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AgriGate

GROW WITH EVERY PAGE!

An International Multidisciplinary Monthly e-Magazine

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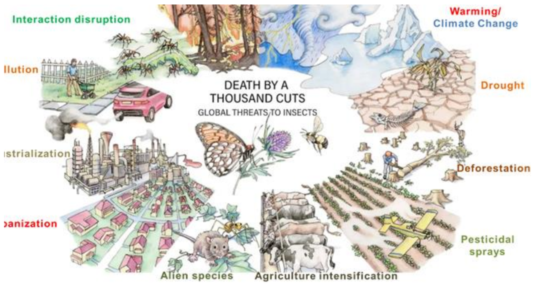
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From the Desk of Editor-in-chief

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I would like to introduce the launch of **"AgriGate - An International Multidisciplinary Monthly e-Magazine Volume 04 Issue No. 06 – June 2024"** with immense pleasure. Ourteam is privileged to dedicate this issue to Father's (Appa)**. World Father's Day** is observed every year on June 15 to to appreciate all fathers for their support and contribution to society. **World Environment Day** is observed every year on 5 June and is celebrated by more than 100 countries. The environment is a major issue, which not only affects the well-being of the people but also hampers economic development throughout the world.

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

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 06

ENHANCING AGRICULTURAL SUSTAINABILITY THROUGH THE BROAD BED FURROW (BBF) PLANTING TECHNIQUE

Article ID: AG-V04-I06-01

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Abstract

The Broad Bed Furrow (BBF) planting technique represents an innovative approach to agricultural production, integrating multiple processes such as wide swathing, sowing, and fertilizing into a single, tractor-driven machine. This article explores the scientific principles behind BBF and its numerous benefits, particularly in terms of water conservation, crop health, and soil fertility. By optimizing resource utilization and enhancing soil structure, BBF has the potential to revolutionize farming practices, promoting sustainability and productivity in diverse agricultural landscapes.

Introduction

In the face of increasing global food demand and environmental challenges, sustainable agricultural practices are paramount. The BBF planting technique offers a holistic solution, addressing key issues such as water conservation, soil health, and crop productivity. This article examines the scientific basis of BBF and its practical implications for modern agriculture.

Principles of BBF

The BBF method operates as a tractor-driven machine, combining various agricultural processes seamlessly. By creating elevated ridges (varamba or Gaadiwafa) during planting, BBF facilitates water management, soil aeration, and nutrient distribution. The integration of sowing and fertilizing ensures efficient resource utilization, minimizing waste and maximizing crop yields. The method allows for excess water to be safely drained off fields by furrows created by

Application of BBF

A wide range of crops, including soybean, maize, gram, tur, groundnut, urad, moong, sorghum, millet, and cotton, can be sown using BBF technique. Tractor-driven BBF sowing machines facilitate efficient and precise planting, optimizing crop establishment and growth.

Benefits of BBF

1**. Water Conservation**: BBF is particularly advantageous in dryland farming regions, where water scarcity poses significant challenges. The method allows for excess water to be safely drained off fields during heavy rains, while maximizing rainwater absorption into the soil. This not only reduces water stress during dry periods but also prevents waterlogging, promoting optimal crop growth.

2. **Crop Health**: The broad bed and furrow pattern created by BBF promote better air circulation and sunlight exposure, fostering vigorous crop growth. This increased airflow also helps prevent diseases like pick kid disease, enhancing crop resilience and productivity.

3. **Inter-cropping and Pest Management**: BBF enables the cultivation of intercrops, diversifying yields and enhancing farm resilience. Additionally, the method facilitates efficient application of insecticides, minimizing pest damage and promoting crop health.

4. **Soil Fertility and Carbon Sequestration**: By retaining moisture and preventing soil erosion, BBF improves soil fertility and carbon sequestration. This leads to increased water retention capacity, enhanced nutrient absorption, and improved soil porosity, ultimately benefiting crop growth and yield stability.

Conclusion

The BBF planting technique offers a scientifically sound and practical approach to enhancing agricultural sustainability. By addressing key challenges such as water conservation, crop health, and soil fertility, BBF has the potential to revolutionize farming practices worldwide. Embracing innovative techniques like BBF will be essential in ensuring food security and environmental stewardship for future generations.

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MERISTEM TIP CULTURE IS A BOON FOR PRODUCING DISEASE FREE PLANTS

Article ID: AG-VO4-I06-02

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Introduction

One of the ultimate aims of agricultural biotechnology is to feed an expanding world population. A survey by the Economist shows that the world population has increased by 90% in the past 40 years while food production has increased by only 25% per head. With an additional 1.5 billion mouths to feed by 2025, farmers worldwide will have to produce 40% more grain. The percentage of crop losses caused by plant pathogens, insect pests, and weeds, has steadily increased to 50% worldwide. Plant diseases reduced crop productivity by 12%. Plant biotechnology ushers in a new era for plant scientists working to maintain healthy plants, optimize crop yields, and minimize pesticide usage. Genetically engineered plants resistant to plant pathogens can prevent crop losses and reduce pesticide usage.

Tissue culture

Tissue culture broadly refers to *in vitro* culture of isolated plant organs (root, shoot, meristem, embryo, etc.), pollen, cell suspension and protoplasts in artificial nutrient medium under aseptic conditions. The findings that plant cells are totipotent and organogenesis is under hormonal regulation created interest for the *in vitro* culture of plant cells. A cell is totipotent if it can develop into a whole plant. It is now possible to grow large populations of homogenous totipotent cells in culture tubes and regenerate plants from cells, pollen and protoplasts from a number of plant species. It is much easier to screen 10^6- 10^7 cells in small petri plates rather than screening a similar number of whole plants in the field which requires more time and space.

Many researchers have been trying to produce disease resistant plants using tissue culture techniques. The methods most commonly used are *in vitro* selection with selective agents and utilization of somaclonal variations with out *in vitro* selection. The selective agents used for *in vitro* selection are crude culture filtrates of the pathogen and partially or completely purified pathotoxins.

***In vitro* selection**

Disease resistant plants produced through *in vitro* selection

Plants used for *in vitro* selection	**Diseases**
Alfalfa	Verticillium wilt- *Verticillium albo-atrum*
Tomato	*Pseudomonas solanacearum*
Tobacco	Wildfire disease –*Pseudomonas tabaci*
Potato	Late blight- *Phytophthora infestans*
Sugarcane	*Helminthosporium sacchari*
Rice	*Helminthosporium oryzae*

Meristem tip culture

The distribution of virus particles within the infected plant is not uniform. Newly growing root and shoot apices are often devoid of virus. Morel and Martin (1952) first demonstrated the elimination of virus from Dahlia by the use of apical meristem cultures. The size of meristem-tip is an important factor governing regeneration capacity of meristems and to obtain virus- free plants.

Five main possibilities have been suggested to explain the mechanisms underlying the resistance of meristems to viruses:

(i) Exclusion of the viruses from the meristems by lack of suitable vascular or plasmodesmatal connections.

(ii) Competition for key metabolites by the rapidly dividing meristem cells.

(iii) The production of substances in meristem cells that result in breakdown of the virus.

(iv) Deficiency in some key components of the machinery of virus replication

(v) Presence of inhibitors of virus replication.

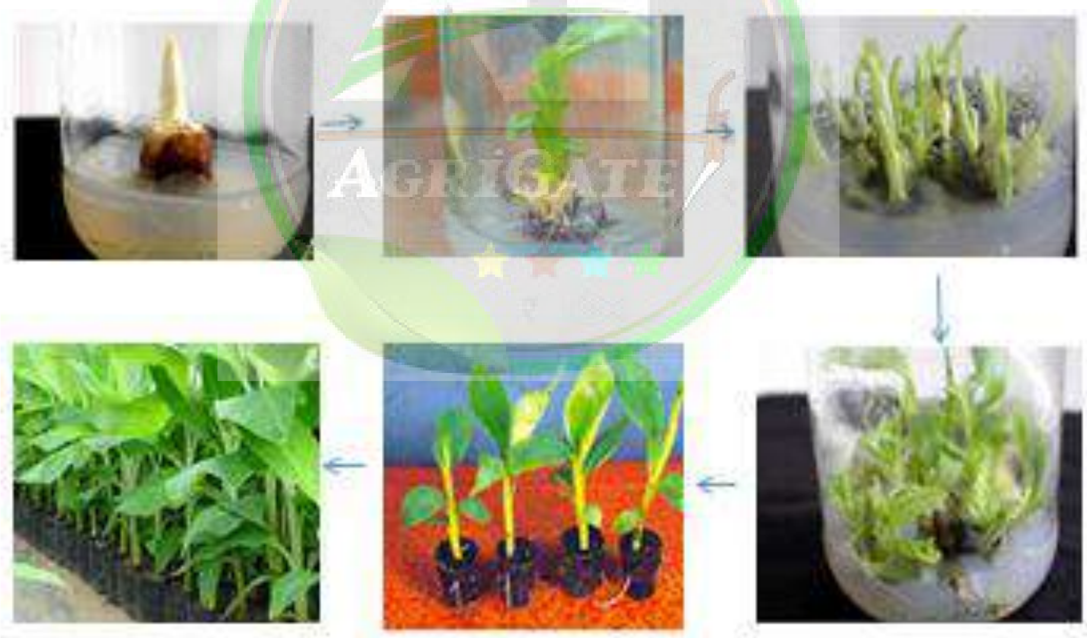
Shoot tips 0.5 – 1.0 mm in diameter and about 0.25 -0.3 mm in length are used in meristem tip culture. The buds are then aseptically transferred to Murashige and Skoog (MS) medium in test tubes and incubated at 25 ± 2"C in light, for 45 days. Meristems upon culturing into nutrient medium under optimal conditions grow and differentiate into whole plant. In general, the larger the meristems, the greater are the number of regenerated plants but the number of virus-free plants is inversely proportional to the size of meristem cultured.

Virus-free plants produced by meristem-tip culture

Plants used	**Virus**
Cassava	Cassava mosaic virus (CMV)
Potato	*Potato leaf roll virus* (PLRV), *Potato virus Y* (PVY) *Potato virus X* (PVX), *Potato spindle tuber viroid* (PSTV)
Banana	Banana bunchy top virus

Factors affecting virus eradication

Factors such as culture medium explant size and culture storage influence the virus eradication. In addition, heat treatment before or during culture significantly influences the efficiency of this technique. The physiological stage of the explants also affects virus elimination by meristem tip culture.



Micro propagation of virus free banana plants through meristem tip culture

(i) The success in obtaining complete plants can be considerably improved by the choice of the culture medium. The major features of the culture medium to be considered are its nutrients, growth regulators and physical mature.

(ii) The size of meristem tip is an important factor governing regeneration capacity of meristems and to obtain virus free plants.

(iii) For meristem - tip cultures light incubation has generally proved better than dark incubation.

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PRODUCTION OF MILKY MUSHROOM AT LOW COST

Article ID: AG-V04-I06-03

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Introduction

White button mushroom is cultivated in most of the northern parts of India, followed by Dhingri mushroom in some parts and milky mushroom in South India on a commercial scale. A crop of milky mushroom can be grown in almost all the plains of the country except the hilly areas, where the temperature remains between 25-40 degrees Celsius for some months. Seasonal mushroom growers of northern India earlier depended only on white button mushroom and used to stop their production after harvesting a crop of white button mushroom in autumn, due to increase in temperature mushroom production throughout the year. Unable to continue work. Some mushroom growers try to take one or two crops of Dhingri mushroom. If mushroom growers include milky mushroom in the current crop cycle, they can extend their mushroom production period and can get self-employment from mushroom production throughout the year. The scientific name of milky mushroom is *Calocybe indica*. The shape and appearance of milky mushroom is similar to that of white button mushroom. Compared to white button mushroom, the stem of milky mushroom is fleshier, longer and the base is quite thick, the cap is very small and opens quickly. The shelf life (storage period after harvesting) of milky mushroom is high.

Due to low demand, the quality of this mushroom does not decrease even if the harvesting is delayed by three-four days.

Climate

Cultivation of milky mushroom requires high temperature. 25-35 degree Celsius and 80-90 percent humidity is required for the fungus to spread. From laying the casing layer till harvesting, the temperature should be 30-35 degree Celsius and humidity should be 80-90 percent. It continues to produce mushrooms even in high temperatures (30-40 degrees Celsius).

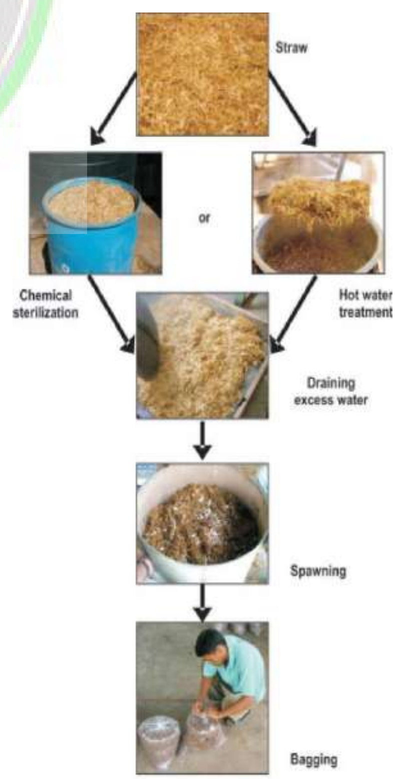
Cultivation procedure

1. **Choice of substrate:**

   Like Dhingri mushroom, this mushroom can also be easily grown on residues obtained from various agricultural crops like wheat straw, paddy straw, sorghum straw, millet straw, maize straw, sugarcane bagasse etc. The substrate should be new and dry and should not get wet in rain. Thus, choose any of these substrate as per availability in locality. A well Chaff straw is being used for preparation of substrate.

2. **Treatment of the substrate:**

   To free the substrate from harmful microorganisms and other contamination and make sure it suitability for the growth of milky mushroom, it is necessary to treat substrate to free it from contamination. The chosen substrate can be treated with two method hot water treatment or chemical treatment.



A. **Hot water treatment method:**

   According to this method, the substrate is filled in a small gunny sack and immersed in clean water thoroughly for at least 6 hours so that the substrate or straw absorbs the water thoroughly. After this, the sack filled with wet straw is kept immersed in boiling hot water for 40 minutes. The thing to be noted here is that after immersing the straw, the water should continue boiling for 40 minutes, only then the treatment of the substrate can be successful. After this, take out the straw from hot water and spread it on the clean floor so that the excess water gets drained and the straw cools down. Before laying straw, wash the floor and spray 2 percent formalin solution (50 ml/liter of water) on it. At this time the water content (moisture) in the straw should be 65-70 percent. This situation can be estimated by squeezing the straw tightly in the fist. If water does not come out of the straw when pressed and the palm becomes slightly moist, then it should be understood that the moisture in the straw is fine. The substrate thus treated is ready for sowing.

B. **Chemical treatment method:**

It is advisable to adopt hot water treatment method on small scale but it proves to be more expensive on large scale. Therefore, chemical method can be adopted as an alternative. The method of treating the medium by chemical treatment method is as follows.

• Take 90 liters of water in a cement tank or drum and soak 10-20 kilograms of straw in it.

• Take 10 liters of water in a bucket and add 7.5 grams of Bavstein and 130 ml. formalin. Pour this solution on the soaked straw in the drum and cover the drum with polythene and place a weight on it.

• After 20-24 hours, take out the straw from the drum and spread it on the clean floor so that excess water gets drained from the straw. The obtained wet straw is ready for Spawning.

3. **Spawning:**

After treating the substrate (chaff or straw) by any one of the methods mentioned above, mix seeds in it at the rate of 2-4 percent (according to the weight of wet straw) i.e. mix 20-40 grams of seeds in one kilogram of wet straw. The method of sowing can be sprinkling or sowing can also be done in the surface. For sowing in the surface, first spread a layer of straw in a polythene bag (15-16 inches wide and 20-21 inches high) and then scatter the seeds on it. Then add a layer of straw on top of it and then add seeds. The gap between the two layers should be about 3-4 inches. In this way sowing can be done in

SPAWN

the surface. About 4-5 kg of wet substrate (treated) is filled in the bag. Keep the seed bags in a dark room and maintain the temperature at 25-35 ^{o}C and 80-90 percent humidity for about 15-20 days.


