field. In agriculture, yeast fermentation is utilized in the production of alcoholic beverages, such as wine, beer, and spirits. Yeast strains are carefully selected to achieve specific flavor profiles and alcohol content, contributing to the diversity and quality of these products. Yeasts are involved in nutrient cycling and contribute to the breakdown and decomposition of organic matter. They play a role in the decomposition of plant residues and contribute to the release of nutrients back into the soil. This process is crucial for nutrient recycling and maintaining soil fertility in agricultural systems. In animal agriculture, specific strains of yeast are used as probiotics to improve animal health and performance.

Yeast-based probiotics can enhance digestive efficiency, support the development of a healthy gut microbiota and improve nutrient absorption in livestock. This can lead to better feed conversion, improved growth rates and reduced incidence of digestive disorders. Yeasts have the ability to degrade and detoxify certain pollutants and contaminants in the environment. They can be employed in bioremediation processes to break down organic pollutants, such as hydrocarbons, pesticides, and industrial waste. Yeasts have been used in soil and water remediation projects to mitigate the negative impacts of pollutants on agricultural ecosystems. Yeasts, particularly nutritional yeast strains, are a rich source of vitamins, minerals, and proteins. They can be used as feed supplements for livestock to enhance their nutritional intake and overall health. Additionally, yeast extracts are utilized as nutrient supplements in plant fertilizers to provide essential nutrients and promote plant growth. It is important to note that the specific applications and benefits of yeast in agriculture may vary depending on the context, crop, or livestock species involved. Proper strain selection, application methods, and understanding of ecological interactions are crucial for maximizing the positive contributions of yeast in agricultural practices.

Nowadays, finding sustainable and environmentally friendly solutions for pest management is of paramount importance. Traditional chemical pesticides have been widely used but are often associated with ecological risks and detrimental effects on human health. In recent years, there has been a growing interest in harnessing the potential of biological control agents, such as yeast, to combat pests and diseases in agriculture. Yeast, known for its fermentation capabilities, is now being recognized for its multifaceted role as a biocontrol agent and beyond.

Certain yeast species have biocontrol properties and are utilized as natural alternatives to chemical pesticides. They can suppress the growth of plant pathogens, such as fungi and bacteria, by producing antimicrobial compounds and competing for nutrients. This makes them valuable in sustainable agriculture practices. Yeast species, such as *Saccharomyces cerevisiae* and *Candida oleophila*, have biocontrol properties and can be used as natural alternatives to chemical pesticides. These yeasts can inhibit the growth and activity of plant pathogens, such as fungi and bacteria, helping to protect crops from diseases. They produce antimicrobial compounds and compete for nutrients, thereby limiting the establishment of pathogens.

Yeast as a biocontrol agent

Certain yeast species, such as *Saccharomyces cerevisiae*, *Candida oleophila*, and *Pichia anomala* exhibit antagonistic properties against plant pathogens. They produce antimicrobial compounds that inhibit the growth and activity of various pathogens, including fungi and bacteria. This natural biocontrol mechanism can help reduce crop diseases without the need for chemical interventions. Yeast can also stimulate the plant's natural defense mechanisms by inducing systemic resistance. When plants are treated with specific yeast strains, they activate their own immune responses, making them more resistant to pathogenic attacks. This priming effect can enhance plant health and reduce disease incidence.

Competence of yeasts with pathogens for nutrients and space contributes to its biocontrol efficacy. By colonizing the plant surface and forming a protective barrier, yeast strains can prevent pathogenic organisms from establishing themselves, thereby reducing the risk of infection. Yeast-based biocontrol agents are compatible with integrated pest management strategies, where multiple approaches are employed to manage pests sustainably. They can be integrated into IPM programs, working synergistically with other control methods such as cultural practices, beneficial insects, and resistant crop varieties.

Yeast plays a crucial role in nutrient cycling in agricultural ecosystems. They are involved in the decomposition of organic matter, breaking down plant residues and releasing nutrients back into the soil. This nutrient cycling process helps improve soil fertility and supports sustainable agriculture. Furthermore, yeast is extensively used in biotechnology for the production of enzymes, pharmaceuticals, and industrial chemicals. Yeast can contribute to soil health through their interactions with plant roots. They can form beneficial associations with roots, such as arbuscular mycorrhizal symbiosis, enhancing nutrient uptake and promoting soil structure and water-holding capacity.

Conclusion

Yeast, once primarily known for its role in fermentation processes, is now being recognized for its immense potential as a biocontrol agent and beyond in agriculture. Its antagonistic properties, ability to induce systemic resistance, and competitive exclusion mechanisms make it an effective and sustainable tool for managing plant diseases. Additionally, yeast's contributions to nutrient cycling, fermentation, biotechnology and soil health further highlight its versatility and significance in agricultural systems. Unlocking the potential of yeast in agriculture not only provides environmentally friendly pest management solutions but also opens up new avenues for sustainable and innovative practices in the field. Embracing yeast's multifaceted role can lead us towards a more resilient, sustainable, and bio-diverse agricultural future.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

MACHINE HARVESTING IS ECONOMICAL IN SUGARCANE

Article ID: AG-VO4-I05-90

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Introduction

Sugarcane is one of the most important cash crops in India. India being a major consumer of sugar occupies the second place in sugarcane production, next to Brazil. Sugarcane is cultivated in an area of 5.8mha, production of 494 mt and productivity of 84.48 t/ha (2022-2023) and a recovery percentage of 10.03% (2021-2022). In recent times, sugarcane has become a preferred crop for renewable and eco-friendly energy production. Excepted rise in demand for energy has improved the scope of sugarcane production. Sugarcane crop and its products contribute about 1.1% to India's GDP. The contribution of sugarcane to the agricultural GDP has increased steadily in the last two decades. Also, Sugarcane and sugar industries act as a major source of employment and livelihood in India. More than 50 million farmers are engaged in sugarcane cultivation and processing industries. But the major impediment is its productivity which has remained stagnant. It is known that productivity is governed by the combination of climate, technology, genetic resources, farm management practices, states pricing policies and decisions. There is no doubt that, the government has intervened in number of forms such as Essential Commodity Act (1955), Sugar Control Order (1966), Sugarcane Development Fund (1982), Delicensing Sugar Sector (1998), Fair and Remunerative Price (2009-10), Ethanol Blending Programme (2012), Scheme for Extending Financial Assistance to Sugar Undertaking (2014) etc. Despite many efforts by both the Central and State Governments, India's sugarcane sector is grappled with lot of issues by varying degree and nature.

Sugarcane, a sweet reed had attracted many from monks to monarches. The word Saccharum seems to be originate from Sanskrit word sarkara. The most ancient reference to sugarcane is in Athervaveda which is 5000 years old. In budhist literature, Gautama , the Budha was known as "king of sugarcane''. The optimum temperature is 30 to 32^{0}C while growth is restricted below 14^{0}C. sugarcane is grown in areas where the average rainfall is about 500 and 2500 mm. it requires lot of sunshine during the growth period.