4. **Making casing mixture and laying the casing layer.**

In the sown bags, the spawn run into the straw within 15-20 days and cover whole substrate with white mycelium is visible on the straw. Such a condition is considered suitable for applying casing layer. Prepare the casing mix a week before casing. To prepare casing mixture, mix 3/4 part loamy soil and 1/4 part of sand soil. Now add 10 percent chalk powder by weight of this mixture and wet the mixture with 4 % phenol (100 ml/liter water) and 0.1 percent Bavstein solution (1 gram/liter water) and cover it with a polythene sheet for eight days. 24 hours before casing, remove polythene from the casing mixture and turn the mixture with a shovel so that the smell of formalin goes away, 2-3 cm of the casing mixture thus prepared and a layer of casing about 1-1.5 inches is spread by opening the mouth of the bag and spreading it on the surface. During this period the temperature is maintained at 30-35 ^{o}C and humidity at 80-90 percent. In about 10-12 days the fungal web (seed filaments) spreads into the casing mixture.


SPAWN RUN


CASING

5. **Crop Management:**

After spreading the fungus net in the casing mixture, the bags are sprayed with water daily, fresh air is provided in the room and temperature of 30-35 degree Celsius and 80-90

percent humidity is maintained for 3-5 days. In this, mushroom pin head start emerging from the substrate which take the form of full mushroom in about a week. Like Dhingri mushroom, this mushroom also requires light for growth.

6. **Harvesting, yield and income:**

When mushroom cap is 5-6 cm. If it becomes thick then it should be considered ripe and should be broken by rotating it with the help of thumb and finger. The lower part of the stem containing soil is cut off and the mushroom is packed in a polythene bag with at least four holes of 4-5 mm. This mushroom also gives very good yield like Dhingri mushroom and its productivity is close to 100 percent i.e. 1 kg of fresh mushroom is obtained in 1 kg of dry straw. Its production cost is around Rs 20-25 per kg when there is good yield and it is sold in the market at the price of Rs 60-80 per kg.

7. **Mushroom by-products:**

Many products can be made from mushrooms such as mushroom soup powder, papad, nuggets, mushroom biscuits, candy, murabba, mushroom chips, mushroom pickles, mushroom ketchup etc. Many delicious dishes are made from mushroom like mushroom soup, pakoras, mushroom curry, mushroom salad, Manchurian, kopta, macaroni, pulao and biryani etc.

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RESPIRATION AND ITS IMPORTANCE

Article ID: AG-V04-I06-04

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Introduction

Respiration can be defined as the metabolic process that provides energy for plant biochemical processes. It is a catabolic process involving consumption of oxygen for oxidative breakdown of starch, sugars, fats, proteins, organic acids to simpler molecules such as carbon dioxide and water along with concurrent production of energy and can be given as (Lee et al., 1991)

$$C_6H_{12}O_6 + 6\,O_2 \rightarrow 6\,CO_2 + 6\,H_2O + 2816\ KJ \qquad \text{----- (1)}$$

Changes in fresh produce induce by respiration

The organic molecules used for respiration are continually replaced through photosynthesis when they are attached to the plant. Once the vegetables and fruits are harvested, photosynthesis ceases and there is no replacement for the lost ones. Thus the biological process that keeps the cell alive slows down and the cell structure breaks down followed by death of cells. The respiration occurring in the presence of oxygen is termed as aerobic respiration and in the absence of oxygen is termed as anaerobic respiration. The weight loss associated with respiration is by water and carbon in the form of carbon dioxide.

Respiration results in the loss of moisture from the fresh produce which in turns results in shrinkage and physiological loss in weight. Respiration induces heat emission, with a temperature increase, which affects metabolic processes and induces an acceleration of decay phenomena (Menon and Gowsami, 2004). Respiration rates have been used as an index for the metabolic activities of fruits during ripening and senescence. The significance of respiration in extending the shelf-life of fresh fruits and vegetables from the fact that there exists an inverse relationship between respiration rate and the shelf-life of the commodity.

Respiration rates

Non-climacteric commodities have higher respiration rates in the early stages of development that decline during maturation (Palma *et al.*, 1993). The respiration rate of climacteric commodities are also high in early development and decline until a rise occurs that coincides with ripening or senescence (Lopez-Galvet *et al.*, 1997).

The respiration rate of fresh produce is a very important factor in quality preservation. Controlling the respiration rate of fresh produce in the period after harvest is very useful for supplying produce of high quality to consumers. For this reason, many studies have been carried out to assess various mathematical models of the respiration rate of fresh fruit and vegetables (Fonseca *et al.,* 2002). The respiration rates of fresh produce can change during time even at constant gas concentration and constant temperature (Yasunaga *et al*., 2002). Time elapsed from harvest is an important factor affecting respiration rate. Respiration rate, which is commonly expressed as rate of O_2 consumption and/or CO_2 production per unit weight of the commodity, reflects the metabolic activity of the fruit tissue in the form of biochemical changes associated with ripening. (Yasunaga *et al.*, 2004; Saltveit and Kasmire, 2004).

The respiration rate of fresh produce is affected by many factors such as storage temperature, environmental gas conditions, time elapsed from harvest, and volume of enzymes and substrate in the cellular solution (Toshitaka *et al.,* 2004 and Waghmare *et al.*, 2013).

Measurement of respiration

The extent of respiration is measured by determining the amount of substrate loss, oxygen consumed, carbon dioxide liberated, heat produced and energy evolved. The extent of respiration is termed as respiration rate which is expressed as mass or volume of oxygen consumed per unit of fresh weight/volume of commodity for unit time (mg or ml O_2 kg^{-1} h^{-1}). It may also be expressed in terms of carbon dioxide produced (mg or ml CO_2 kg^{-1} h^{-1}) or heat liberated per unit weight of the produce in a given time (kcal ton^{-1} day^{-1}).

The respiration rates of harvested fruits are usually quantified via analysis of CO_2 production or of the consumption of O_2 per kilogram of fresh weight per hour. Several techniques can be used for collecting gas samples from a fruit in which the respiration is being monitored (Kays, 1991).

The respiration takes place not only due to the cellular respiration process but also the gas exchange process. In a more detailed description, oxygen and carbon dioxide movement entails the following steps (Andrich *et al*., 1991).

(i) Oxygen diffusion in the gas phase through the dermal system (Stomata, lenticels or breaks in the dermal system).

(ii) Exchange of oxygen through the intercellular atmosphere and the cellular solution.

(iii) Solubilisation and diffusion of oxygen in solution within the cell to the mitochondrial membrane.

(iv) Oxygen consumption in the mitochondrial membrane.

(v) Carbon dioxide production in the mitochondrial matrix.

(vi) Diffusion of carbon dioxide in the mitochondrial matrix to cellular solution.

(vii) Exchange of carbon dioxide through the cellular solution and the intercellular atmosphere.

(viii) Diffusion of carbon dioxide in the gas phase through the dermal system opening to the surrounding atmosphere.

In the closed system, a gas-tight container of known volume was kept with known weight of product and the container with the ambient air as the initial atmosphere was closed. Changes in the concentration of oxygen and carbon dioxide over a certain period of time were measured and used to estimate respiration rate as follows (Cameron *et al.*, 1989).

$$Ro_2 = \frac{(yo_2^{ti} - yo_2^{tf}) \times V}{100 \times m \times (t_f - t_i)} \qquad \text{----- (2)}$$

$$Rco_2 = \frac{(yco_2^{tf} - yco_2^{ti}) \times V}{100 \times m \times (t_f - t_i)} \qquad \text{----- (3)}$$

where

Ro_2 and Rco_2 - respiration rate, in terms of O_2 consumed and CO_2 evolved respectively, m^3/kg h

V - free volume inside package, m^3

yo_2^{ti} and yo_2^{tf} - volumetric concentration of O_2 at initial and final time respectively, per cent

yco_2^{ti} and yco_2^{tf} - volumetric concentration of CO_2 at initial and final time respectively, per cent

M - mass of the stored product, kg

t_i and t_f - initial and final time respectively, h

The fruit or vegetable can be enclosed for a certain period of time inside a respiration vessel (closed jar) and differential CO_2 or O_2 from respiration can be measured. The product should not be enclosed for too long because the decreasing oxygen and increasing carbon dioxide concentrations will subsequently affect the respiration rate of the product. Because of the changes in O_2 concentration that occur are small when compared with the large O_2 concentration in air, it is generally easier to measure CO_2 production (Bower *et al.*, 1998).

Respiratory quotient (RQ)

The respiratory quotient (RQ) is defined as the ratio of the volume of carbon dioxide released to the volume of oxygen consumed. The value of RQ = 1 for oxidation of glucose. In reality, many other substrates such as organic acids are oxidized together with glucose in the respiration process. When these substrates are oxidized the values of RQ ranges from 0.7 to 1.3 for aerobic respiration .

The respiratory quotient is much greater than 1.0 when anaerobic respiration takes place. In fermentative metabolism, ethanol production involves decarboxylation of pyruvate to CO_2 without O_2 uptake .

The RQ values for fresh produce is depending on the organic reserve being oxidized . (Fonseca *et al.*, 2002). Very high values of the respiratory quotient or a sudden shift in RQ value would indicates a shift in the respiration cycle to the anaerobic cycle (Saltveit, 2004).

Bernard *et al.* (2011) stated that respiratory quotient value grater than one may indicate that the organism is burning carbohydrates to produce fat or, that there is an oxygenated substrate utilized in the respiration process, like organic acid.

Factors affecting the respiration rate

Temperature

Temperature is a major factor for respiration, transpiration and decay by the organisms. If the temperature is too low, physiological injury may occur which may lead to an increase in the respiration rate. If the temperature is very high, enzymatic denaturation may occur which reduces the respiration rate.

Temperature also influences the water vapour deficit between the commodity and its microenvironment (Van de Berg and Lem, 1978; Grierson and Wardowski, 1978 and Peleg, 1985). Depending on the direction of the deficit, water may diffuse out of the product (transpiration) or condense on the product surface (sweating). The former leads to desiccation, shriveling, loss of saleable weight and limpness, therefore, reducing the market value of the product. The latter may result in splitting of the plant tissues which makes the product more susceptible to microbial infection. As a consequence, senescence is facilitated .

The influence of temperature on respiration rate was first quantified with the Q_{10} value which is the respiration rate increase for a 10°C rise in temperature.

$$Q_{10} = \left(\frac{R_2}{R_1}\right)^{10/(T_2 - T_1)} \qquad \text{---- (4)}$$

where R_2 and R_1 are the respiration rate at temperatures T_2 and T_1 respectively. For various products Q_{10} values ranged from 1 to 4 depending on the temperature range (Kader, 1987).

Proper management of temperature in storage of fresh produce would be the most important part of good post harvest handling. The effects of temperature can be minimized by pre-cooling the products prior to storage (Shewfelt, 1986 and Mitchell, 1992). For highly respiring commodities, pre-cooling may be the single most important step in extending postharvest life. Effective cooling requires knowledge of thermal properties of the product such as specific heat capacity and thermal heat conductivity.

The Arrhenius equation was also used to quantify the effect of temperature on respiration rate (Exama *et al.*, 1993) and is expressed as ,

$$R = \delta \exp\left(-\frac{E}{R_c T}\right) \qquad \text{----- (5)}$$

where,

R	-	respiration rate, $m^3/kg\ s$
δ	-	model parameter
E	-	activation energy, $Pa.m^3/mol$
R_c	-	universal gas constant, $Pa\ m^3/mol\ K$
T	-	temperature , K

The estimation procedure with a reference temperature and the modified equation is as follows.

$$R = \delta_{ref} \exp\left[-\frac{E}{R_c}\left(\frac{1}{T}-\frac{1}{T_{ref}}\right)\right] \qquad \text{----- (6)}$$

Where δ_{ref} - model parameter and T_{ref} - reference temperature K

Low temperature storage when combined with controlled atmospheres (CA) or modified atmosphere packaging (MAP), results in reduced respiration and ethylene production rates, retarded softening, and slowing down of compositional changes associated with ripening and senescence.

Storage temperature can significantly influence fruit firmness and the loss increases with storage time. The loss of firmness in apples (Landfald, 1966), and avocado (Zauberman and Jobin- Decor, 1995) with an increase in color, hence related more to ripening than a direct effect of temperature on firmness. Similar losses of firmness due to ripening have been found in six melon cultivars stored at different temperatures (Miccolis and Saltveit, 1995). The maturity or harvest (early or late) can interact with storage temperature to vary the effect on the firmness in apples.

Storage recommendations for vegetables are generally the minimum temperature that provides the maximum shelf life . Chilling susceptible tropical vegetables such as sweet basil need to be stored at about 15°C, as chilling injury develops rapidly at lower temperature (Lange and Cameron, 1994). For these commodities ripening is not an issue, senescence at higher temperature and injury at lower temperature impose the limits on storage.

In general, the lower the storage temperature (above the freezing point), the longer will be the shelf-life of the fruit or vegetable. Some commodities, particularly those of tropical or subtropical origin are susceptible to chilling injury. The most common preventive measure to avoid chilling injury is to store chilling susceptible produce at or above the lowest temperature at which no injury occurs (Kays, 1998).

Biochemical reaction rates generally increase two or three-fold for every 10ºC rise in temperature within the range of temperatures normally encountered in the distribution and marketing chain. Controlling product temperature during refrigerated storage is of critical importance: an optimum temperature maintains the visual quality of fresh cut fruits and reduces their respiration rate, tissue softening and microbial spoilage.The impact of temperature could also be minimized by varying the gas composition of the environment. Hardenburg *et al.* (1990) indicated that reduced chilling injury in some crops has been associated with elevated CO_2.

The post harvest respiratory response of fresh produce depends on the storage air temperature and its composition in terms of O_2, CO_2 and ethylene. The reduction of enzymatic activities by providing low temperature, low O_2 and slightly high CO_2, in general, reduces the utilization rate of substrates (i.e. carbohydrates, organic acid and other reserves) and uptake of O_2 . It is associated with reduction in CO_2 production and increase post harvest life of fruit beyond normal span. Water vapor loss is associated with the dissipation of respiratory and sensible heat, especially in leafy tissues, the impact of water vapor in the external atmosphere on respiratory activity has been little studied.

Relative Humidity

This is a second important environmental factor in shelf-life of fruits and vegetables (Grierson and Wardowski, 1978 and Shewfelt, 1986). Relative humidity or relative saturation, which indicates the ratio of water content present to the maximum water holding capacity of air at a given temperature.

Low RH environment reduces the spread of most decay organisms at the cost of increased transpiration and thus increase moisture loss. Moisture loss is associated with structural damage in some fruits like apple. Each species and even each variety of fruits and vegetables has an optimum atmospheric humidity range where weight loss is reduced without inducing excessive rot development. It is therefore, important to determine this range and also as a guide to establish storage conditions on an industrial scale.

Experimental results have shown that the storage life of produce can be extended by 50% at RH of 90-100%. Carrots, parsnips, and rutabagas stored well at RH of 98% (Van den Berg and

Lentz 1978; Raghavan *et al.*, 1984). As noted by Shewfelt (1986), Chemes and lemons had their shelf life extended by a week and a month, respectively, when stored in near-saturated storage environment. Some physiological disorders such as red blotch in lemons, breakdown in oranges and puffiness in tangerines may also be minimised by storing the products in plastic bags in which relative humidity is 90-95 per cent.

Exposure of fresh produce to an environment of low humidity can result in desiccation and weight loss, and will induce water stress leading to quality deterioration . For non-chilling-sensitive produce, a lower temperature is helpful in reducing transpiration and also infection. In practice, a Relative humidity of 90-95 per cent is recommended for much fresh fruits and vegetables (Will *et al.*, 1982). Meanwhile, for chilling- sensitive produce, alternative solutions are required to reduce transpiration and infection, such as using controlled atmospheres.