The major constraint in sugarcane production is harvesting. Harvesting of sugarcane and its transportation to sugar mills is energy and labour intensive, and involves human drudgery when performed manually. Now after the advent of machineries in sugarcane harvesting; harvesting is easy and covers large area in short span of time.

Trained labourers are engaged to harvest the cane but now machinery is available and slowly popularizing among the farmers. Over a decade, constraints in machinery harvesting were looked and simplified (an hectare area in 2 hours) unlike the manual harvesting which requires an hectare area in 16 hours. Machines cut down the cane in to small bits known as billets and transported to the mill.

Total expenditure due to Machine harvesting and Manual harvesting

Harvesting techniques	Rs./t	Yield/acre (t)	Total expenditure (Rs.)
Manual Harvesting	1250	50	62,500
Machine harvesting	600	50	30,000 + Miscellaneous 10,000 (on higher side) 40,000

Income and expenditure and net returns in Manual harvesting and Machine harvesting

Harvesting techniques	Total income (Rs.)	Expenditure (Rs.)	Net returns (Rs.)	Saving in Rs./acre
Manual harvesting	1,45,950	62,500	83,450	0
Machine harvesting	1,45,950	40,000	1,05,950	22,000

Mechanical harvesting offers efficiency and environmental benefits, manual harvesting remains crucial for employment in rural areas but trash burning is a problem. The choice often depends on the scale of the farm, economic factors, and regional practices. As technology advances, finding a balance that respects both environmental sustainability and social impact is key in the evolution of sugarcane harvesting.

Conclusion

Machinery harvesting in sugarcane is the recent decadal adventure. Due to high cost, this was not purchased earlier in larger numbers. But now this is commercially available to the farmers in their door step by Sugar mills. In a simple comparison of economics we found that sugarcane mechanical harvesting saves an amount of Rs. 22,000 and time per acre. Hence this can be promoted on large scale among sugarcane farmers as it does not have negative effect on ratooning, productivity and quality of the sugarcane.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

MICROPROPAGATION IN NEEM

Article ID: AG-VO4-I05-91

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Introduction

Tissue culture, in Neem plant is a sophisticated technique that involves the cultivation of plant cells, tissues, or organs in a controlled aseptic environment. This method has revolutionized the propagation of plant species by allowing the rapid multiplication of plants and preservation of valuable germplasm. It helps in understanding the use of various explants with different growth regulators combinations on successful regeneration of organogenesis. Neem extract and neem-based products has tremendous pharmaceutical values, Medicinal properties which contributes to advancements in neem improvement conservation of endangered species through tissue culture technologies, and the.

Objectives of Tissue Culture

i. Clonal Propagation: Tissue culture enables the rapid production of genetically identical neem plants, ensuring the uniformity of desired traits such as high oil content, pest resistance, and medicinal properties.

ii. Disease-Free Plantlets: It helps produce neem plantlets free from diseases and pests, reducing the risk of infections in the early stages of growth.

iii. Genetic Transformation: Neem tissue culture allows for the introduction of foreign genes or genetic modifications for the improvement of Neem plants.

iv. Secondary Metabolite Production: Neem tissues can be cultured to produce secondary metabolites like neem oil, which has numerous agricultural and medicinal uses.

Different methods of regeneration

i. Induction of the formation of multiple shoots from axillary buds

ii. Direct regeneration from somatic tissues

iii. Direct somatic embryogenesis

iv. Indirect somatic embryogenesis

Steps to be followed in culturing neem explants

i. Either *in vitro* induction of multiple shoots from axillary buds or direct somatic regeneration from leaf discs or stem are certainly the fastest way to propagate a great number of genetically identical plantlets true -to-type to the mother plant.

ii. Nodal segments and shoot tips were collected from mature (15-year-old) trees and from greenhouse-grown juvenile (1.5-year-old) seedlings of Neem. The explants were rinsed in Bavistan (BASF India) (0.1% w/v) for15 min to reduce fungal contamination. Later, these were thoroughly washed with teepol (2% v/v) and kept in running tap water for 15 min.

iii. The explants were given a quick dip in 70% ethanol, followed by surface sterilization with a solution of mercuric chloride (0.1%) and sodium lauryl sulphate (0.1% w/v) for 10 min under aseptic conditions in a Laminar Air Flow Cabinet. The solution was placed on a stirrer to provide uniform contact between chemicals and explants. The explants were then thoroughly rinsed (4–5 times) with autoclaved double-distilled water. The exposed ends of the explant were trimmed and were placed aseptically in25 mm × 150 mm test tubes (Borosil India Ltd.) containing 15 ml MS medium supplemented with 3% sucrose and solidified with 0.7% agar (Bacteriological grade, CDH chemicals Ltd. India).

iv. The pH of the medium was adjusted to 5.9 prior to autoclaving for 20 min at 121ºC and15 psi pressure.

MEDIUM FOR CULTURE:

The culture medium most widely used for the *in vitro* cultivation of *Azadirachta indica* is the Murashige and Skoog medium (Murashige and Skoog, 1962). It is important to add growth regulators in the medium in order to obtain a morphogenetic response. MS medium was supplemented with 6-Benzylaminopurine (BAP) (1mgl^{-1}) and Kinetin (0,5 mgl^{-1}) with the formation of 3.37 ± 0.66 shoot buds/explant and a response of the explants of 80%. These shoot buds were once more sub cultured on the same medium and after eight weeks 20 to 25 buds were obtained and addition of adenine sulphate increased the shoot production. For *in vitro* plant tissue culture, the molar ratio between the different PGR's used is very important. In Neem tissue culture an increase of the Kinetin concentration upto 1.29 mgl^{-1} induces the formation of shoot buds with callus. A further increase of adenine sulphate till 3,68 mgl^{-1} in the culture medium induces callus formation from leaf disc explants.

A STANDARD PROCEDURE FOR THE MICROPROPAGATION MEDIUM OF THE NEEM

Micro propagated shoots were initiated from leaf explants cultured on Murashige and Skoog medium containing BAP (1 mgl^{-1}) Kinetin (0.8 mgl^{-1}) and adenine sulphate (6 mgl^{-1}) in complete darkness. These shoots were further multiplied on MS medium containing BAP (0,1 mgl^{-1}) Kinetin (0,08 mgl^{-1}) and adenine sulphate (0,6 mgl^{-1}). Within 32 weeks, 80 shoots could be produced from a single leaf explant. Fifty-five percent of these shoots rooted on MS medium supplemented with indolebutyric acid (IAA) (1 mgl^{-1}) and then finally transferred to soil (Figure 1).

a. Callus formation b. Shoot initiation c. Subculturing d. Shoot multiplication e. Hardening

Fig. 1. Steps in Micropropagation

ACCLIMATIZATION:

The rooted plantlets were carefully removed from test tubes without damaging the roots. The roots were thoroughly washed under running tap water to remove adhering agar medium and the plantlets were placed in plastic cups containing different potting mixtures (sand, sand + soil, vermiculite). The plantlets were covered with transparent polythene bags to maintain high humidity and were watered on alternate days.