95% RH treatment maintained the firmness and better weight of apple. However, although water vapor loss is associated with the dissipation of respiratory and sensible heat, especially in leafy tissues, the impact of water vapor in the external atmosphere on respiratory activity has been little studied.

The effect of relative humidity on harvested produce also varies depending on the characteristics of the produce and environmental factors other than temperature. Commodities with high surface to volume ratio tend to have higher transpiration rates while those with thick cuticles transpire less . Low RH accompanied by high air velocity also facilitates moisture loss from produce.Many vegetable crops benefit from RH in storage of 95% or greater, which is effective in reducing water loss that would result in shriveling and physiological stress.

Juan *et al.* (2006) reported that the rate of O_2 consumption increased with increasing temperature and decreased with increasing RH. The respiratory rate at 25ºC was approximately 30–40 times higher than at 5ºC. The respiratory rate at 65% RH was between 30 and 90% greater than at 90% RH, depending on the temperature.

Tests with Brussels sprouts, cabbage, cauliflower, celery, Chinese cabbage and leeks stored at 0–1°C at two humidity levels, 90–95% and 98–100%, showed that these vegetables had a longer storage life at higher humidity. Factors contributing to increased storage life included reduced trimming losses necessitated by wilting, yellowing and decay, as well as reduced loss of cripsness and juiciness. For leeks, a storage temperature of -1°C was substantially better than 0–1°C. Comparison of the results of this study with those obtained in earlier work shows agreement and provides a substantial body of data indicating the benefits of high humidity for many vegetables subject to moisture loss during storage (Waghmare *et al.*, 2013).

Conclusion

There are many post harvest technologies that can be performed on fruits and vegetables to improve its shelf life. Respiration is important for modified atmospheric storage and controlled atmospheric storage with low temperature storage and relative humidity.

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MODIFIED ATMOSPHERIC PACKAGING AND ITS IMPORTANCE

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Introduction

Fresh fruits and vegetables that are packaged using a modified atmosphere (MAP) are those that are sealed in polymeric film packages while actively respiring, hence altering the levels of oxygen and carbon dioxide in the package's atmosphere. In order to affect the product's metabolism or the activity of organisms that cause decay, it is frequently preferable to create an atmosphere that is low in oxygen and/or high in carbon dioxide. This will increase the product's storability and/or shelf life. It may be preferable for some products to change both the O2 and CO_2 levels; in fact, changing the O_2 level also changes the CO_2 level. MAP significantly increases moisture retention in addition to altering the environment, which may have a bigger impact on quality preservation than O2 and CO_2 concentrations. Additionally, packing keeps the goods sealed off from the outside world and aids in . Furthermore, packaging isolates the product from the external environment and helps to ensure conditions that, if not sterile, at least reduce exposure to pathogens and contaminants.

Gas permeability of specific films must be such that oxygen can enter the package at a rate that is equal to the amount of oxygen that the commodity is respiring in order to create and preserve an acceptable atmosphere inside the package. In a similar vein, carbon dioxide must be released from the container to prevent buildup (Kader, 1997). Additionally, the packets would help to maintain a high relative humidity by acting as a barrier to the movement of water vapor. It was found that using modified environment packaging could double the commodity's shelf life, and using refrigeration in addition to the changed atmosphere packaging could quadruple the shelf life.

The interaction of the package film with the internal gas atmosphere and the product being stored is known as modified atmosphere packaging. It's critical to understand that, although modifying the climate can help some fruits and vegetables store longer, it can also have unfavorable consequences. If reduced oxygen levels are insufficient to maintain aerobic respiration, fermentation and off-flavors may occur (Kays, 1997). In a similar vein, damage will result from CO2 levels that are too high. According to Rajesh (2001), because horticulture commodities are living beings, they vary from other food products. For the duration of the marketing cycle, these products maintain their high respiration rate and other ripening-related metabolic processes. The utilization of modified environment packaging approach has the potential to successfully impede both chemical and biological degradation.

MAP creates an MA around the packaged product and selective permeability of the packaging material by using polymeric with selective permeability for O2, CO2, and water vapour. Fresh fruits and vegetables deterioration is successfully delayed by MAP, which is most useful for extremely perishable items. According to Zhang et al. (2003), MAP can prevent respiration and weight loss, extend the shelf life of Pleurotus nebrodensis mushrooms to 90 days, and delay the titrable acidity, anthocyanin decline, and soluble sugars of strawberries.

When compared to peppers held in vacuum packaging, fresh cut peppers with MAP showed superior visual quality, less juice leakage, and increased stiffness. A 21-day shelf life was found by microbiological and quality tests when fresh-cut peppers were kept at 5ºC. When compared to peppers held in vacuum packaging, fresh cut peppers with MAP showed superior visual quality, less juice leakage, and increased stiffness. A 21-day shelf life was found by microbiological and quality tests when fresh-cut peppers were kept at 5ºC.

To maintain quality and increase shelf life, fresh-cut cucumbers were packed in argon, nitrogen, and air-based MA after being coated with varying concentrations of edible chitosan solutions. Throughout a 12-day storage period at 5°C, the impact of both single and combination treatments on a few quality parameters was evaluated on a periodic basis. Fresh-cut cucumbers' shelf life was increased and their quality and microbiological safety were preserved when chitosan coating and MA packaging were combined.

The primary candidates for MAP are horticultural products, and fresh food appears to benefit from lower oxygen and higher CO2 levels in the atmosphere in a number of ways. MA delays ripening and senescence, lowers the rate of microbial development and spoiling, enhances the retention of chlorophyll and other pigments, lowers ethylene production, sensitivity, and texture losses.

Active and passive modified atmospheric packagings are the two systems generally recognised for packaging of fresh-cut produce. A passive modification consisted of allowing the appropriate atmosphere to evolve within a closed chamber by respiration of the produce and maintaining that atmosphere by selective permeability of gasses through the membranes or by diffusion channels.

Active MAP

While passive modification happens when the product is packaged using a chosen film type and a desired atmosphere develops naturally as a result of product respiration and the diffusion of gases through the film, active modification involves moving the gases in the package and replacing them with a desired mixture of gases. In China, passive MAP is widely used to increase the shelf life of fresh produce, including cut fruits and vegetables. This is because passive MAP is a far more cost-effective method of extending the shelf life than controlled atmosphere(CA)methods.

Active MAP refers to systems that are added to emit (e.g., N2, CO2, ethanol) or remove (e.g., O2, CO2) gases during packaging or distribution. More recently, systems that are gas-scavenging or emitting have also been included. In case of a gas-scavenging or emitting system, reactive compounds are either contained in individual sachets or stickers associated to the packaging material or, more recently, directly incorporated into the packaging material.

Reactive compounds are either held in separate sachets or stickers attached to the packaging material in the case of a gas-scavenging or emission device, or, more recently, directly incorporated into the packaging material.

O_2 scavengers could also have a beneficial effect on O_2 sensitive respiring products such as fresh or minimally processed fruits and vegetables. modified atmosphere of green asparagus combined with refrigeration at 2ºC, showed the best results among the treatments (packaged and non-packaged, refrigeration at 2ºC, MAP at 2ºC, and MAP at 10ºC after 5 days at 2ºC.) in terms of retaining sensory and nutritional quality, increasing the safety, and extending the shelf-life.

This storage system was shown to be the most suitable, increasing the shelf-life of green asparagus by 12 days when compared with refrigerated storage and 6 days when compared with MAP at 10ºC (after 5 days at 2ºC). MAP has also shown a significant difference among packaged and non- packaged green asparagus in terms of the following parameters like Gases (O_2 and CO_2), external appearance, weight loss, pH and acidity, vitamin C, texture, and microbial quality, along with a microscopical analysis.

The right cleaning method (using ozone and chlorine) combined with MAP extended the shelf life, preserved the quality, and improved food safety of asparagus. Freshly cut asparagus kept its quality for 23 days at 4ºC after being cleaned in chlorinated water and stored in an active MAP of oriented polypropylene (OPP) bags with 8.15 kPa CO2 and 17.51 kPa O2.

MAP testing on celery sticks in various films (OPP, LDPE), with PE perforated bags serving as the control, showed that MAP enhanced the sensory experience, prevented the color from fading, reduced the emergence of pithiness, and slowed the growth of microbes. Additionally, it was found that no treatment contained any odd flavors or smells. After 15 days at 4ºC, the oriented polypropylene bags reached a steady-state environment, and the celery sticks kept within these bags had the best quality.

After being minimally processed and flushed with 5% O2 and 2% CO2, the modified atmosphere packaging (MAP) of bok choy reduced respiration rate, ion leakage, chlorophyll content, and chlorophyll fluorescence. The MAP was then stored at 10ºC and sealed either directly in a polyethylene (PE) bag or in a perforated oriented polypropylene (POPP) bag. Comparing minimally processed Bok Choy in MAP to direct sealing in PE and POPP bags, the shelf life of the former was around ten days. According to reports, broccoli packaged in a modified atmosphere with minimal processing did not significantly alter the food's stability of carotenoids and tocopherols, nor did it change the phytochemicals' in vivo bioavailability—even after up to nine days of storage—or the serum responses that resulted from eating the food.

When endives were packed with macro perforated oriented polypropylene (OPP), the effect of passive MAP on color changes was comparable to that of UAP (unmodified atmosphere packaging) in a stable modified atmosphere with a composition of 3 kPa O2 and 4.5 kPa CO2. O2 scavengers or low density polyethylene (LDPE) were the two alternative packaging materials utilized. The benefit of MAP of endives was achieved by employing an O2 scavenger, or active MAP, which, in contrast to passive MAP, did not alter the partial pressure of O2 and CO2 during the steady state period but instead caused a 50% reduction of the transient duration. Endive greening and browning were significantly delayed as a result of this reduction.

The length of storage had an impact on rocket leaves' metabolic activity (generation of CO2 and ethylene), but cutting degree had no effect. This led to non-significant variations in the color and a few nutritional characteristics of the rocket leaves, as well as in the atmospheric composition (CO2 and ethylene concentration) of the packages containing leaves with varying degrees of cutting.

Cucumbers (*Cucumis sativus* L.) stored in perforated modified atmosphere packaging (MAP) under cold room (4 ± 1 °C and 90 ± 2 % RH) and ambient condition (23–26 °C and 63–66 % RH) were evaluated for firmness, weight loss (WL), colour, chilling injury and sensory characteristics. The study revealed that cucumber can be stored under MAP with 2 perforations at 4 ± 1 °C and 90 ± 2 % RH and ambient condition (23–26 °C and 63–66 % RH) for 12 and 6 days, respectively.

Table.1 Type of MAP for fresh cut-produce

	Passive	**Active**
Definition	Modification of the gas composition inside the package due to interplay between the product respiration rate and the gas exchange rate through the package	Modification of the gas composition inside the package by replacing, at the moment of packaging, the air with a specific gas mixture either by drawing a vacuum or filling a gas mix
Equilibrium time	1 – 2 days to 10 – 12 days	1 – 2 h
Products suitable for	Mushrooms, carrots, strawberry, spinach	Cut apples, dry fruits
Cost	No extra cost involved if the package is properly designed	Extra investment is required for special machinery *i.e.*, gas, gas mixer, packaging machine for MAP
Requirements for labelling	No	Yes

Factors Influencing Modified Atmosphere Packaging

Gas composition

Temperature

Relative humidity

Packaging Materials

Film type and thickness used in MAP

MAP involves the use of plastic film, with known permeability to gases, for the packaging of products. Many factors influence film permeability, among which polymer type and film thickness are most important. Many plastic films have been in for MAP of a variety of produce. Packaging film of correct permeability can create desirable MA of fresh fruit and vegetables. Due to difference in the respiration rates of individual fruits or vegetables, the type of plastic film required to achieve any special equilibrium MA must be defined for each commodity.

MAP utilises polymeric films with selective permeability for O_2, CO_2 and water vapour to create an MA around the packaged product due to the respiration of the produce and the selective permeability of the packaging materials (Guevara *et al*., 2003). Mangaraj *et al.* (2009) reported that though the MAP industry has an increasing choice of packaging films, most packs are still constructed from four basic polymers viz., Polyvinyl chloride(PVC), Polyethylene teriphthalate (PET), Polypropylene(PP) and Low density polyethylene(LDPE) for packaging of fresh produce.

Plastic film

LDPE films are the most used films for packaging of fresh produce. According to a study the best packaging material for MAP storage of pioneer cherry has been reported as 0.02mm LDPE film and Nectarines packed in 0.03mm LDPE showed significantly less polygalacturonase and cellulase activities, decreased respiration rate and ethylene production, and a slower decrease in flesh firmness and increase in relative membrane permeability than the control. PP and PVC films are often used to pack fruits and vegetables such as waxberry (0.025mm PVC).

Composite membrane containing LDPE and PVC was superior to single LDPE and PVC membranes to optimize the gas composition of (2.5 % O_2 plus 16 % CO_2) in MAP for strawberry. MAP could inhibit the respiration and weight loss strawberries and retard soluble sugars, titrable acidity and Anthocyanin decrease. (Zhang *et al.*, 2003).

Packaging material containing Biaxially Oriented Polypropylene (BOPP): PET: LDPE was reported to be the best choice for keeping bamboo shoots free. Fuji apples packed in five types of plastic film bags for seven months showed that apples in MAP film of PVC or LDPE had a fresh like quality.

Silicon gum film

Jacobson *et al.* (2004) studied the sensory quality of broccoli stored in modified atmosphere packages (OPP, PVC and LDPE). The LDPE package contained an ethylene absorbing sachet. The samples were stored at different storage temperatures for 1 week. After storage, the broccoli was evaluated both raw and cooked using a triangle test and a quantitative descriptive analysis. It has been observed that the sensory properties of broccoli packaged in LDPE (5 % O_2, 7 % CO_2) that contained an ethylene absorber was perceived to be the sample most similar to fresh broccoli. There were no differences in weight loss between broccolis stored in the different packaging materials.

Shengmin Lu, (2007) investigated the effectiveness of different packaging materials *viz.*, MAP, polyethylene (PE) bag or in perforated oriented polypropylene (POPP) bags in inhibiting quality deterioration of minimally processed Bok Choy. Modified atmosphere packaging (MAP) flushed with 5 per cent O_2 and 2 per cent CO_2 resulted in a reduction of respiration rate and ion leakage and the shelf life also extended up to 10 days in MAP than in poly films.

Li *et al.* (2007) stated that packages with silicon gum film window with initial concentrations of 5 per cent O_2 and 10 per cent CO_2 were the most effective for maintaining mushroom quality. The effect of silicon gum films as windows for gas exchange on the respiration and quality change of stored edible mushroom *Agrocybe chaxingu* was evaluated, and proved that silicon gum film windows could extend the shelf life by 8 days compared to the control. Different sizes of silicon gum film windows had a significant effect on the mushroom quality (Li and Zhang, 2008).

Fresh celery stalks were packed in two packaging films *viz.*, polyolefin with an antifogging additive (AF) and Micro perforated film were kept at 4 ± 1ºC, 90 per cent RH for 35 days, using unpacked celery as control. Both the films allows the shelf life of 31 days but the qualitative parameters such as weight loss, texture and colour in AF were close to the fresh samples than the MAP Packed. Moreover, the weight loss in AF film was less than 3 per cent (Rizzo and Muratore, 2009).

The results of cut broccoli florets packed with different packages (OPP, MP - PP and PVC) confirmed that the mass transport properties of the packaging film strongly influenced the headspace gas concentration, thus suggesting that the selection of the proper packaging is of crucial importance to create conditions able to guarantee the maintenance of quality characteristics. The MP - PP - 20 and MP - PP - 7 films were the most effective films in controlling mass loss, wilting and sensory quality for a longer period and extend the shelf life of cut broccoli florets for about 20 days compared to control samples (Lucera *et al.*, 2011).

Conclusion

Modified atmospheric packaging system was most effective method compared to storing under normal condition

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RIBONUCLEIC ACID (RNA), ITS IMPORTANCE AND TYPES

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Introduction

RNA, or ribonucleic acid, is a diverse class of molecules found in cells, performing various essential functions in gene expression, protein synthesis and regulation. RNA is composed of nucleotides, which consist of three components: a sugar molecule (ribose in RNA), a phosphate group and a nitrogenous base. The four nitrogenous bases found in RNA are adenine (A), cytosine (C), guanine (G) and uracil (U). In DNA, uracil is replaced by thymine (T). RNA can form complex secondary and tertiary structures due to its ability to base-pair with itself or other nucleic acid molecules. This structural flexibility allows RNA molecules to perform diverse functions beyond information transfer, such as catalyzing biochemical reactions (ribozymes) and regulating gene expression (non-coding RNAs). The study of RNA has profound implications in various fields, including molecular biology, genetics and medicine. Understanding RNA's structure and functions provides insights into fundamental biological processes and enables the development of novel therapeutics and biotechnological applications.

The RNA world hypothesis is a fascinating concept in the field of molecular biology and origins of life research. It suggests that in the early stages of life on earth, RNA (ribonucleic acid) played a crucial role as both a carrier of genetic information and a catalyst for biochemical reactions, preceding the emergence of DNA and proteins.

RNA possesses two key properties that make it central to this hypothesis:

a) **Information storage**: Like DNA, RNA can store genetic information in its sequence of nucleotides.

b) **Catalysis**: Certain RNA molecules, called ribozymes, have the ability to catalyze chemical reactions, similar to the function of proteins in modern cells.

The RNA world hypothesis proposes that in the primordial soup of early Earth, simple RNA molecules capable of self-replication and catalysis arose spontaneously. Over time, these molecules evolved and became more complex, eventually giving rise to the first living organisms. Support for the RNA world hypothesis comes from various lines of evidence, including the discovery of ribozymes capable of catalyzing important biological reactions, as well as the ability of RNA to self-replicate under certain conditions in laboratory experiments.

However, the hypothesis also faces challenges and unanswered questions, such as how RNA molecules could have formed under the conditions of early Earth and how the transition from an RNA-based world to one dominated by DNA and proteins occurred. Despite these challenges, the RNA world hypothesis remains a leading theory in the study of life's origins and ongoing research continues to shed light on the plausibility and mechanisms of this intriguing idea.

RNA holds immense importance in biological systems for several reasons:

i. **Genetic information transfer**: Messenger RNA (mRNA) carries genetic information from the DNA in the cell nucleus to the ribosomes in the cytoplasm. This information is then translated into proteins, which are essential for the structure, function and regulation of cells and organisms.

ii. **Protein synthesis**: Alongside ribosomal RNA (rRNA) and transfer RNA (tRNA), mRNA plays a central role in protein synthesis. Ribosomes, composed of rRNA and proteins, read the mRNA sequence and coordinate the assembly of amino acids into polypeptide chains according to the genetic code.

iii. **Gene regulation**: Various types of RNA, such as microRNA (miRNA) and small interfering RNA (siRNA), regulate gene expression by targeting specific mRNA molecules for degradation or by inhibiting their translation. This process is crucial for controlling cellular processes like growth, development and response to environmental stimuli.

iv. **Structural and catalytic functions**: RNA molecules can fold into complex three - dimensional structures, allowing them to perform structural and catalytic roles in cells. Ribozymes, RNA molecules with enzymatic activity, participate in key biochemical reactions, including RNA splicing and peptide bond formation during protein synthesis.

v. **Viral replication**: In viruses such as retroviruses, RNA serves as the genetic material instead of DNA. For example, HIV contains RNA as its genome, which is reverse transcribed into DNA upon infection of host cells. Understanding RNA biology is crucial for developing antiviral strategies against RNA viruses.

vi. **Biotechnological applications**: RNA-based technologies, such as RNA interference (RNAi) and CRISPR-Cas systems, have revolutionized gene editing and gene expression regulation. These tools enable precise manipulation of gene expression and hold promise for treating genetic disorders, cancer and other diseases.

vii. **Evolutionary insights**: The RNA world hypothesis suggests that RNA may have been the first biomolecule to emerge in primitive life forms, preceding DNA and proteins. Studying RNA's properties and capabilities provides insights into the origins of life and the early evolution of cellular processes.

viii. **Epigenetic regulation**: Certain RNA molecules, such as small interfering RNAs (siRNAs) and Piwi-interacting RNAs (piRNAs), participate in epigenetic regulation by modulating chromatin structure and gene expression patterns. They can silence gene expression by directing DNA or histone modifications.

ix. **Cellular signaling**: RNA molecules can act as signaling molecules in cellular communication and signal transduction pathways. For example, some RNA species, including small nucleolar RNAs (snoRNAs), regulate RNA modifications, while others, like circular RNAs (circRNAs), may function as signaling molecules in various biological processes.

x. **Cellular metabolism**: RNA molecules participate in various metabolic pathways within cells, including RNA processing, modification and degradation. They are involved in the synthesis of other RNA molecules and in the regulation of metabolic enzymes and pathways.

xi. **Disease mechanisms and therapeutics**: Dysregulation of RNA metabolism and function is associated with numerous human diseases, including cancer, neurodegenerative disorders and viral infections. Understanding RNA's roles in disease pathogenesis can lead to the development of RNA-based therapeutics and diagnostic tools.

Overall, RNA's multifaceted roles in information transfer, gene regulation, catalysis and evolutionary history make it a keystone of biological research and a target for therapeutic intervention in various diseases.

RNA can be classified into several types based on its structure, function and role in cellular processes. The main types of RNA are as follows,

1. **Messenger RNA (mRNA):** is a type of RNA molecule that carries genetic information from the DNA in the cell nucleus to the ribosomes in the cytoplasm. It serves as a template for protein synthesis, conveying the genetic instructions encoded in DNA to the protein-making machinery of the cell. The key features of messenger RNA are:
    a. **Transcription**: mRNA is transcribed from DNA during the process of transcription. RNA polymerase enzyme synthesizes mRNA by reading the DNA template and assembling complementary RNA nucleotides. This process occurs in the nucleus of eukaryotic cells.
    b. **Coding for proteins**: mRNA carries the genetic code in the form of codons, which are sequences of three nucleotides. Each codon specifies a particular amino acid or serves as a start or stop signal for protein synthesis. The sequence of codons in mRNA determines the sequence of amino acids in the resulting protein.
    c. **Processing**: In eukaryotic cells, newly synthesized mRNA undergoes several processing steps before it is ready to be translated into protein. This includes the addition of a 5' cap and a polyadenylated tail to the mRNA molecule, as well as the removal of introns (non-coding regions) through RNA splicing, leaving only the exons (coding regions) in the mature mRNA transcript.
    d. **Export from the nucleus**: Once processed, mature mRNA molecules are transported out of the nucleus and into the cytoplasm, where they can be translated into protein by ribosomes.
    e. **Translation**: In the cytoplasm, mRNA serves as a template for protein synthesis by ribosomes. During translation, transfer RNA (tRNA) molecules deliver amino acids to the ribosome based on the codons in the mRNA sequence, leading to the formation of a polypeptide chain that folds into a functional protein.
    f. **Short lifespan**: mRNA molecules have a relatively short lifespan compared to other types of RNA. They are continuously synthesized and degraded in response to cellular needs and environmental cues, allowing for rapid changes in gene expression.

g. **Regulation**: The expression of genes can be regulated at the level of mRNA transcription, processing, stability and translation. Various factors, including transcription factors, RNA-binding proteins, microRNAs and other regulatory molecules, can influence the abundance and activity of mRNA molecules in the cell.

Overall, messenger RNA plays a central role in the flow of genetic information from DNA to protein, serving as a crucial intermediary in gene expression and cellular function.

2. **Transfer RNA (tRNA):** is a type of RNA molecule found in all living cells. tRNA is responsible for delivering amino acids to the ribosome during protein synthesis. Each tRNA molecule carries a specific amino acid and has an anticodon sequence that base-pair with the codon sequence on the mRNA. The important features of transfer RNA are:

a. **Amino acid carrier**: One of the primary functions of tRNA is to carry specific amino acids to the ribosome during protein synthesis. Each tRNA molecule is attached to a specific amino acid by an enzyme called aminoacyl-tRNA synthetase, which ensures the accurate pairing of amino acids with their corresponding tRNA molecules.

b. **Anticodon**: tRNA molecules contain a region called the anticodon, which consists of three nucleotides that are complementary to a specific codon in the mRNA sequence. The anticodon allows tRNA to recognize and base-pair with the corresponding codon on the mRNA during translation.

c. **Structure**: tRNA molecules have a characteristic cloverleaf structure, with four stem-loop structures formed by base-pairing between complementary nucleotides. The acceptor stem at one end of the tRNA molecule carries the amino acid, while the anticodon loop at the opposite end pairs with the mRNA codon.

d. **Specificity**: Each tRNA molecule is specific for a particular amino acid and contains an anticodon sequence that recognizes a specific codon in the mRNA sequence. The specificity of tRNA ensures that the correct amino acid is added to the growing polypeptide chain during translation.

e. **Wobble base pairing**: The genetic code is degenerate, meaning that multiple codons can code for the same amino acid. tRNA molecules use a phenomenon known as wobble base pairing, where the third nucleotide in the codon - anticodon interaction can tolerate non-standard base pairing, allowing for flexibility in the genetic code without affecting protein synthesis accuracy.

f. **Ribosomal interaction**: During translation, tRNA molecules interact with the ribosome, a complex molecular machine that catalyzes protein synthesis. The ribosome facilitates the binding of tRNA molecules to the mRNA template and coordinates the formation of peptide bonds between amino acids to build the polypeptide chain.

g. **Energy requirement**: The process of aminoacylation, where tRNA molecules are attached to amino acids, requires energy in the form of adenosine triphosphate (ATP). This step is catalyzed by aminoacyl-tRNA synthetase enzymes, which ensure the fidelity of tRNA charging by matching each tRNA with its corresponding amino acid.

Overall, transfer RNA plays a crucial role in the accurate translation of genetic information from mRNA into proteins, ensuring the fidelity and specificity of protein synthesis in cells.

3. **Ribosomal RNA (rRNA):** is a component of the ribosome, the cellular machinery responsible for protein synthesis. It plays a fundamental role in the process of translation, where the genetic information encoded in messenger RNA is used to synthesize proteins. It catalyzes the formation of peptide bonds between amino acids to build the protein chain. The key features of ribosomal RNA are:

a. **Structural component of ribosomes**: Ribosomal RNA constitutes a significant portion of the ribosome's mass and provides the structural framework for the ribosome. It forms the core of the ribosome, around which other proteins and RNA molecules assemble to create the functional ribosomal complex.

b. **Catalytic activity**: Despite being primarily structural, certain regions of rRNA exhibit catalytic activity, particularly in the peptidyl transferase reaction. This reaction is responsible for forming peptide bonds between amino acids during protein synthesis.

c. **Conservation**: rRNA sequences are highly conserved across species, reflecting the essential role of ribosomes in cellular function and the evolutionary conservation of translation machinery. This conservation allows researchers to infer evolutionary relationships among organisms by comparing rRNA sequences.

d. **Three types**: There are three main types of rRNA in eukaryotic ribosomes: 18S rRNA, 5.8S rRNA and 28S rRNA. These rRNA molecules, along with additional small RNA molecules and proteins, are assembled into the small (40S) and large (60S) subunits of the eukaryotic ribosome.

e. **Transcription and processing**: rRNA is transcribed from ribosomal DNA (rDNA) by RNA polymerase I in the nucleolus, a specialized region within the cell nucleus. The precursor rRNA transcript undergoes extensive processing, including cleavage and modification, to generate the mature 18S, 5.8S and 28S rRNA molecules.

f. **Ribosome function**: Ribosomes consist of two subunits, each composed of rRNA and proteins. During translation, ribosomes interact with mRNA and tRNA to facilitate the synthesis of proteins. The small ribosomal subunit binds to mRNA, while the large subunit catalyzes peptide bond formation and elongation of the polypeptide chain.

g. **Regulation**: The expression of rRNA is tightly regulated to maintain appropriate levels of ribosomes in the cell. Factors such as cell growth, nutrient availability and stress conditions can influence rRNA transcription and ribosome biogenesis.

Overall, ribosomal RNA is essential for the structure, function and regulation of ribosomes, making it a critical component of the protein synthesis machinery in cells.

4. **Small Nuclear RNA (snRNA):** is a class of small RNA molecules found in the cell nucleus. They primarily function as components of the spliceosome, a large and dynamic RNA-protein complex responsible for the removal of introns from pre-mRNA molecules during mRNA splicing. The spliceosome ensures that only exons, the protein-coding regions of genes, are retained in the mature mRNA transcript. Key features of snRNAs includes:

a. **Splicing**: The primary function of snRNAs is to participate in the splicing process. Along with protein components, snRNAs form small nuclear ribonucleoprotein particles (snRNPs), which recognize specific sequences at exon-intron junctions and catalyze the excision of introns and the ligation of exons.

b. **Base-pairing with pre-mRNA**: Each snRNA molecule contains short stretches of nucleotides that are complementary to sequences within the pre-mRNA molecule. This base-pairing facilitates the precise recognition and removal of introns during splicing.

c. **Conservation**: Many snRNAs are highly conserved across species, indicating their essential roles in gene expression and cellular function.

d. **Spliceosome assembly**: SnRNAs play a critical role in the assembly and activation of the spliceosome complex. They interact with other protein factors to form functional spliceosomes capable of catalyzing the splicing reaction.

e. **Alternative splicing**: Some snRNAs are involved in regulating alternative splicing, a process where different combinations of exons are included or excluded from the mature mRNA transcript, leading to the generation of multiple protein isoforms from a single gene.

Common examples of snRNAs include U1, U2, U4, U5 and U6 snRNAs, each of which plays a specific role in the splicing process. Dysfunction or mutations in snRNAs or components of the spliceosome can lead to aberrant splicing events, contributing to various human diseases, including certain types of cancer and genetic disorders.

5. **MicroRNA (miRNA):** are small non-coding, typically about 21-23 nucleotides in length RNAs that regulate gene expression by binding to specific mRNA molecules, leading to their degradation or inhibiting their translation. They play crucial roles in various biological processes, including development, differentiation and disease. The key features of microRNAs are:

a. **Regulation of gene expression**: miRNAs regulate gene expression by binding to complementary sequences in the 3' untranslated regions (UTRs) of target mRNAs. This binding can lead to repression of translation and/or degradation of the target mRNA, thereby reducing the levels of the corresponding protein.

b. **Biogenesis**: miRNAs are transcribed from genomic DNA by RNA polymerase II or RNA polymerase III into long primary miRNA transcripts (pri-miRNAs). These pri-miRNAs are processed in the nucleus by the enzyme Drosha and its cofactor DGCR8 to generate precursor miRNAs (pre-miRNAs), which are hairpin-shaped RNA molecules. Pre-miRNAs are then exported to the cytoplasm and further processed by the enzyme Dicer to produce mature miRNAs.

c. **Mature miRNA**: The mature miRNA strand is incorporated into the RNA-induced silencing complex (RISC), where it guides the RISC to target mRNAs through base-pairing interactions. The miRNA-RISC complex then mediates translational repression and/or mRNA degradation, depending on the degree of complementarity between the miRNA and its target mRNA.

d. **Target specificity**: Each miRNA can potentially regulate the expression of multiple target genes and a single mRNA can be targeted by multiple miRNAs. The specificity of miRNA targeting is primarily determined by the degree of sequence complementarity between the miRNA and its target mRNA, as well as additional factors such as secondary structure and accessibility of target sites.

e. **Cellular functions**: miRNAs play critical roles in various cellular processes, including development, differentiation, proliferation, apoptosis and metabolism. Dysregulation of miRNA expression or function has been implicated in numerous human diseases, including cancer, cardiovascular disorders, neurological diseases and metabolic disorders.

f. **Experimental Tools**: miRNAs are widely studied and manipulated in research settings. Researchers use techniques such as miRNA profiling, miRNA mimics and miRNA inhibitors (antimiRs) to investigate the functions of miRNAs and their roles in disease pathogenesis.