Conclusion

Selection of Plants that reproduce themselves through seeds undergo considerable variations from one generation to the other. Furthermore, in the case of the Neem tree the seeds are vital for only short period, two to four weeks and germinability may also be quite low. Hence different plant tissue culture method for producing a more plant without any variation in a short time and less space. Overall, tissue culture in Neem plants has contributed significantly to Neem's commercial, agricultural, and medicinal significance, making it an essential tool in the cultivation and propagation of this versatile crop.

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Volume: 04 Issue No: 05

CORRELATION STUDY OF YIELD PARAMETERS IN SUGARCANE; CANE WEIGHT WAS POSITIVELY CORRELATED WITH INTERNODE LENGTH AND CANE GIRTH

Article ID: AG-VO4-I05-92

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Introduction

For doing correlation study, a field of 1.5 acres growing with the same sugarcane variety was chosen at Sugarcane Research Station, Cuddalore. In the variety CoC 13339, the observation on yield parameter was observed randomly. Number of internodes, internode length, Cane girth and Cane weight was observed and correlation was done. 120 observation were made and undergone the correlation analysis. The result is given hereunder with discussion.

Correlation analysis	**no of internodes**	**internode length**	**cane girth**	**Cane weight**
no of internodes	1	-0.281360441	-0.035620522	-0.026155196
internode length	-0.281360441	1	0.464175674	0.248960541
cane girth	-0.035620522	0.464175674	1	0.260317101
Cane weight	**-0.026155196**	**0.248960541**	**0.260317101**	**1**

No of internodes

Number of internodes was negatively correlated with Internode length(-0.2813604). Number of internode decreased with increase in internode length. This (number of internodes) was less influenced with both the parameters cane girth and weight and was negatively correlated. Cane weight decreased with increase in number of internodes (-0.0261551). As number increased length and girth was lesser.

Table 2. **Sample of observations made**

Sample number	No of internodes	internode length (cm)	cane girth (cm)	Cane weight (kg/cane)
1.	19	12	9.8	1.454
2.	16	13	10	1.408
3.	17	14	10.5	1.926
4.	21	10	8.8	0.957
5.	19	12.5	10	1.542
6.	24	8.5	9.5	1.07
7.	26	8	9.5	1.011
8.	15	10.2	8.5	1.074
9.	22	8	10.5	1.098
10.	20	9.5	9.1	1.39

Internode length

Negatively correlated with number of internodes (-0.2813604). Positively correlated with cane girth (0.464175) and cane weight (0.2489605)

Cane girth

Less negatively correlated with number of internodes(-0.0356205) and positively correlated with internode length (0.464175). Cane weight improved with cane girth and was positively correlated (0.260317).

Cane weight

Cane weight was less negatively correlated with number of internodes (-0.026155). Cane weight was positively influenced by internode length (0.248960541) and cane girth (0.260317101).

Conclusion

Cane weight was positively correlated with internode length and girth. Negatively correlated with number of internodes.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 05

PLANT'S BATTLE AGAINST TRENCH WARFARE AT THE MOLECULAR LEVEL

Article ID: AG-V04-I05-93

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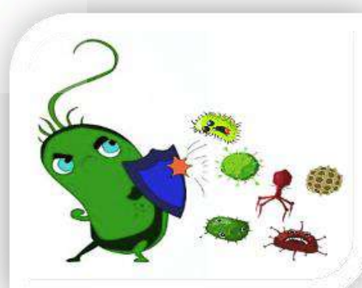
Introduction

Trench warfare is not just a problem for soldiers on the battle field, but also for plants in their natural environment. Plants face a constant battle against pests, disease, and environmental stresses that can cause significant damage to their health and productivity. At the molecular level, plants have developed a complex defense mechanism to protect themselves from these threats. In this presentation, we will explore how plants fight back against trench warfare and the exciting possibilities for the future of plant defense.

What is Trench warfare?



- Trench warfare is a term used to describe the **long-term struggle** that plants face when they are under attack by pathogens and pests. At the molecular level, this battle involves a complex interplay between the plant's defense mechanisms and the invading organisms' ability to evade or overcome those defenses.
- To illustrate this concept, consider the example of a plant infected with a pathogenic fungus. The fungus may produce enzymes that break down the plant's cell walls, allowing it to penetrate deeper into the plant tissue.
- In response, the plant may activate its own defense mechanisms, such as producing toxic compounds or strengthening its cell walls. However, the fungus may also evolve new

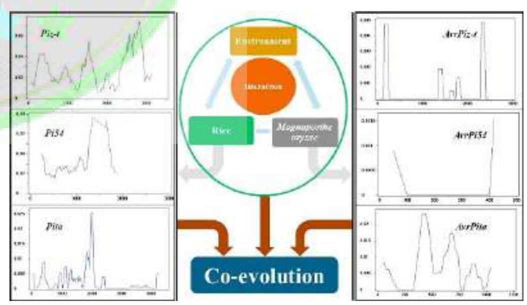
strategies to overcome these defenses, leading to an ongoing cycle of adaptation and counter- adaptation.

- Cycles of disease epidemics maintain relatively stable forms of **resistance** and **susceptible genes** over **long period** of time.
- Trench warfare hypothesis says that the alleles of one of the counterparts, **either R or *Avr* gene are under balancing** selection (Bergelson *et al*., 1999).

History

- Gregory B. Martin says- “It's like radar detecting an incoming missile” so they Consider it **“trench warfare at the molecular level.”**

- One combatant is *Pseudomonas syringae*, causing bacterial speck disease in tomato.
- Despite the attack, the plant cell is prepared for the invading attack.
- Behind the cell wall, the plant cell detects alien proteins and mounts a defense.
- They were able to find nearly 30 genes in the *P. syringae* bacterium involved in the attack and resistance system.
- Trench warfare hypothesis says that the alleles of one of the counterparts, either R or Avr, are under balancing selection while the other is under positive selection. So, according to this hypothesis, advance retreat cycles of diseases can maintain relatively stable form of R- or Avr- alleles in nature (Singh *et al*., 2018).

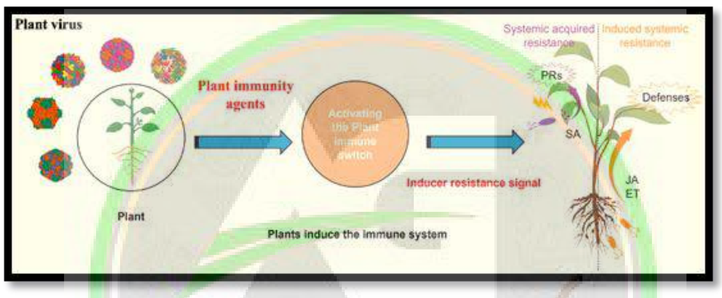


- Co-evolution of *Pita* and *AvrPita* loci in the plant and the pathogen, respectively has taken place according to trench warfare hypothesis.
- ‘Trench warfare’ concept was supported for avr and R-gene proportions in Arabidopsis thaliana for resistance to *Pseudomonas syringae* pv. *maculicola* (RPM1 alleles) (Stahl *et al*., 1999), and was also suggested to account for resistance to WPBR in pines (Kinloch and Dupper, 2002).

- Trench warfare suggests that resistant and susceptible alleles are maintained over large time spans (more than 9 million years for RPM1) and that proportions within populations vary in response to periodic epidemics.

Defense mechanism

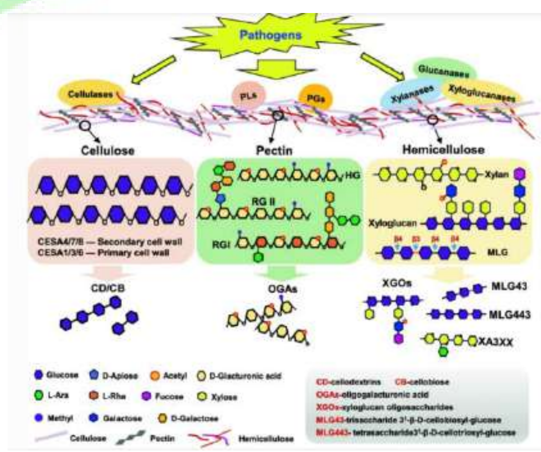
- Here are some examples of how plants can be thought of as "battling" against challenges at the molecular level:
- **Plant immune response:** It triggers a series of defense responses, including the production of antimicrobial compounds, phytoalexins and the reinforcement of cell walls to prevent pathogen entry.



Reinforcement of cell walls:

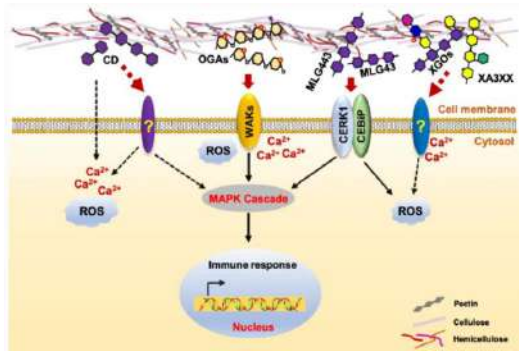
When under attack, plants can strengthen their cell walls by depositing additional structural components, such as lignin, suberin, and callose. This reinforcement makes it harder for pathogens to penetrate plant tissues.

- To overcome the barrier of the plant cell wall, pathogens produce CWDEs to degrade plant cell wall polysaccharides, resulting in the release of cell wall oligosacchrides like cellodextrins and cellobiose from cellulose, oligogalacturonic acids from pectin, the xyloglucan oligosaccharides, XA3XX from arabinoinxylan and the MLG43 from mixed-linked glucans.



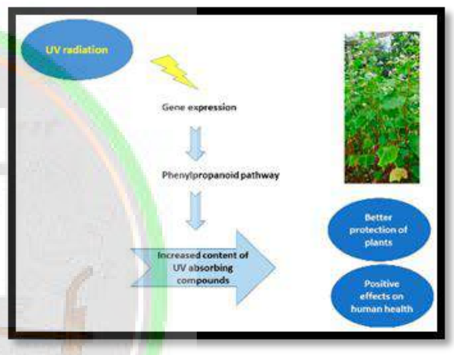
- Signaling pathways triggered by cell wall-derived oligosaccharides. Cell wall-derived oligosaccharides function as elicitors recognized by pattern recognition receptor (PRRs) including WAKs, CERK1 and CEBiP to trigger immune response. Cellodextrins derived from cellulose induce the elevation of free cytosolic calcium, generation of ROS and upregulation of *PR* genes. Oligogalacturonic acids derived from pectin are perceived by WAK1 to activate MAPK cascade, which in turn elevates free cytosolic calcium and promotes ROS generation.

- Xyloglucan oligosaccharides are able to activate the MAPK cascade, deposition of callose, expression of PR genes and increase the biosynthesis of hormones. XA3XX from arabinoinxylan is able to trigger Ca^{2+} influxes, ROS burst, MAPK phosphorylation and the expression of PTI related genes.



UV radiation protection:

Plants exposed to high levels of ultraviolet (UV) radiation activate molecular pathways to produce protective compounds like **flavonoids and anthocyanins**. These compounds act as sunscreens, shielding the plant from harmful UV radiation.



Pathway of impacts of UV-B radiation on buckwheat plants

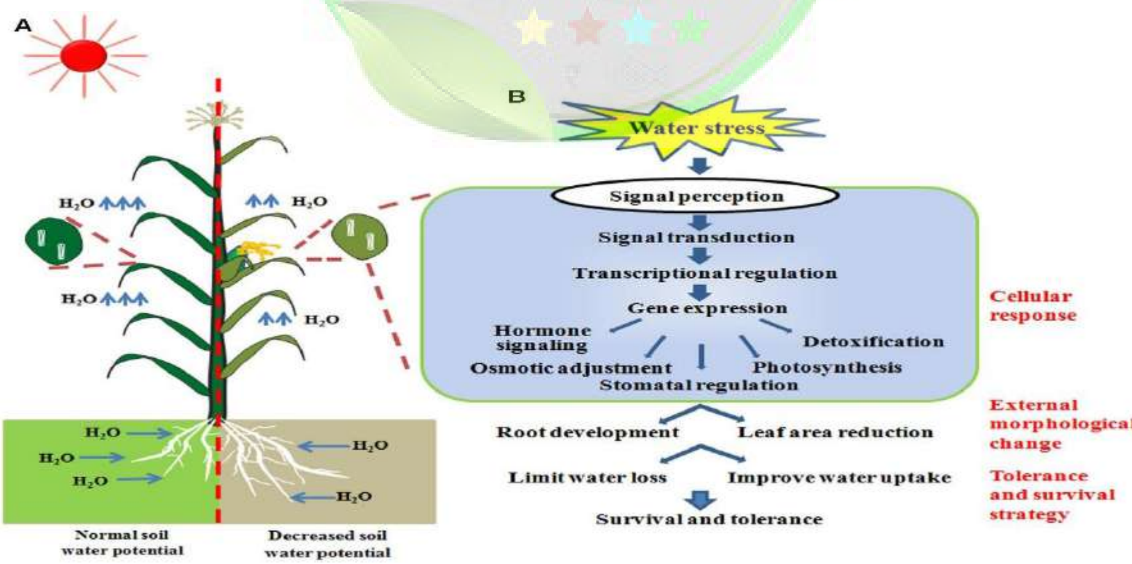
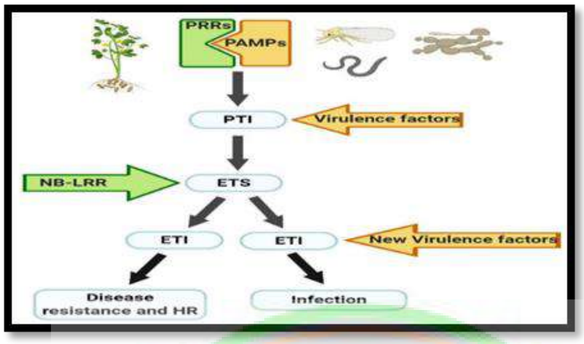