Overall, microRNAs are important regulators of gene expression that exert widespread effects on cellular processes and contribute to the maintenance of cellular homeostasis. Understanding the roles of miRNAs in health and disease holds promise for the development of novel therapeutic strategies and diagnostic tools.

6. **Long Non-Coding RNA (lncRNA):** is a heterogeneous group of RNA molecules that are longer than 200 nucleotides and do not code for proteins. They regulate gene expression through various mechanisms, including chromatin modification, transcriptional regulation and post-transcriptional regulation. The key features of long non-coding RNAs are:

a. **Structural diversity**: lncRNAs exhibit considerable structural diversity and can adopt a wide range of secondary and tertiary structures. Some lncRNAs form intricate RNA secondary structures or interact with proteins and other nucleic acids to exert their functions.

b. **Gene regulation**: lncRNAs regulate gene expression at multiple levels, including transcriptional regulation, chromatin remodeling, post-transcriptional processing and mRNA translation. They can act as transcriptional activators or repressors by recruiting chromatin-modifying complexes to specific genomic loci or by interacting with transcription factors.

c. **Subcellular localization**: lncRNAs can be localized to different cellular compartments, including the nucleus, cytoplasm and various subcellular organelles. Their subcellular localization often correlates with their functions, with nuclear lncRNAs primarily involved in transcriptional regulation and cytoplasmic lncRNAs participating in post-transcriptional processes.

d. **Interactions with proteins and RNA**: Many lncRNAs function by interacting with proteins, DNA or other RNA molecules. They can serve as scaffolds for the assembly of ribonucleoprotein complexes, act as decoys to sequester regulatory factors or function as guides to direct protein complexes to specific genomic regions or mRNA targets.

e. **Cellular Processes**: lncRNAs have been implicated in various cellular processes, including development, differentiation, cell cycle regulation, apoptosis, immune response and cellular senescence. Dysregulation of lncRNA expression or function is associated with numerous diseases, including cancer, neurodegenerative disorders, cardiovascular diseases and autoimmune conditions.

f. **Evolutionary conservation**: Although lncRNAs generally exhibit lower sequence conservation compared to protein-coding genes, some lncRNAs show conservation of functional domains or structural motifs across species. Evolutionary studies have revealed that certain lncRNAs play conserved roles in gene regulation and development across diverse organisms.

g. **Emerging therapeutic targets**: Due to their roles in disease pathogenesis and cellular homeostasis, lncRNAs have emerged as potential therapeutic targets for the treatment of various diseases. Strategies for modulating lncRNA expression or activity, such as antisense oligonucleotides, small interfering RNAs or CRISPR-based approaches, are being explored for therapeutic intervention.

Overall, long non-coding RNAs represent a fascinating and diverse class of molecules that contribute significantly to the complexity of gene regulation and cellular function. Continued research into the mechanisms and functions of lncRNAs holds promise for uncovering novel insights into gene regulation and disease mechanisms.

7. **Small Interfering RNA (siRNA):** are short double-stranded RNA molecules typically 20-25 nucleotides in length. They are involved in the RNA interference (RNAi) pathway, a highly conserved cellular mechanism for gene regulation and defense against viruses and transposable elements. They are often used in research and therapeutic applications for gene knockdown. The key features of siRNA are:

a. **Gene silencing**: siRNAs play a central role in gene silencing by guiding sequence-specific degradation of target mRNAs. They achieve this by complementary base-pairing with target mRNAs, leading to the formation of an RNA-induced silencing complex (RISC), which contains proteins that cleave the target mRNA, resulting in its degradation.

b. **Biogenesis**: siRNAs are typically generated from long double-stranded RNA (dsRNA) molecules through the action of an enzyme called Dicer. Dicer cleaves the dsRNA into small RNA duplexes, which are then unwound to form mature siRNA molecules. Alternatively, siRNAs can also be synthesized chemically or *in vitro* for experimental purposes.

c. **Sequence specificity**: siRNAs exert their effects in a sequence-specific manner, meaning they can be designed to target virtually any gene of interest by ensuring complementarity between the siRNA sequence and the target mRNA sequence. This specificity allows for precise and efficient gene silencing without affecting non-targeted genes.

d. **Off-target effects**: While siRNAs are highly specific for their target sequences, they can potentially induce off-target effects by imperfectly binding to unintended mRNAs with partial complementarity. Strategies such as careful siRNA design and validation can minimize off-target effects and enhance the specificity of gene silencing.

e. **Therapeutic potential**: siRNAs hold significant therapeutic potential for the treatment of various diseases, including viral infections, genetic disorders and cancer. They can be delivered to target cells or tissues using various delivery vehicles, such as lipid nanoparticles, viral vectors or conjugates with targeting ligands, to achieve specific and efficient gene silencing *in vivo*.

f. **Research tool**: In addition to their therapeutic applications, siRNAs are widely used as research tools for studying gene function and regulation. They enable the selective knockdown of target genes in cell culture and animal models, allowing researchers to investigate the consequences of gene silencing on cellular processes and disease phenotypes.

g. **RNAi pathway**: siRNAs are part of the broader RNAi pathway, which also includes other small RNA molecules such as microRNAs (miRNAs) and Piwi-interacting RNAs (piRNAs). Together, these small RNAs play critical roles in regulating gene expression, genome defense and epigenetic modifications in various organisms.

Overall, siRNAs are versatile molecules with widespread applications in both research and therapeutics, offering powerful tools for studying gene function and potential avenues for developing novel treatments for human diseases.

8. **Piwi-interacting RNA (piRNA):** is a class of small non-coding RNAs molecules typically 24-32 nucleotides in length. That plays a role in silencing transposable elements in the germline cells, thereby maintaining genome stability and integrity. They interact with proteins of the Piwi family (hence the name "Piwi-interacting") to form RNA-protein complexes known as piRNA-induced silencing complexes (piRISCs). The key features of Piwi-interacting RNAs are:

   a. **Genomic origin**: piRNAs are derived from long single-stranded precursor RNAs transcribed from discrete genomic loci called piRNA clusters. These clusters are enriched in repetitive sequences, transposon remnants and other sequences prone to genomic instability.

   b. **Biogenesis**: piRNAs are generated through a multi-step biogenesis pathway that involves processing of precursor RNAs by nucleases and nucleotidyl transferases. Unlike miRNAs and siRNAs, piRNAs are not processed by Dicer but instead rely on the activity of the Piwi proteins for their maturation.

   c. **Association with Piwi proteins**: piRNAs form complexes with Piwi family proteins, including Piwi, Aubergine (Aub) and Argonaute 3 (Ago3) in *Drosophila melanogaster* and Piwi-like (PIWI) proteins in mammals. These protein complexes play essential roles in recognizing and silencing target sequences, particularly transposable elements and other genomic parasites.

   d. **Transposon silencing**: One of the primary functions of piRNAs is to silence transposable elements (TEs), also known as transposons or mobile genetic elements, in the germline cells of animals. By targeting and cleaving TE transcripts or guiding epigenetic modifications, piRNAs help maintain genome integrity and protect against genomic instability caused by transposon mobilization.

   e. **Epigenetic regulation**: In addition to their role in post-transcriptional silencing, piRNAs are involved in epigenetic regulation of chromatin structure and gene expression in the germline. They can guide the deposition of repressive histone modifications and DNA methylation at target loci, leading to heritable gene silencing.

f. **Germline development**: piRNAs are essential for germline development, gametogenesis and fertility in many organisms. Disruption of piRNA biogenesis or function often leads to defects in germline development, meiosis and gamete formation, resulting in sterility or embryonic lethality.

g. **Evolutionary Conservation**: Although piRNA sequences and genomic loci can vary widely between species, the basic principles of piRNA-mediated silencing are conserved across diverse organisms, from insects to mammals. This conservation underscores the importance of piRNAs in genome defense and germline maintenance throughout evolution.

h. **Emerging roles**: Recent studies have implicated piRNAs in various biological processes beyond transposon silencing, including regulation of gene expression, stem cell maintenance and stress responses. The functional diversity of piRNAs continues to be an active area of research in molecular biology and genetics.

Overall, Piwi-interacting RNAs are critical regulators of genome stability, germline development and gene expression in animals, with implications for evolution, fertility and human health.

9. Small Nucleolar RNAs (snoRNAs): is a class of small RNA molecules typically ranging from 60 to 300 nucleotides in length. They are primarily located in the nucleolus, a subnuclear compartment where ribosome biogenesis occurs. The key features of snoRNAs are:

a. **Biogenesis**: snoRNAs are transcribed from genomic DNA by RNA polymerase II or RNA polymerase III into longer precursor molecules. These precursor molecules undergo processing, including cleavage and modification, to generate mature snoRNAs. The processing of snoRNAs often involves the activity of endonucleases and exonucleases.

b. **Functional categories**: There are two main classes of snoRNAs based on their primary function - box C/D snoRNAs and box H/ACA snoRNAs. Box C/D snoRNAs guide 2'-O-methylation of ribosomal RNA (rRNA) molecules, while box H/ACA snoRNAs guide pseudouridylation, which is the conversion of uridine to pseudouridine in rRNA and other RNA substrates.

c. **SnoRNP complexes**: snoRNAs function as part of ribonucleoprotein (snoRNP) complexes, which consist of the snoRNA bound to specific proteins. Box C/D snoRNAs associate with proteins such as fibrillarin, NOP56, NOP58 and NHP2L1, forming C/D snoRNPs. Box H/ACA snoRNAs interact with proteins such as dyskerin, NHP2, NOP10 and GAR1 to form H/ACA snoRNPs.

d. **Guide sequences**: The sequences within snoRNAs are complementary to specific regions of rRNA or other RNA targets. These guide sequences base-pair with the target RNA molecules, directing the enzymatic modifications (methylation or pseudouridylation) at specific nucleotide residues.

e. **Ribosome biogenesis**: snoRNAs play crucial roles in ribosome biogenesis by guiding the chemical modifications of rRNA molecules, which are essential for ribosome assembly, stability and function. By modifying rRNA, snoRNAs contribute to the fine-tuning of ribosome structure and function, ultimately affecting protein synthesis.

f. **Other functions**: In addition to their roles in ribosome biogenesis, snoRNAs have been implicated in other cellular processes, including mRNA splicing, mRNA stability and telomere maintenance. Some snoRNAs have been found to interact with other RNA molecules, such as small nuclear RNAs (snRNAs) and participate in RNA processing and modification pathways.

g. **Disease implications**: Dysregulation or mutations in snoRNAs and their associated proteins have been linked to various human diseases, including cancer, neurodegenerative disorders and congenital diseases. Alterations in snoRNA expression or function can disrupt ribosome biogenesis and other cellular processes, contributing to disease pathogenesis.

Overall, small nucleolar RNAs are essential players in ribosome biogenesis and other cellular processes, highlighting their significance in fundamental aspects of cell biology and their potential implications for human health and disease.

10. **Brain cytoplasmic RNA (BC RNA):** is a class of RNA molecules found specifically in the cytoplasm of brain cells, particularly neurons. These RNA molecules are distinct from those found in other cellular compartments such as the nucleus or the dendrites and they play important roles in various aspects of neuronal function and plasticity. The key features of brain cytoplasmic RNA are:

a. **Localization**: BC RNA is localized specifically to the cytoplasm of neurons within the brain. This localization is essential for the regulation of local protein synthesis, which is crucial for processes such as synaptic plasticity, learning and memory.
b. **mRNA transport and translation**: BC RNA includes mRNA molecules that are actively transported from the nucleus to the cytoplasm of neurons, where they undergo translation into proteins. Local translation of mRNAs in the dendrites and axons of neurons allows for rapid and spatially restricted responses to synaptic activity.
c. **Role in synaptic plasticity**: BC RNA is involved in synaptic plasticity, the ability of synapses to strengthen or weaken over time in response to activity. Local translation of specific mRNAs at synapses contributes to synaptic plasticity mechanisms such as long-term potentiation (LTP) and long-term depression (LTD), which are thought to underlie learning and memory.
d. **Regulation by RNA-binding proteins**: The localization and translation of BC RNA are regulated by RNA-binding proteins that interact with specific sequences or structures within the RNA molecules. These proteins control various aspects of RNA metabolism, including transport, stability and translation.
e. **Disease implications**: Dysregulation of BC RNA metabolism has been implicated in various neurological disorders, including Alzheimer's disease, Parkinson's disease and autism spectrum disorders. Abnormalities in RNA localization, translation or stability may disrupt neuronal function and contribute to disease pathogenesis.
f. **Technological challenges**: Studying BC RNA poses unique challenges due to its relatively low abundance and heterogeneous composition. However, advances in high-throughput sequencing technologies and single-cell RNA sequencing have enabled researchers to investigate the diversity and dynamics of BC RNA populations with greater precision.
g. **Therapeutic potential**: Understanding the roles of BC RNA in neuronal function and dysfunction may lead to the development of novel therapeutic strategies for neurological disorders. Targeting RNA metabolism pathways or specific RNA-binding proteins could potentially restore normal neuronal function and alleviate disease symptoms.

In outline, brain cytoplasmic RNA represents a specialized class of RNA molecules that play critical roles in neuronal function, synaptic plasticity and neurological disease. Investigating the composition and regulation of BC RNA holds promise for advancing our understanding of brain function and developing new treatments for neurological disorders.

11.Circular RNA (circRNA): is a type of RNA molecule characterized by a covalently closed loop structure. Unlike linear RNA molecules, which have two distinct ends, circRNAs are formed by back-splicing, where a downstream 5' splice site is joined to an upstream 3' splice site, resulting in a circularized RNA molecule. Key features of circular RNA include:

a. **Circular structure**: circRNAs lack free ends and form a continuous loop structure, making them resistant to degradation by exonucleases.

b. **Diverse origins**: circRNAs can originate from various genomic regions, including exons, introns, intergenic regions and antisense transcripts. They are generated through the back-splicing of precursor mRNA transcripts by RNA splicing machinery.

c. **Abundance and conservation**: circRNAs are abundant in eukaryotic cells and tissues and exhibit tissue-specific expression patterns. Some circRNAs are evolutionarily conserved across species, suggesting functional importance.

d. **Regulatory functions**: Although the precise functions of circRNAs are still being elucidated, they have been implicated in gene regulation at multiple levels. circRNAs can act as miRNA sponges, sequestering miRNAs and preventing them from repressing target mRNAs. They can also interact with RNA-binding proteins and influence RNA splicing, transcription, and translation.

e. **Cellular processes**: circRNAs have been implicated in various cellular processes, including cell proliferation, differentiation, apoptosis, and development. Dysregulation of circRNAs has been associated with numerous diseases, including cancer, neurological disorders, and cardiovascular diseases.

f. **Potential biomarkers and therapeutic targets**: Due to their stability, tissue-specific expression and dysregulation in diseases, circRNAs hold promise as diagnostic biomarkers and therapeutic targets. They can serve as indicators of disease progression and response to treatment and targeting circRNAs may offer novel therapeutic strategies for disease intervention.

Overall, circRNAs represent a fascinating class of RNA molecules with diverse functions and regulatory roles in cellular processes. Further research into circRNA biology is essential for understanding their functional significance and exploiting their diagnostic and therapeutic potential in various diseases.

RNA is crucial for the central dogma of molecular biology, where genetic information flows from DNA to RNA to proteins. It plays essential roles in gene expression regulation, protein synthesis and various cellular processes. RNA-based technologies, such as RNA interference (RNAi) and CRISPR-Cas systems, have revolutionized gene editing and gene expression regulation. Understanding the structure, function and biological significance of RNA is fundamental to unraveling the complexities of cellular processes and developing novel therapeutic interventions for various diseases.