Fig. 1 (A) The physiological and morphological adaptations of plants grown under water-deficit conditions. **(B)** Cellular response to water stress, including signaling transduction and physiological changes to achieve survival strategies. Wang *et al*. (2022)

Drought resistance: Plants activate molecular pathways that enable them to conserve water and maintain cellular functions under stress. They might produce specific proteins and signaling molecules to regulate their water balance and protect cellular structures.

Recognition and response: Plants possess receptors that can detect molecules produced by potential pathogens or damage-associated molecular patterns **(DAMPs)** released during injury.

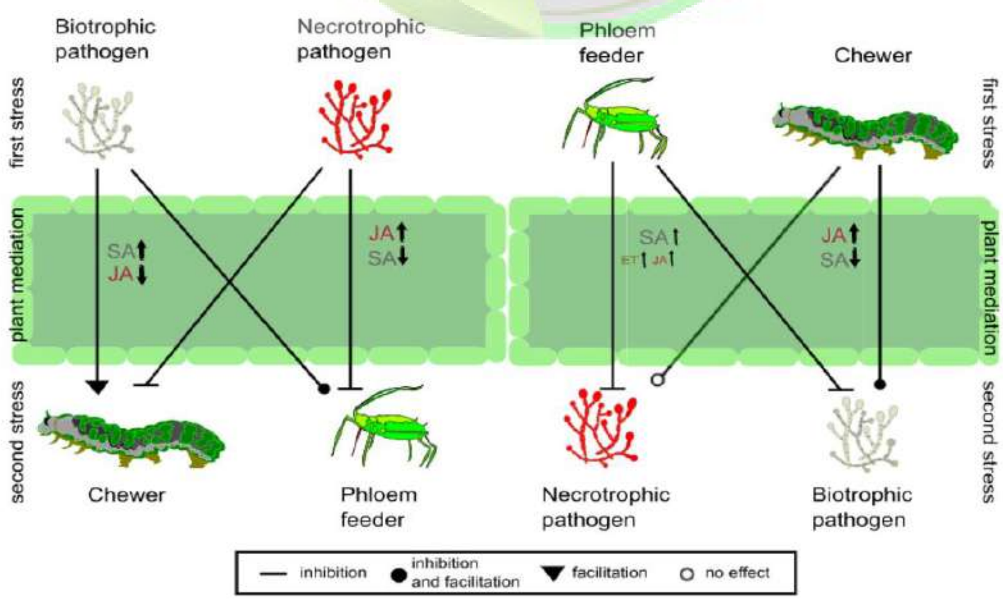


Legume Responses to Pathogen Attack

Hormonal signaling: Plants use hormones, such as salicylic acid (SA), jasmonic acid (JA), and ethylene, to regulate their defense responses.

- Biotrophic pathogens → SA
- Necrotrophic pathogens → JA

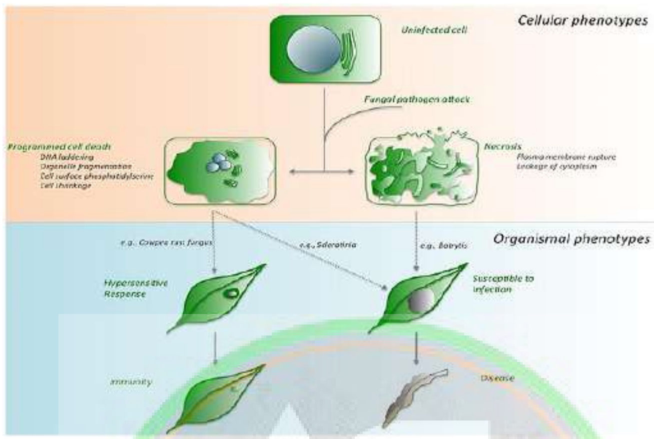
Biotrophic pathogens facilitate chewing herbivores unless plants exhibit ETI to the pathogen. Biotrophic pathogens facilitate or inhibit phloem feeders. **Necrotrophic pathogens** can inhibit both phloem feeders and chewers.



Activation of programmed cell death:

In certain cases, plants can trigger a process known as programmed cell death, or apoptosis, in response to pathogen invasion.

This mechanism allows infected cells to self-destruct, limiting the spread of the pathogen within the plant.



Two major types of evolutionary dynamics have been described for host-parasite coevolution: Arms race and trench warfare (Ebert, 2008)

Trench warfare	**Arms race**
Fast cycles of allele frequencies	Slow recurrent fixation of alleles
Coevolutionary cycles are not faster as compared to the arms race, except for large population sizes	Coevolutionary cycles are faster
A battle between a host and its pathogen in which one wins sometimes and loses other times at the front line, but the overall situation does not change drastically	A battle in which one acquires a new weapon and almost eliminates the other, then the other fights back with another new weapon
These two dynamics are driven by balancing selection (trench warfare).	These dynamics are driven by positive directional selection (arms race).

Conclusion

In conclusion, we have learned about the fascinating battle that plants fight against trench warfare at the molecular level. We explored the concept of trench warfare and how it affects plants, as well as the plant's defense mechanism and the role of hormones in regulating their response. Looking towards the future, we see great potential for genetic engineering and other technologies to enhance plant resistance and protect our crops from the devastating effects of trench warfare so that we can continue to feed our growing population and sustain our planet's biodiversity.

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Volume: 04 Issue No: 05

AZOLLA: A SUPER FERN

Article ID: AG-V04-I05-94

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Introduction

Azolla is aquatic floating fern, found in temperate climate. The fern appears as a small, flat, compact green mat over water surface. Azolla is one of the fastest growing plants on the globe, and it can double its surface area every 5-10 days, making it an extremely valuable resource. The Blue Green Algae cyanobacteria (*Anabaena azollae*) present as a symbiont with this fern in the lower cavities actually fixes atmospheric nitrogen. An azolla plant is a fern frond consisting of a main stem growing at the surface of the water, with alternate leaves and adventitious roots at regular intervals along the stem. Secondary stems develop at the axil of certain leaves. Azolla fronds are triangular or polygonal and float on the water surface individually or in mats.