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NANOTECHNOLOGY IN AGRICULTURE

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Introduction

In the face of mounting environmental challenges and increasing food demands, the need for sustainable agriculture is crucial. Higher demands of water, energy and other resources made world food production and distribution under a huge stress. 'Zero hunger' can be achieved by the practice of sustainable agriculture and needed for this era as there are approximately 815 million people are currently undernourished and expected the addition of 2 billion people by 2050.Nanotechnology has the potential to solve this issue by promoting sustainable agriculture in the way of increasing the efficiency of agricultural inputs and offering solutions to environmental and agriculture problems concerned in food productivity and security. By introducing this technology, profound changes can happen in the global food production system.

Nanotechnology and Nano agriculture

Nanotechnology is the branch of technology which understands and control of matter of sizes in the range of 1 to 100 nanometres. The particle has one of the dimensions in this size is considered as nanoparticle. When bulk materials reduced to nanoscale from macroscale, it shows difference in some properties such as melting point, surface area, physical strength, magnetism etc from what they exhibited in macroscale. Nanoparticles can either be natural or engineered. At nanoscale, properties such as surface tension and van der Waal forces considered more important than gravity. They have unique chemical, thermal electronic, optical, magnetic properties because of nanoscale dimension. Nano-agriculture is the adoption of nanotechnology, concepts and principles in agricultural sciences in-order to develop processes and products that precisely deliver inputs and promote productivity without causing any adverse impact on environment. By using nanomaterials, nano-electronics, nano-sensors, it develops more efficient and sustainable farming methods.

Properties of Nanoparticles

- Catalytic activity of nanoparticles enhances as the particle size decreases; surface area increases.
- Optical property of nanoparticles influenced by reduction in the particle size from micron to nanometer scale.
- The reduction of size also influences the thermal properties like melting point and thermal conductivity.
- Melting temperature is size dependant in nanoparticles as it decreases with the decrease in particle size diameters.
- Decreasing the particle size of nano particles helps in improving the quality of magnets obtained from it.

Scope of Nanotechnology in Agriculture

By implementing nano technology in agriculture, the main objectives are to increase the production rate and yield, to increase the efficiency of resource utilisation and to reduce the waste production to meet future needs. In soil, we can use nano-zeolites for soil conservation and slow release of nutrients, nanomagnets for removal of soil contaminants and nano-sensors for automation. In water, we can use nano-sensors for contaminant detection and water flow detection, nano-membranes for purification, desalination, and detoxification. In addition to this, carbon nanotubes are used for seed germination.

In soil, nanozeolites are used for soil conservation, slow release of fertilizers and nano sensors for automation. In water, nanosensors are used for water flow detection and contaminant detection and nanomolecules for robus water tanks to prevent leakage.

Application of Nanotechnology in Agriculture

- **Nano-Fertilizers:** Foliar application of nanoparticles as fertilizer has contributed to significant increase in yields. Fertilizers encapsulated in nanoparticles will increase uptake of nutrients. It can also mitigate soil degradation and increase soil fertility. Eg: Nano NPK, Nano Lime.

- **Biosensors:** Nanomaterials play the role to increase the sensitivity and performance of biosensors which allows the introduction of many new signal transduction technologies in it. Nano-biosensors are effective devices to detect the composition of the soil, nutrients and also the toxic substances in the soil.
- **Smart delivery of nutrients:** Nano- encapsulated agro chemicals are made with characteristics like effective concentration, stability, time-controlled release in response to certain stimuli, easy mode of delivering helps to avoid repeated applications.
- **Nano-Herbicides:** Nano-herbicides causes minimum environmental damage by targeting the weed and allow slow and controlled release of active ingredients.
- **Nano-Insecticides:** Nano-insecticides like surface modified hydrophobic nano-silica are safe for plants and cause less environmental damage than conventional insecticides.
- **Nano -Fungicides:** Nano-fungicides like Ag-NPs contain small nano particles and can penetrate easily and colonise fungal spores which are source of plant pathogens.
- **Precision farming:** Precision farming is the science of improving yields by minimising input using high technology sensor and analysis tools. Nanotechnology contributed variety of devices to reduce the cost of precision farming. For example,nano devices and sensors which can penetrate the soil and inform about environmental changes so that we can change the plans and act accordingly.

Challenges

Significant hazards are also caused by the application of nano-particles for humans, animals and plants when used non-judiciously.

- Various ill-effects and disorders occur to animals when they inhale nanoparticles. They may enter the blood stream.
- Nano -pesticides reduce environmental contamination through the reduction in pesticide application rates but they may also create contamination in soil and waterways because of its characteristics such as longer persistence and higher toxicity.
- Air borne nano-particles may enter the lungs and blood stream and there is a chance to cause inflammation, protein fibrillation and induction of genotoxicity.
- Pollen tube penetration can be prevented as a result of forming a toxic layer on stigma when air borne nanoparticles deposited on plant parts.

- Nanoparticles may enter the vascular tissues and impair translocation of water, minerals and photosynthate.

Conclusion

Nanotechnology has so many applications in agriculture such as nano-herbicides, nano-pesticides, nano-biosensors and promote sustainable agriculture. The concepts raised by it show how can we plant crops and manage fields effectively to raise productivity by protecting the environment. In every application of new technologies, there is a need to perform a reliable assessment before wide spread implementation. In case of nano technology, as they possess some challenges, this also requires some reliable methods for identifying the risk and its impact on human and environmental health. With continued research and responsible application, nanotechnology promises a good future in agriculture by enhancing its contribution.

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SOCIAL MEDIA APPLICATION IN AGRICULTURAL SECTOR

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Introduction

The modern man's life has been altered in the era of information and communication technologies (ICTs). One of the biggest challenges for any country is the need for accurate and up-to-date information. ICTs have shown to have a major influence on rural development by moderating the diffusion of contemporary technology and by keeping local knowledge and skills up-to-date.

Agricultural production techniques have improved significantly in recent years as a result of evolving technologies. New techniques for communicating these advancements are being introduced in tandem with technological advancements. A negative perception of farming exists because of groups that oppose the industry's disregard for the environment and its abuse of animals. However, new communication strategies are attempting to alter public opinion by educating the public and giving them the tools they need to make an informed decision about agriculture and food production.

Developing a social media application specifically tailored for the agriculture sector could be highly beneficial. It could facilitate knowledge sharing among farmers, provide market information, enable networking opportunities, and offer support for various agricultural activities like pest control, crop management, and irrigation techniques. Additionally, features such as forums, expert advice sections, and virtual marketplaces could enhance user engagement and provide valuable resources for farmers worldwide.

Usage of Social Media Application among Farmers

The use of social media among farmers in agriculture has been steadily increasing in recent years. Platforms like Twitter, Facebook, and Instagram are being used for knowledge sharing, market updates, networking, and even direct sales. However, the extent of adoption and the specific platforms vary depending on factors like region, age demographics, and technological infrastructure. It became an essential tool for many farmers to stay connected and informed within their communities and the outside world.

Social Media for knowledge on Agricultural Production

Social media plays a crucial role in providing agricultural production-related information to farmers. Platforms like Twitter, YouTube, and LinkedIn are used by agricultural experts, researchers, and extension services to share timely updates, research findings, and practical tips on crop management, pest control, soil health, and more. Farmers can follow relevant accounts, join groups, and participate in discussions to stay informed about the latest practices and trends in agriculture. Additionally, social media allows farmers to access virtual workshops, webinars, and online courses to enhance their skills and knowledge from the comfort of their homes. By leveraging social media, farmers can access a wealth of information to improve their agricultural practices, increase productivity, and adapt to changing environmental conditions more effectively.

Social Media in Transfer of Technology

Social media has become a powerful tool for technology transfer among farmers. Through platforms like WhatsApp groups, Facebook pages, and Twitter chats, farmers can share knowledge, experiences, and innovative practices in real-time. These platforms facilitate the rapid dissemination of information about new agricultural technologies, techniques, and best practices, helping farmers stay updated and adopt new methods more quickly. Additionally, social media allows for peer-to-peer learning, enabling farmers to connect with and learn from others facing similar challenges and opportunities in different parts of the world. Overall, social media has revolutionized technology transfer in agriculture by making information more accessible and fostering collaboration and knowledge exchange among farmers globally.

Social Media Application in Agricultural Marketing

Social media has transformed agricultural marketing by providing farmers with direct access to consumers and markets. Social Media Platforms like Instagram, Facebook, etc allow farmers to showcase their products, share stories about their farms, and engage with customers in a more personal and interactive way. Through targeted advertising and strategic content creation, farmers can reach specific audiences interested in local, sustainable, or organic products. Social media also enables farmers to receive instant feedback from customers, build brand loyalty, and establish relationships that extend beyond traditional transactions. Overall, social media has become a vital tool for farmers to promote their products, increase visibility, and diversify their marketing channels in the digital age.

Social Media for Agribusiness

Introducing social media into agribusiness can revolutionize the sector by connecting farmers, suppliers, buyers, and other stakeholders in real-time. It can facilitate market access, knowledge exchange, and networking opportunities. Platforms tailored for agribusiness could include features like market insights, weather updates, crop management tips, and forums for discussions and collaboration. By leveraging social media, agribusinesses can streamline operations, improve decision-making, and ultimately enhance productivity and profitability.

Thus, the application of social media in agriculture has revolutionized the way farmers access information, market their products, and connect with their communities. From technology transfer to marketing and production-related insights, social media has become an indispensable tool for farmers worldwide. By embracing these platforms, farmers can not only stay updated on the latest advancements but also foster collaboration, innovation, and sustainable practices within the agricultural industry. As social media continues to evolve, it's potential to empower farmers and drive positive change in agriculture remains promising.

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EFFECT OF MICROPLASTICS ON THE AQUATIC ORGANISMS

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Abstract

Microplastics, small plastic particles that effect environment, particularly in aquatic ecosystems. Their presence in marine and freshwater environments poses a significant threat to aquatic organisms, including fish, invertebrates, and plankton. This review examines the current state of knowledge regarding the effects of microplastics on aquatic organisms, focusing on their ingestion, accumulation, and potential impacts Studies have shown that microplastics can be ingested by a wide range of aquatic organisms, the accumulation of microplastics in the tissues of aquatic organisms can result in the transfer of toxic chemicals associated with plastics, further exacerbating the potential harm. Future research efforts should focus on elucidating the mechanisms of toxicity, developing standardized methods for assessing microplastic pollution, and implementing strategies to mitigate its impact on aquatic organisms and ecosystems.

Key words: Microplastics, Pollution, Aquatic ecosystems, Toxic chemicals, Accumulation.

1. Introduction

Since 1950, the production of fisheries and aquaculture has grown by almost eight times (FAO). It adds about 1% to the GDP of India and more than 5% to the GDP of agriculture, which in turn adds 8% to the world's fish production.25 million Indians rely on the primary fisheries and aquaculture sector for their livelihood, employing 57 million people globally. The percentage of workers in this sector rose from 17 percent in 1990 to 33 percent in 2014 (FAO, 2016). According to Dwivedi (2018), water pollution, also known as aquatic pollution, is the entry or release of substances, typically chemicals, into a body of water above its threshold level, which can degrade the water's quality. Numerous human-caused anthropogenic activities lead to the release of various pollutants that contaminate aquatic environments, including plastics, detergents, micofibres, heavy metals (from agrochemicals), and microfibers (Hampelet al., 2015). The amount of plastic produced worldwide has grown from two million tonnes in 1950 to 370 million tonnes in 2019 and is expected to rise further (Kumar et al., 2021).After 2020, the annual production of plastic garbage is expected to reach 400 million tonnes (Kumar et al., 2021).According to studies, the production of plastics will quadruple once again in 20 years.

2. Microplastics

Microplastics, according to the National Oceanic and Atmospheric Administration (NOAA), are particles of marine plastic trash that are smaller than five millimetres (<5 mm).In the 2016 EFSA (European Food Safety Authority) report, microplastics are defined as a heterogeneous mixture of materials of different shapes (fragments, fibers, spheroids, granules, pellets, splinters, or beads) whose size ranges between 0.1 micrometers to 5000 micrometers (µm) in their longest dimension.Kurtela and Antolović(2019) calculated that 1.5 million tonnes of primary microplastics are discharged into different water bodies every year.Polyethylene makes up about 54.5% of the microplastics floating in the water, followed by polypropylene (16.5%) and polyvinyl chloride, polyester, and polyamides (Issac&Kandasubramanian, 2021).

3. Source of Microplastics in Aquatic Environments

Wind, currents, and other environmental factors carry microplastics across great distances, dispersing them globally in the sky, on land, in rivers, lakes, estuaries, offshore, and in pelagic, polar, and deep oceans (Machado et al., 2018).Microplastics are created when plastic trash gradually breaks down into extremely small particles with very little dimensions by mechanical and photochemical processes, especially when exposed to sunshine (Ultraviolet radiation), high temperatures, and absorption (Cole et al., 2011).

4. Pathways of MPs into Aquatic Ecosystem

Rochman (2018) notes that although it was probably happening long before then, the first formal reports on the existence of plastic trash (14 million tonnes, or 80% of marine debris) in the marine environment were identified around 1970 (Kuhn &Franeker, 2020).There are numerous studies that demonstrate plastic in sea turtles, sea birds, and other charismatic mega fauna, like whales and dolphins. Ingestion has been reported in over 700 marine species (80% of examined individuals contained 60% fish) (Kuhn &Franeker, 2020).According to Kasamesiri and Thimuangphol (2020), microplastic has been detected in a wide range of fish species from freshwater, marine, and estuarine aquatic systems, as well as in shallow to deep seas.

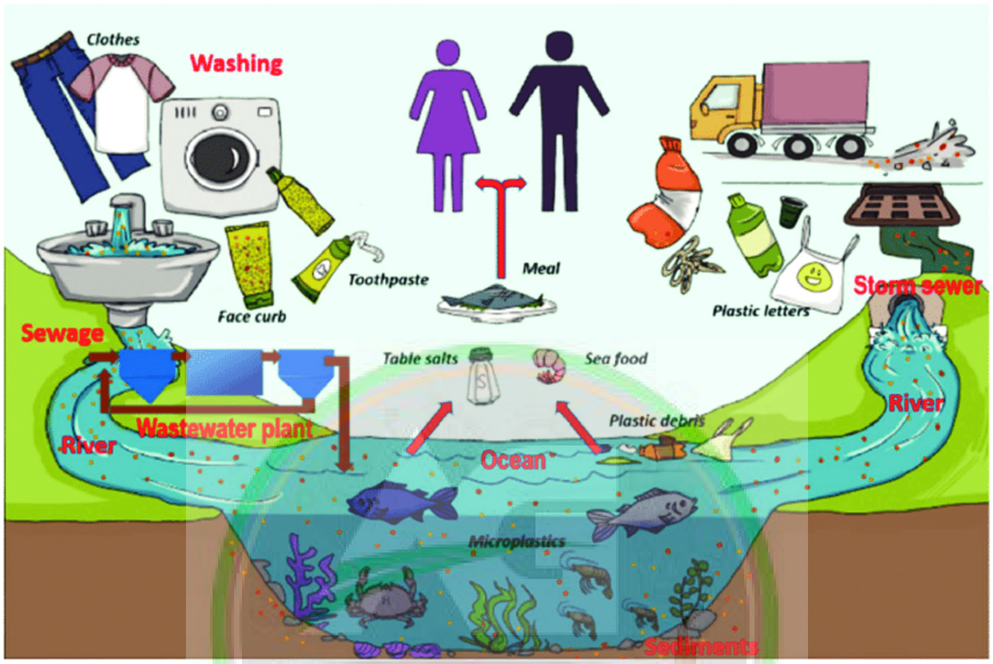

Fig. 1: Microplastic pollution in aquatic environments and impact on food chain (Wu *et al.*, 2017)

According to Wu et al. (2020), there has been evidence of varied levels of microplastic contamination in the guts, gills, and tissues of fish samples obtained from markets, wild fish, and fish reared from aquaculture.Fish can digest microplastics either by secondary digestion, which happens when prey that already includes plastic is consumed, or by primary ingestion, which commonly happens when fish mistake it for food or inadvertently swallow it .The latter is referred to as and can lead to bioaccumulation and biomagnification (Farrell & Nelson 2013), and potentially to increased accumulation of microplastic in higher trophic level predators (Miller *et al*., 2020).