There are at least eight species of Azolla worldwide; *A. caroliniana*, *A. circinata*, *A. japonica*, *A. mexicana*, *A. microphylla*, *A. nilotica*, *A. pinnata* and *A. rubra*. The common species of Azolla in India is *Azolla pinnata*. It produces more than 4 to 5 times of protein of excellent quality i. Azolla has gained popularity as a biofertilizer, green manuare, poultry feed and cow fodder (Dawar and Singh, 2002). Azolla is an excellent alternative to concentrates/fodder/feed, thereby providing a sustainable feed for livestock. It contains most of the nutrients which are required for all classes of livestock, including poultry and fish. Azolla can be fed to these animals without any adverse effects. Various studies revealed that feeding of azolla to dairy cows increased milk production by 15 to 20% and also improved the weight of broiler potassium, ferrous, copper, magnesium. On a dry weight basis, Azolla has 25-35% protein content, 10-15%

mineral content, and 7-10% comprising a combination of amino acids, bioactive substances and biopolymers.

Azolla is rich in proteins, amino acids, vitamins (A, B12, beta-carotene), growth promoter intermediates, and minerals (calcium, phosphorus, potassium, iron, copper, and magnesium). Azolla is one of the most cost-effective and efficient feed substitutes for cattle due to its high protein and low lignin content. It is also easily digested by animals (Wagner, 1997).Hence Azolla can be rightly called the “super plant” as it is vital in improving livestock production.

Environmental requirements

Azolla is found in ponds, ditches, and wetlands of warm temperate and tropical regions throughout the world. It Azolla must grow in water or wet mud, and it dies within a few hours under dry conditions. Azolla can survive a water pH range of 3.5–10, but optimum growth occurs when the water is between pH 4.5 and 7. The optimum temperature for azolla is between 64 and 82°F (18–28°C). The growth rate gradually declines as salinity increases. Azolla grows in full to partial shade (100–50% sunlight), with growth decreasing quickly under heavy shade.

Azolla-Anabaena symbiosis

In its lifetime, Azolla forms symbiotic relationships with cyanobacteria. Anabaena belongs to the Phylum-Cyanobacteria, Order- Nostocales, and Family-Nostocaceae members. To meet the symbiotic Anabaena's total nitrogen requirement, the nitrogenase enzyme is activated, which breaks down atmospheric nitrogen. Nitrogen comprises 3–6% of the association's dry weight (Zahran et al., 2007). As a result of the Azolla application, the soil's microbial health has improved. Small-scale rice farming relies on the mineralization of organic nitrogen to ammonia, which is essential. Among other things, the C:N ratio affects mineral formation rate. In contrast, Azolla with a high C:N ratio mineralized in 5 days . The Azolla-Anabaena symbiosis is unique in that both the eukaryotic Azolla and the bacterial Anabaena can fix CO2. A chemical reaction occurred when $^{14}CO_2$ was introduced into *A. azollae* leaf cavities. No indication of cyan bacterial photosynthesis using 14C-sucrose was discovered. Serag et al. (2000) say that *A. azollae* may be able to use either photoheterotrophic or myotropic metabolism, with the sucrose made by the fern acting as a source of less carbon.

Azolla as an organic input

Nutrients improve root volume, area, diameter, total and main root length, and also enhance nutrient uptake, balance, and dry mass production. Soil organic carbon content increased with organic nutrient management, which included Azolla inoculation. Compared to chemical fertilizers, organic management increases soil physical features, including soil available water capacity (AWC) and water retention capacity (WRC) (Goyal et al., 2005). AWC increased as micro- and microporosity increased. Azolla-Anabaena may be used as a biofertilizer for crops such as rice, wheat, and others. Using biofertilizers instead of chemical fertilizers has many benefits. (A) Azolla uses widely available solar energy, nitrogen from the air, and water to enrich the soil. It is quite inexpensive. (B) Besides delivering nitrogen for crops, it also gives vitamins and growth hormones to animals. (C) Unlike chemical fertilizers, which are made from petroleum, organic fertilizers are made from sustainable resources. So biofertilizers are non-polluting in nature.

Azolla as an animal feed

Azolla as a livestock feed Protein, essential amino acids, vitamins (A, B12, Beta-carotene), growth promoter intermediates, trace elements, and minerals are abundant in Azolla . By dry weight, azolla contains 25-35 percent protein, 10-15% minerals, and 7-10% amino acids, bioactive compounds, and biopolymers. Azolla is low in carbohydrates and fat, making it a nutritious snack. The bio -composition of Azolla makes it one of the most cost-effective and efficient cow feed choices. Azolla is also readily digestible by animals because of its high protein content and low lignin level (Bhatt et al., 2020). When cultivated in favorable conditions, all Azolla strains contain a balanced combination of essential amino acids and high-quality protein. By using its nutrients more efficiently than ruminants, Azolla has lower amounts of acid detergent fiber (ADF) and neutral detergent fiber (NDF). Azolla is an excellent source of plant proteins, pro-vitamin A, carotenoids, and lutein (Kathirvelan et al., 2015). The outcomes of Azolla as a fish feed as alternative experiments have also been reported (Lejeune et al., 2000). Rawat et al. (2015) found a 11.85% increase in milk output when Azolla was supplemented with concentrate in a 1:1 ratio in crossbred cows. Sharma (2012) studied the effects of Azolla (*A. microphylla*) supplementation on milk production and milk quality in crossbred bovine animals.

Weed supression

Azolla's ability to create a light-proof mat that suppresses other weeds has been used for centuries in rice production to save the expensive labor costs of weeding.

Pest problems

Azolla is a preferred food of apple snails, a serious pest of taro. Care must be taken when transferring azolla from one location to another to ensure that apple snails and their eggs are not present. Ducks may be helpful in snail control. A weevil (probably *Stemopelmus spp.*) and larvae of the moth *Agrotis ipsilon* have also been reported on azolla. Azolla can become weedy in slow moving waterways.

(Zahran et al., 2007).

Advantages of Azolla

1. It easily grows in wild and can grow under controlled condition also.
2. It can easily be produced in large quantity required as green manure in both the seasons – Kharif and Rabi.
3. It can fix atmospheric CO2 and nitrogen to form carbohydrates and ammonia respectively and after decomposition it adds available nitrogen for crop uptake and organic carbon content to the soil.
4. The oxygen released due to oxygenic photosynthesis, helps the respiration of root system of the crops as well as other soil microorganisms.
5. It solubulises Zn, Fe and Mn and make them available to the rice.
6. Azolla suppresses tender weeds such as Chara and Nitella in a paddy field.
7. Azolla releases plant growth regulators and vitamins which enhance the growth of the rice plant.
8. Azolla can be a substitute for chemical nitrogenous fertilizers to a certain extent (20 kg/ha) and it increases the crop yield and quality.
9. It increases the utilisation efficiency of chemical fertilizers.
10. It reduces evaporation rate from the irrigated rice field.