5. Ecotoxic impact:

Fish, mussels, prawns, crabs, and other commercial species have been shown to contain microplastics. In seawater, the average concentration of MPs was 1.75 ±5.17 MP/L (Rezania et al., 2018).Shrimp from coastal waters in the southern North Sea and channel area were found to have synthetic fibers, with an average value of 1.23 ± 0.99 items/individual, ranging from 200 to

1000 μm. The amount and type of plastic that fish ingest is likely influenced by trophic level as well as feeding strategy, biogeography, habitat, and ecological niche. Plastic pollution varies throughout the world; for example, there is more plastic pollution in the sediment than in the water column (Harris, 2020).The socio-economic aspects of the tourism business, shipping, trawling, and fish farming are negatively impacted by the existence of plastics in the aquatic environment (Thushari and Senevirathna 2020).Because of their persistent nature and ability to float (almost 92% of the 5.25 trillion plastic particles), microplastics are a common marine contaminant in aquatic environments, serving as a conduit for the spread of pollutants to aquatic creatures (Rodrigues et al., 2019).The tissues of food chain creatures contain intrusive fragments of microplastics and polystyrene (PS), as well as persistent bioaccumulative and poisonous compounds (PBTs) that have heightened physiological effects at higher trophic levels.

Conclusion

The pervasive presence of microplastics in aquatic environments poses a multifaceted threat to the health and sustainability of aquatic organisms and ecosystems. From physical harm and chemical toxicity to disruptions in behavior and reproduction, the impacts of microplastics are far-reaching and concerning. To address this issue effectively, concerted efforts are needed to reduce plastic pollution at its source, enhance waste management strategies, and mitigate the existing contamination of microplastics in aquatic ecosystems. Only through collaborative action can we safeguard the delicate balance of aquatic environments and ensure the well-being of marine life for generations to come.

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GENE SILENCING: A PROBLEM OF TRANSGENIC GENE EXPRESSION IN PLANTS

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Introduction

The job of a scientist does not end with the successful transfer of a transgene into a targeted plant tissue. He should also make sure that transferred gene should stably integrate and express in the transformed cells. In order to apply gene technology to modern agriculture, it is essential to understand transgene expression. Sometimes when a transgene is introduced into an organism it may not show its expression. This partial or complete inactivation of gene(s) is known as gene silencing. It has also been established that in all such cases of transgene silencing, loss of expression of the transgenes is not due to the loss of these genes but due to their inactivation.

Causes of gene silencing:

Silencing of a gene can be complete or partial. It may occur at transcriptional or translational level. There are various causes for gene silencing which are elaborated below:

1. DNA methylation

When foreign DNA is introduced into plants, the modification and restriction system of cell causes methylation of foreign sequence to make it inactivated. DNA methylation is imposed on cytosine residues within symmetrical target sequences. In plants an inverse correlation between gene transcription and cytosine methylation has been observed for certain controlling elements as methylated DNA prevents transcription by directly hindering trans-acting factors and basal transcription machinery accessibility. On the basis of DNA methylation, gene silencing may be

i. *Transcriptional silencing*, which is linked to methylation of promoter region:

ii. *Post-transcriptional silencing*, which involves inactivation of the coding sequence by methylation.

2. **Homology-dependent gene silencing**

Not only did homologous sequences affect the stability of transgene expression but also the activity of endogenous genes could be altered after insertion of transgene into genome. This homology-dependent inactivation occurs by different modes:

a. Inactivation of homologous transgenes:

When transgenic plants were retransformed with constructs that are partly homologous with the integrated transgene, in the presence of second construct, the primary transgene becomes inactivated and hypermethylated within the promoter region.

b. Paramutation:

It is the interaction of homologous plant alleles that leads to heritable epigenetic effects. Thus, combination of two homologous alleles that differed in their state of methylation results in paramutation phenomenon.

c. Cosuppression;

Expression of endogenous genes can be inhibited by the introduction of a homologous sense construct that is capable of transcribing mRNA of same strandedness as transcript of the gene. In co-suppression, there is suppression of both the transgene and homologous resident gene or inactivation of either of two.

3. **Suppression by antisense genes**

It is the post-transcriptional inhibition of gene expression. Antisense gene often leads to reduced levels of target mRNA and can potentially form a double-stranded structure with complementary mRNAs. Antisense RNA may interfere with the following processes:

a. Antisense transcripts affect the target gene directly in the nucleus, thereby preventing synthesis of mRNA.
b. Antisense RNA may block processing of mRNAs by masking the sequences recognized by splicing and polyadenylation.
c. Antisense RNA may disturb the normal transport of mRNAs out of the nucleus by forming a hybrid with their target mRNAs and disturbs the regular flow of transcripts.
d. Many antisense RNAs complementary to ribosome binding site have been shown to inhibit translation initiation.

e. Antisense RNA prevents the accumulation of target mRNA. Sense and antisense RNAs form a double RNA intermediate that is rapidly degraded by dsRNA specific ribonucleases.

4. **Position effect**

Whenever a transgene gets integrated into an improper region (hypermethylated, heterochromatic, telomeric, compositionally different genomic region), due to suppressing effect of the adjacent region or environment, it gets inactivated.

5. **Increased copy number**

A correlation between number of integrated copies and the frequency of inactivation is well documented for copies arranged in *cis* position. A reduction in copy number inside a locus was shown to increase gene expression or decrease the suppressing effect. It may be either duplication of promoter or addition of a truncated transgene-coding region that can cause decreased expression. Increased copy number may be due to direct gene transfer methods as there is no control over copy number.

Strategies for avoiding gene silencing:

To obtain stable expression and inheritance of transgenes in genetically transformed plants, the following criteria should be considered:

A. It is better to opt for integration of single inserts of transferred gene without duplication in the form of tandem or inverted repeats and consisting of single unique elements.

B. Homology at DNA or RNA levels should be avoided or length and degree of homology should be controlled by interrupting perfect homology with mismatch or intron sequences.

C. Integration of single-copy, unmethylated sequences of plant genome may increase the probability for continuous stable expression as the structure of integrated DNA itself, the environment of insert, may influence the stability of gene expression.

D. In some cases, transgene expression decreased progressively over subsequent generations. Therefore, continuous monitoring of expression levels in progeny of even well-established transgenic lines might be a precaution against unexpected epigenetic modifications.

It is also necessary to arrange for the gene product to appear in the correct subcellular location. Also, it may be acceptable to have nuclear-encoded genes that are involved in functions such as detoxification or resistance switched on all the time in some situations. Sometimes, however, it is desirable to ensure expression of foreign gene at a particular development stage or in response to environmental signals. Once the gene is integrated into the genome, DNA is usually stably maintained.

Conclusion:

Gene silencing is a powerful tool for regulating gene expression and has significant implications for research, therapeutics, and biotechnology. Understanding and manipulating gene silencing mechanisms can lead to advancements in treating diseases, improving crop yields, and exploring gene functions.

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CLIMATE RESILIENT AGRICULTURE- OBJECTIVES, APPROACHES AND TRAITS FOR ABIOTIC STRESS TOLERANCE

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Introduction

Farmers need to intelligently adapt to the changing climate in order to sustain crop yields and farm income. Enhancing resilience of agriculture to climate risk is of paramount importance for protecting livelihoods of small and marginal farmers. In the context of climate change and variability, farmers need to adapt quickly to enhance their resilience to increasing threats of climatic variability such as droughts, floods and other extreme climatic events. Efficiency in resource-use, environmental and social safeguards, sustainability and long-term development of agriculture has greater importance.

Major objectives of this initiative

1. To enhance the resilience of Indian agriculture covering crops, livestock and fisheries to climatic variability and climate change through development and application of improved production and risk management technologies.
2. To demonstrate site specific technology packages on farmers' fields for adapting to current climate risks.
3. To enhance the capacity of scientists and other stakeholders in climate resilient agricultural research and its application.

Various field level farmer friendly approaches for climate resilient agriculture:

- Direct seeded rice for promoting water use efficiency
- Drum seeding of rice for water saving and timeliness in planting
- Drought tolerant paddy cultivars to tackle deficit rainfall situations

- Short duration finger millet varieties for delayed monsoon / deficit rainfall areas
- Short duration crop varieties suitable for late sowings
- Crop diversification for livelihood security and resilience to climate variability
- Flood tolerant varieties impart resilience to farmers in flood-prone areas
- Improving the resilience of poor farmers reclaiming cultivable wastelands
- Community tanks / ponds as a means of augmentation and management of village level water resources
- Individual farm ponds for improving livelihoods of small farmers
- Jalkund - low cost rainwater harvesting structures
- Check dam - storing excess-runoff in streams
- Rainwater harvesting and recycling through temporary check dam
- Enhancing resilience through improvement in conveyance efficiency
- Shelter management for small ruminants to tackle heat stress and rain storm
- Improved planting methods for enhancing water use efficiency and crop productivity
- Zero till drill wheat to escape terminal heat stress
- In situ incorporation of biomass and crop residues for improving soil health
- Village level seed banks to combat seed shortages
- Fodder cultivars to tackle fodder scarcity.

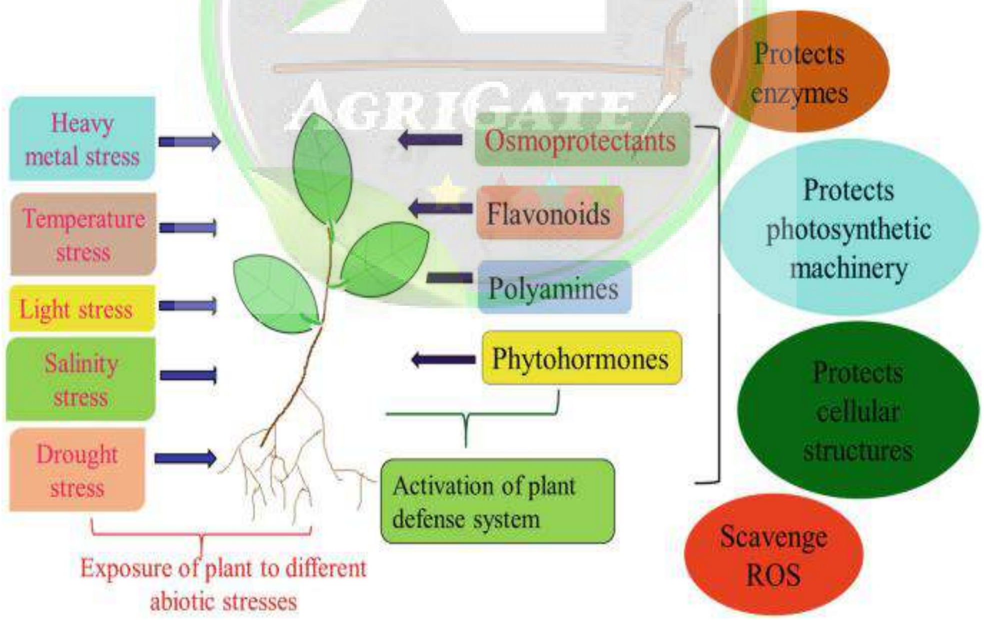
Physiological Approaches for climate resilient agriculture:

Development of varieties that could resist abiotic stresses such as drought, Heat, Salinity and flooding forms an important strategy to maintain sustainability under changing global climatic conditions. The following figure and table describes few of the physiological traits that provide tolerance to various abiotic stresses.

S.No	Abiotic stress	Important physiological traits that confer tolerance
1	Drought	• Improved water use efficiency through plant characters like early closure of stomata (Stomatal conductance) • Increased photo synthetic efficiency • Efficient and deeper root system • Waxy leaf surface

2	Heat	• Canopy temperature depression • Membrane thermo stability • Chlorophyll fluorescence • Chlorophyll content and stay green • Stem reserve mobilization • Photosynthetic efficiency
3	Salinity	• Osmoregulation (osmolyte production) • K^+/Na^+ selectivity • LEA (Late embryogenesis abundant proteins) • Ion homeostasis • Antioxidant enzymes
4	Flooding	• Adventitious roots • Well developed aerenchyma • Plant height and leaf length (Exposure of leaf tip above the water surface under complete submergence) • Quiescence strategy (under flash flooding)

A simplified scheme of mechanism for abiotic stress tolerance in plants.



Source: Narula,*et al.*, 2022.

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PLANT DISEASES MONITORING THROUGH REMOTE SENSING TECHNOLOGY

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Introduction

Plant diseases and pests are severe threats to worldwide agriculture and forestry. Knowing the location, extent and severity of the occurrence of diseases and pests is essential in guiding plant protection procedures. Given the fact that conventional field scouting of plant diseases and pests is labor intensive, prone to be subjective and generally shows low efficiency, remote sensing (RS) techniques can be a key supplement to enable the monitoring of plant diseases and pests at a coarse scale (Mahlein, 2015). Remote sensing is a quick and efficient technique which can obtain and analyze spectral properties of earth surfaces from different distances, ranging from satellites various platforms. This modern technology can prove to be a boon for crop production including crop protection. Using various specific parameters of sensors like spatial, spectral, radiometric and temporal resolution and imaging techniques like visible, infrared, multispectral, hyperspectral imaging and thermal sensors *etc*. have been studied for the detection of plant diseases. Remote sensing technologies will be extremely helpful to greatly specialize diagnostic results and thereby rendering agriculture more sustainable and safe, avoiding expensive use of pesticides in crop protection.

Remote sensing of plant diseases and pests could be viewed as an approach of "radiodiagnosis" of plants, which is able to provide noncontact and spatially continuous monitoring of diseases and pests efficiently. The incipient studies and applications about this can be traced back to the 1980s. With a rapid development of computer science and sensing technology, a wide spectrum of RS data has been used to detect diseases and pests. In this process, connections between RS methodologies and plant pathology theories have been strengthened thus improving our understanding of the agriculture system in many aspects. For example, existing studies not only focus on detecting the occurrence of a specific disease or pest, but also seek to discriminate different diseases and pests concurrently, assess their infection severities, and map their distributions at plot or regional levels. In some cases, the detection and monitoring of diseases and pests have begun to show a great potential in some practical applications, such as facilitating the precision spray in field for disease and pest control or loss assessment in agricultural insurance investigations.

What is remote sensing?

• Referred to collection of information an object without coming into physical contact**.**

• RS is defined as the technique of obtaining information about objects through the analysis of data collected by special instruments, not in physical contact with the object of investigation.

• The output of a remote sensing system is usually an image representing the scene being observed.

History of Remote Sensing

- The modern remote sensing began with the invention of camera more than 150 years ago.
- Remote sensing began in the 1840s as balloonists took pictures of the ground using the newly invented photo-camera. Perhaps the most novel platform at the end of the last century is the famed pigeon fleet that operated as a novelty in Europe.
- In 1850 Gaspard-Félix Tournachon, more commonly known by his pseudonym Nadar, captured the first aerial photograph. Using a hot air balloon, Nadar produced the first successful aerial photograph of a French village in 1858.
- The oldest aerial photograph that has survived was taken in Boston in 1860 by James Wallace Black. Nadar's earliest surviving aerial image was taken from a balloon above Paris in 1866.
- The aerial photography is the original form of remote sensing started in 1909.
- The colour infrared photography began 1931, and widely used in agriculture and forestry.
- The development of satellite based remote sensing began with the "space race" in the 1950s and 1960s. In 1957 the Soviet Union launched Sputnik 1, the world's first artificial satellite. The United States followed in 1960 with the successful launch of Explorer 1.
- The terms "Remote Sensing" first used in the United State in the 1950s by Ms. Evelyn Pruitt.

- Satellite remote sensing can be traced to the early days of the space age (both Russian and American programs) and as a dual approach to imaging surfaces using several types of sensors from spacecraft.
- Colwell (1956) first used remote sensing technique for monitoring stem rust of wheat.