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Volume: 04 Issue No: 05

MANAGEMENT OF DISEASE IN GUAVA: SYMPTOMS AND EFFECTIVE CONTROL METHODS

Article ID: AG-VO4-I05-95

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Introduction

Guava Also Known as *Psidium gajava* is a popular tropical fruit known for its sweet and nutritious flesh. It is not only enjoyed fresh but is also used in various culinary preparations such as jams, jellies, and juices.

In India Guava farming is done across India. Major states producing guava are Uttar Pradesh, Madhya Pradesh, Bihar, Andhra Pradesh, Haryana, Punjab Maharashtra, West Bengal, Chhattisgarh, Gujarat and Karnataka. Uttar Pradesh is the most important state for guava production. India Also Exports good-quality guava to Europe, the Middle East, and Central Asian Countries.

Common Guava Diseases

1.Anthracnose (Colletotrichumgloeosporioides):-

Symptoms:

- Anthracnose primarily affects the fruit, causing small, dark, sunken lesions with pinkish spore masses.
- Infected leaves may exhibit brown or black spots with irregular margins.
- Severe infection can lead to fruit drops and yield loss.

Control Methods:

Cultural Practices: Prune infected branches and remove fallen fruit to reduce the disease's source. Maintain proper spacing between trees to improve air circulation.

- *Fungicides:* Apply appropriate fungicides before the flowering season to prevent infection. Regular spraying during fruit development is also effective. For better control Spray
- Suggested products to Control Anthracnose are:
- **BiostadtRoko** - Spray @ 100 to 200 gm per ha. (0.5 g/lit of water)
- **Multiplex Tecozo** - Dissolve 1 to 2 ml (about 0.07 oz) per liter and Spray

2.Guava Wilt (Fusariumoxysporum)

Symptoms:

- Wilting of leaves, starting from the lower branches and progressing upwards.
- Yellowing and necrosis of leaves.
- Browning of vascular tissue in the stem.
- Stunted growth and reduced fruit production.

Control Methods:

Resistant Varieties: Choose guava varieties resistant to Fusarium wilt.

- *Soil Sterilization:* Solarize or steam-sterilize the soil before planting to kill pathogens.
- *Proper Irrigation:* Ensure adequate but not excessive soil moisture, as overly wet conditions can exacerbate wilt. Suggested products to Control **Guava Wilt** are:
- **Multiplex Bio Jodi** - Use Bio-Jodi 2 ml /liter of water
- **T Stanes Bio Cure -F** - Dissolve 1.2 lit / acre and 3 lit / ha and Spray

3. Powdery Mildew (Oidiumpsidii):-

Symptoms:

- White, powdery spots on leaves, young shoots, and fruit
- Affected leaves may curl, wither, and drop prematurely
- Reduced fruit quality and yield

Control Methods:

Pruning: Prune affected branches to improve air circulation and sunlight penetration.

- *Neem Oil:* Neem oil can also be effective in managing powdery mildew.
- Suggested products to Control **Powdery Mildew** are:
- **Tata Contaf Plus** - Dissolve 2 ml/ liter of water and Spray the Bottom of the leaves
- **Multiplex Multiclear Bio Pesticide** - Dissolve 4 - 5 ml/litre of water and spray on the inflorescence and affected areas

4.Bacterial Wilt (Erwiniapsidii):-

Symptoms:

- Wilting of leaves and entire branches.
- Yellowing and drooping of leaves.
- Dark, necrotic streaks in the stem.

Control Methods:

- *Sanitation:* Remove and destroy infected plants promptly.
- *Resistant Varieties:* Consider planting guava varieties known for their resistance to bacterial wilt.
- Suggested products to Control **Bacterial Wilt** are:
- **Multiplex Bactinash-200** - Use Multiplex Bactinash 0.3 -0.5 g/liter of water for spray or drenching
- **Tata BlitoxFungicid** - Dissolve 2-3 g per liter of water. For soil application, the recommended dosage is 1-2 kg per hectare.

5.Guava Rust (Pucciniapsidii):-

Symptoms:

- Small, raised pustules on the leaves, which turn orange or reddish-brown.
- Premature leaf drop.
- Reduced fruit quality.

Control Methods:

- *Fungicides:* Apply copper-based fungicides during the rainy season to prevent rust.
- *Pruning:* Remove and destroy severely infected leaves and branches.
- *Proper Spacing:* Ensure adequate spacing between trees for better air circulation.
- Suggested products to Control Guava Rust are:
- **Syngenta Tilt Propiconazole** - Recommended dosage 150-200ml per acer
- **Multiplex Treat Fungicide** - 1 ml /liter of water spray on both the sides of leaves
- **Multiplex Multiclear Bio Pesticide** - Dissolve 4 - 5 ml/litre of water and spray on the inflorescence and affected areas

6.Root-Knot Nematodes (Meloidogyne spp.):-

Symptoms:

Yellowing and wilting of leaves.

- *Soil Solarization:* Solarize the soil before planting guava to reduce nematode populations.
- *Resistant Varieties:* Choose guava varieties that are less susceptible to root-knot nematodes.
- *Nematode-Resistant Cover Crops:* Incorporate nematode-resistant cover crops into your orchard management plan.
- Suggested products to Control Root-Knot Nematodes are:
- **T Stanes Bio-Nematon** - 1.2 kg / acre and 3.0 Kg / ha
- **Bayer Velum Prime Nematicide** - Use Velum Prime 2-2.5 ml per lit of water

General Disease Management Tips for Guava:-

- **Proper Sanitation:** Regularly clean the orchard by removing fallen leaves and fruit to reduce disease reservoirs.
- **Pruning:** Prune the guava trees to improve air circulation and sunlight penetration, which can help prevent and manage diseases.

- **Healthy Soil:** Maintain well-draining, fertile soil with proper pH levels to promote healthy guava growth.
- **Fertilization:** Apply balanced fertilizers to provide essential nutrients and enhance the plant's immune system.
- **Integrated Pest Management (IPM):** Implement IPM practices to manage both diseases and pests, reducing the need for chemical controls.

Conclusion

Guava disease management is crucial for maintaining a healthy and productive guava orchard. By being proactive in identifying symptoms and employing effective control methods, growers can minimize the impact of diseases and ensure a bountiful harvest of this delicious tropical fruit. Remember that a combination of cultural practices, chemical treatments, and proper orchard management is often the key to success in guava disease management.

Volume: 04 Issue No: 05

UNLOCKING THE THERAPEUTIC POTENTIAL OF GUDUCHI (TINOSPORA CORDIFOLIA) IN DISEASE MANAGEMENT AND HEALTH PROMOTION

Article ID: AG-VO4-I05-96

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Introduction

In our contemporary society, where synthetic medications often dominate the healthcare system, the significance of harnessing nature's bounty for well-being cannot be overstated. Nature has bestowed upon us a wealth of plants with remarkable medicinal properties, accessible to individuals of all ages, genders, and cultural differences, dietary regimes. These natural remedies, with their minimal side effects compared to synthetic drugs, are increasingly gaining recognition in clinical and scientific research.

Among this plethora of herbs, Tinospora cordifolia, widely known as Giloy or Guduchi, has gained substantial global attention for its therapeutic effects and diverse applications in traditional medicine. This climbing shrub, belonging to the Menispermaceae family, holds a revered place in ancient wisdom, termed as "Guduchi" in Sanskrit, meaning "one that protects the entire body," and in Hindi as "Amrita," signifying "immortality." Its lush stems and fleshy roots, sprawling across trees, are characteristic features of this plant, thriving in tropical regions across Asia, Australia, and Africa.

Ayurveda has extensively documented the manifold health benefits of Giloy. Its regular consumption has shown protectice effects against various diseases. Though every part of the plant contributes to medicinal benefits, stem is subject to extensive study owing to the presence of wide array of bioactive compounds.

Bioactive Compounds

The therapeutic efficacy of Guduchi is attributed to its rich composition of bioactive compounds, including alkaloids, glycosides, steroids, sesquiterpenoids, phenolics, aliphatic compounds, and more. This diverse array of constituents can be primarily categorized into four major classes: terpenoids, alkaloids, lignans, and steroids, each contributing to the plant's remarkable therapeutic potential. Terpenoids, responsible for Guduchi's aroma and color, have demonstrated efficacy against a spectrum of ailments, from viral infections to inflammation and chronic diseases like diabetes and cancer.

Despite their bitter taste, alkaloids offer numerous health benefits, from fever reduction to diabetes management, and addressing urinary and respiratory issues. Lignans, prevalent in fibrous plants, exhibit potent antimicrobial activity, while steroids contribute to cardiovascular health and cholesterol management. Key constituents such as tinosporin, tinosporide, cordifolide, and berberine confer upon Guduchi its immunomodulatory, anti-inflammatory, antioxidant, and antimicrobial properties.

Of significant note is Guduchi's potential impact on diabetes management, as it aids insulin production and facilitates glucose metabolism, thereby regulating blood sugar levels. Moreover, its immunomodulatory effects enhance cellular function and vitality, while its antioxidant properties detoxify the body, promoting skin health and overall well-being. Incorporating Guduchi into one's dietary regimen can be achieved through various forms, including fresh juice blends, dried stems, capsules, tablets, and powders, readily available in the market.

Thus, Guduchi serves as a natural reservoir of bioactive compounds with immense therapeutic potential, providing a safer alternative to synthetic drugs. Revered for over 2000 years for its multifaceted healing properties, it continues to enthrall researchers and physicians, offering promising avenues for disease management and health promotion. In the face of the challenges presented by the COVID-19 pandemic, the importance of strengthening immunity through natural remedies such as Guduchi has become paramount. It is essential to advocate for further research into Guduchi and unlock its full potential for application in both the food and pharmaceutical industries. Nature has bestowed upon us the gift of healing, and it is incumbent upon us to wholeheartedly embrace it for the betterment of global health and well-being.

Boosting Immunity and Combating Infections

One of Guduchi's hallmark benefits lies in its ability to strengthen the immune system. Research indicates that its immunomodulatory effects stimulate the production and activity of white blood cells, thereby strengthening body's defense mechanism. Furthermore, its antimicrobial properties render it effectiveness against a spectrum of pathogens, including bacteria, viruses, and fungi, making it a valuable ally in combating various infections.

Anti-inflammatory Powerhouse

Chronic inflammation is increasingly recognized as a root cause of many diseases, from arthritis to cardiovascular disorders. Guduchi's potent anti-inflammatory properties help mitigate inflammation by inhibiting pro-inflammatory cytokines and enzymes, providing relief from conditions like rheumatoid arthritis, inflammatory bowel disease, and allergic reactions.

Supporting Liver Health

The liver plays a pivotal role in detoxification and metabolism, thereby effects the over all well-being of an individual. Guduchi renders hepatoprotective properties thus shield the liver from damage caused by toxins, free radicals, and several allopathic medications. Studies suggest that it aids in the regeneration of liver cells thus restoring liver function thereby serving as a valuable adjunct in the management of liver disorders like hepatitis and fatty liver disease.

Stress Relief and Mental Well-being

In today's fast-paced world, stress and anxiety have become prevalent concerns affecting millions worldwide. Guduchi, with its adaptogenic properties, helps the body adapt to stressors, promoting resilience and mental well-being. By modulating stress hormones like cortisol and promoting the production of neurotransmitters like serotonin and dopamine, it offers a natural solution for stress management and mood swings.

Promoting Healthy Aging

With increasing longevity, the focus shifts towards promoting healthy aging and maintaining vitality in later years. Guduchi's rejuvenating properties, coupled with its antioxidant prowess, make it a valuable adjunct in anti-aging regimens. By scavenging free radicals and combating oxidative stress, it helps protect cells from damage, preserving youthfulness and vitality.

Incorporating Guduchi into Daily Wellness Regimens

Incorporating Guduchi into one's daily wellness routine can be achieved through various forms, including powders, capsules, extracts, and teas. However, it's essential to source Guduchi from reputable suppliers to ensure purity and potency. As with any herbal supplement, consulting with a healthcare professional is advisable, especially for those with existing medical conditions or taking medications.

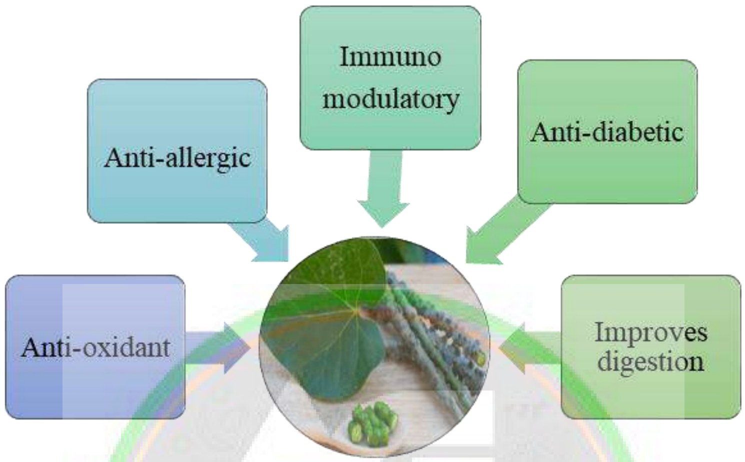

Fig 1) Major health benefits of Giloy (*Tinospora cordifolia*)

Thus, Guduchi, with its time-honored legacy and scientifically validated benefits, holds immense promise in disease management and health promotion. As modern science continues to unravel its secrets, this botanical gem from Ayurveda stands poised to make significant contributions to holistic well-being. By embracing the wisdom of traditional medicine and integrating it with contemporary healthcare practices, we can harness the full potential of Guduchi in our journey towards optimal health and vitality.

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May 2024 | Vol. No. 04| Issue No. 05


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