Objectives of remote sensing in plant pathology

- Assessment of disease over a vast area
- To know the relationship of diseases and environment
- For detection, identification, of plant disease
- Management of plant disease
- Miscellaneous

Type of remote sensing

Remote sensing can be divided into two types of methods: *Passive remote sensing* and *Active remote sensing*.

Passive sensors gather radiation that is emitted or reflected by the object or surrounding areas. Reflected sunlight is the most common source of radiation measured by passive sensors. Examples are film photography, infrared, charge-coupled devices, and radiometers.

Active collection, on the other hand, emits energy in order to scan objects and areas whereupon a sensor then detects and measures the radiation that is reflected or backscattered from the target. RADAR and LiDAR are examples of active remote sensing

Advantages of remote sensing in agriculture

Agriculture is one of the most significant land-use activities around the world. Apart from changing the land cover, agriculture also profoundly impacts the sustainable development of the social economy, carbon cycle, climate change, ecosystem services, food security, etc. There are types of remote sensing in agriculture. The location, area, status, and conversion information of farmlands are vital if you want to understand how human activities will affect the lithosphere, hydrosphere, and biosphere. Additionally, you can also formulate sustainable agricultural development policies and study the simulation of the carbon-nitrogen cycle. Hence, understanding remote sensing and its application in agriculture are vital.

Remote sensing use in Plant Pathology

Remote sensing techniques such as satellite imagery, drones, and hyperspectral imaging, researchers and agriculturists can detect, diagnose and mitigate the plant diseases with unprecedented precision.

- **Early disease detection**

  Remote sensing plays a pivotal role in early disease detection. By utilizing the Normalized Difference Vegetation Index (NDVI), experts can identify subtle changes in plant health that may indicate the presence of disease. These early warnings enable farmers to take prompt action, preventing extensive crop damage.

- **Disease severity assessment**

  Remote sensing tools provide quantitative data on disease severity, enabling precise decisions on treatment strategies. By monitoring changes in plant reflectance and other indicators, pathologists can gauge the extent of disease spread and its impact on crop health.

- **Precision disease management**

  Precision agriculture is the future, and remote sensing plays a pivotal role in it. With detailed spatial data, farmers can implement targeted disease management strategies. which includes the precise application of pesticides and fungicides when to needed, reducing environmental impact and lowering production costs.

- **Yield estimation**

  Remote sensing technology can help predict crop yields by monitoring plant health throughout the growing season. By analyzing data on plant growth and vitality, farmers and policymakers can make informed decisions about resource allocation and distribution.

- **Soil health monitoring**

  Healthy soil is the foundation of robust crop growth. Remote sensing extends its capabilities to assess soil health parameters. It can measure soil moisture, nutrient content, and pH levels, providing valuable insights for optimizing fertilization and irrigation practices.

- **Climate impact analysis**

  Climate change poses significant challenges to agriculture. Remote sensing allows for the monitoring of climate-related changes such as temperature, precipitation, and humidity. These data help farmers adapt to shifting weather patterns and make informed decisions about crop selection and planting times.

- **Fungal disease identification**

  Fungal diseases can devastate crops if not promptly identified and managed. Remote sensing technologies, including hyperspectral imaging, can detect specific spectral signatures associated with fungal infections. This allows for targeted disease identification and treatment.

- **Bacterial disease identification**

  Like fungal diseases, bacterial infections can harm crops. Remote sensing aids in identifying bacterial diseases by detecting unique spectral patterns associated with bacterial pathogens. This early detection facilitates timely intervention.

- **Viral disease identification**

  Remote sensing's hyperspectral capabilities extend to viral disease identification. By analyzing the spectral signatures of infected plants, researchers and farmers can identify viral outbreaks swiftly, preventing further spread.

- **Weed detection and management**

  Weeds compete with crops for resources and can significantly reduce yields. Remote sensing technology can distinguish between crops and weeds, enabling precise herbicide application. This targeted approach minimizes herbicide use and reduces environmental impact.

- **Nutrient deficiency diagnosis**

  Remote sensing can detect early signs of nutrient imbalances by analyzing leaf reflectance patterns. This information guides farmers in adjusting their fertilization practices for optimal crop nutrition.

- **Post-harvest disease monitoring**

  Remote sensing aids in post-harvest disease monitoring by assessing storage conditions and tracking changes in crop quality. This helps prevent post-harvest losses and ensures the delivery of high-quality produce to consumers.

Case studies of remote sensing in plant disease management

- Nilsson *et al*. observed that the flag leaves of oats infected by barley yellow dwarf virus were 3-4°C warmer than visually healthy leaves.
- Smith *et al*. reported that stripe rust on wheat initially reduced stomata closure and disrupted the cuticle.

- Colwell (1956) demonstrated the potential of aerial photography using panchromatic and infrared films to detect and quantify crop diseases e.g cereal rusts and virus diseases of citrus.
- Southern corn blight watch project in the USA (*Helminthosporium maydis*) demonstrated the efficacy of large-scale application of aerial IR-photography to crop disease surveillance.
- Clark *et al.* (68) used aerial IR-photography to estimate damage by diseases such as spot blotch of barley, crown rust and barley yellow dwarf virus of oats (BYDV), and powdery mildew of wheat in field plot experiments.
- In the early 1930s infrared plate-films were used in studies of virus diseases of potatoes and tobacco (Bawden).
- Blazquez & Edwards used IR-color photography and spectral reflectance for studies of tomato and potato diseases.

Examples of plant diseases detection by different optical sensors (Mahlein, 2016)

Sensor	Crop	Disease/Pathogen	Reference
RGB	Cotton	Bacterial angular (*Xanthomonas campestris*)	Camargo and Smith (2009)
		Ascochyta blight (*Ascochyta gossypii*)	
	Sugar beet	Cercospora leaf spot (*Cercospora beticola*),	Neumann *et al.* (2014)
		Sugarbeet rust (*Uromyces betae*)	
	Grapefruit	Citrus canker (*X. axonopodis*)	Bock *et al.* (2008)
	Tobacco	Anthracnose (*Colletotrichum destructivum*)	Wijekoon *et al.* (2008)
Spectral sensors	Barley	Net blotch (*Pyrenophora teres*)	Kuska *et al.* (2015)
		Brown rust (*Puccinia hordei*)	
	Wheat	Head blight (*Fusarium graminearum*),	Bravo *et al.* (2003), Moshou *et al.* (2004)
		Yellow rust (*Puccinia striiformis* f. sp. *tritici*)	
	Sugarbeet	Cercospora leaf spot (*C. beticola*)	Mahlein *et al.* (2010, 2012) Bergstrasse *et al.*
		Sugarbeet rust (*U. betae*)	

			(2015)
	Tomato	Late blight (*Phytophthora infestans*)	Wang *et al*. (2008)
Thermal sensors	Sugarbeet	Cercospora leaf spot (*C. beticola*)	Chaerle *et al*. (2004)
	Cucumber	Downy mildew (*Pseudoperonospora cubensis*)	Oerke *et al*. (2006), Berdugo *et al*. (2014)
Fluorescence imaging	Wheat	Leaf rust (*Puccinia triticina*),	Burling *et al*. (2011)
		Powdery mildew (*Blumeria graminis* f.sp. *tritici*)	
	Sugarbeet	Cercospora leaf spot (*C. beticola*)	Chaerle *et al*. (2007); Konanz *et al*. (2014)

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HYDRO-MULCH: A PROMISING TOOL FOR SUSTAINABLE AGRICULTURE AND ENVIRONMENTAL CONSERVATION

Article ID: AG-VO4-I06-13

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Abstract

Hydro-mulching offers a revolutionary approach to landscaping that combines efficiency with environmental consciousness. By blending a mix of water, seed, fertilizer, and protective mulch, this innovative technique jumpstarts the growth of lush greenery in record time. Unlike traditional methods, hydro-mulching delivers quick and uniform coverage, eradicating barren patches and promoting soil stabilization. With its ability to adapt to various terrains and climates, hydro-mulching stands as a beacon of sustainable landscaping, transforming dull landscapes into vibrant, thriving ecosystems.

Historical background of Hydromulching

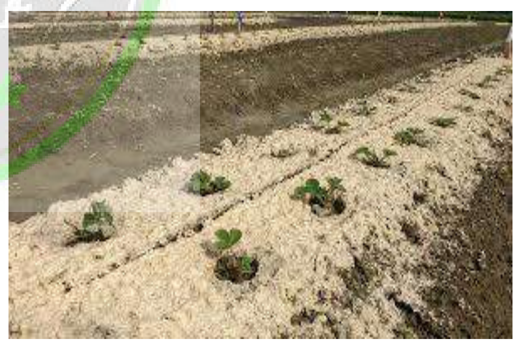
Maurice Mandell, a worker for the Connecticut Highway Department, developed hydro mulching in the late 1940s as a productive technique for seeding the sides of expressway embankments. An ambitious man named Charlie Finn promptly put it to use. He was the first to sell hydro-seeders for a profit. For the purpose of maintaining a steady stream of hydroseeding mixture at constant pressure, this early model combined mixing units with a spray unit (Country Green Turf Farms, 2019). One of the newest methods for planting grasslands is hydroseeding, which is well-recognized. Residential lawns, business spaces, sports fields, parks, slopes, and mountainous terrain are all being seeded with hydroseeding nowadays.

Plastic mulching vs Hydro-mulching

The use of plastic films for mulching has significantly improved agricultural yields. It is a major step towards maintaining the sustainability of agriculture, which is the foundation of our global food supply in the face of climate change and population growth (Kasirajan *et al*., 2012), especially in areas where environmental considerations and the availability of water are limiting variables.

Its ability to raise soil temperature is what led to the adoption of this approach in the 1950s. Increasing total crop yields, reducing soil erosion, and inhibiting weed growth are just a few advantages of these soil covers. Furthermore, mulches change the energy balance of the soil by influencing its temperature and structure, which creates a microclimate that maximizes the use of water and fertilizers.

Low-density polyethylene (LDPe), with its advantageous physical features such as flexibility, water resistance, heat and chemical resistance, impact resistance, and processability, is the material of choice for mulching (Kader *et al*., 2017). Furthermore, LDPe has a positive economic impact. Nevertheless, the usage of LDPe presents serious environmental issues due to its non-biodegradable nature, which creates problems and leads to trash accumulation and negative ecological effects, as well as the fact that its manufacture depends on fossil fuels. Because LDPe mulches are used excessively, significant volumes of plastic trash have accumulated and are causing environmental problems for agricultural ecosystems. Most of these mulches (around 80%) wind up in landfills or natural ecosystems after being used for the intended purpose. Plastic fragments from these waste items have been found in soils, water supplies, and even living things like humans. Hence, detrimental effects are observed in public health and as well as the environment.



The use of hydro-mulch in agriculture is one novel technique that has gained popularity recently. Hydro-mulches have been suggested as an LDPe-based plastic mulch substitute. A mixture of water, lignocellulosic material or polymers, and other additives appropriate for the specific application, known as hydro-mulch (Cline *et al.*, 2011) is applied as a liquid rather than a film to encourage the growth of vegetation on the soil surface. Hydroseeding, another name for hydro-mulch, is a similar process that has several benefits that can greatly assist modern agriculture.

Making of Hydromulch (Machnoor and Sujatha, 2023)

1. **Water:** This mixture's foundation, water acts as a medium for the germination of seeds and the early growth of plants.
2. **Mulch:** A protective covering that preserves moisture, stabilizes the soil and acts as a barrier against erosion, mulch is usually formed from a mixture of wood, paper, or straw.
3. **Seeds:** Select seeds, including those for grass or cover crops, are a crucial component of hydro-mulch and sprout inside the mulch layer.
4. **Additives:** These may include bonding agents or fertilizers that can be applied with the hydro-mulch so that the efficiency of mulch can still be improved.

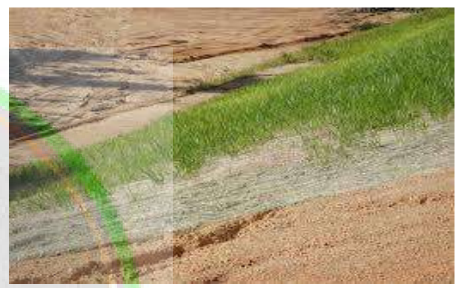
The advantages of hydro-mulch in farming

Erosion Control: One of hydro mulch's main advantages is its capacity to stop soil erosion. By acting as a shield, the mulch layer lessens the effects of wind and water, which have the potential to uproot soil and important nutrients. In agricultural areas that are hilly or sloping, this is especially crucial.

1. **Moisture Retention:** By keeping moisture in the soil longer, hydro-mulch lessens the frequency of irrigation. In addition to saving water, this makes the environment more stable and conducive to plant growth.
2. **Seed Germination:** The right conditions for seed germination are moisture, protection, and nutrients from additions. Plant growth is as a result healthier and more consistent.
3. **Soil Health:** By increasing the amount of organic matter and nutrients in the soil, hydro-mulch promotes soil health. Over time, the decomposing mulch nourishes the soil and increases its fertility.

Green Growth: Harnessing Hydromulch for Sustainable Environment

- **Reseeding:** Hydro-mulch serves as a carrier for seeds, providing them with a protective environment and a moisture-retaining medium for germination. The mulch component of hydro-mulch ***helps to stabilize the seeds and soil, preventing erosion and enhancing seed-to-soil contact***, which is essential for successful germination and establishment of vegetation.



- **Land Rehabilitation:** Eroded or degraded land often suffers from loss of topsoil, nutrient depletion, and reduced water retention capacity. Hydro-mulch formulations typically include organic materials such as wood fibers or paper mulch, along with a slurry of seeds, fertilizer, and soil stabilizers. When applied to degraded land, hydro-mulch forms a protective layer that prevents further erosion ***promotes soil aggregation, and creates a microclimate conducive to plant growth***. As vegetation establishes, it helps to restore soil structure, increase organic matter content, and enhance nutrient cycling, ***ultimately reclaiming the land for productive agricultural use.***
- **Slope Stabilization:** Steep slopes are particularly susceptible to erosion due to gravity, rainfall, and surface runoff. Hydro-mulch forms a protective barrier on sloping terrain, ***reducing the impact of rainfall and runoff, and minimizing soil displacement***. By

mitigating erosion and landslide risks, hydro-mulch contributes to the long-term stability and safety of agricultural landscapes.

- **Stabilization of streambanks:** Streambanks are prone to erosion due to the erosive force of flowing water, especially during periods of high flow or flooding. Hydromulch can be applied to streambanks to stabilize the soil, ***prevent erosion, and promote the establishment of riparian vegetation.***

- **Wildfire Rehabilitation:** Wildfires can cause severe damage to ecosystems, including loss of vegetation, soil erosion, and habitat destruction. Hydro-mulch can be used in post-fire rehabilitation ***efforts to stabilize burned areas, prevent erosion, and facilitate the regeneration of native vegetation.***

- **Dust Suppression**: Dust emissions from agricultural activities, construction sites, and unpaved roads can pose environmental, health, and safety hazards. Hydro-mulch can be applied to dusty surfaces to ***suppress dust emissions and improve air quality.*** The mulch component helps to bind loose soil particles together, reducing dust generation by wind or vehicle traffic.

- **Water Conservation:** Water scarcity is a growing concern in agriculture, particularly in arid and semi-arid regions where water resources are limited. Hydro-mulch formulations that include water-absorbing polymers or soil amendments can help to ***improve soil water retention and reduce the need for irrigation.*** Enhancing soil structure and increasing water-holding capacity, helps to conserve water, ***improve drought resilience, and sustain agricultural productivity in water-limited environments.***

CONCLUSION

In conclusion, hydro-mulch presents a viable way to establish a sustainable agricultural environment. Hydro-mulch lessens plastic waste, enhances crop development, and preserves soil health by substituting biodegradable mulches for plastic ones. Using hydro-mulch is a step toward a more environmentally friendly farming method that benefits the earth and agriculture's future. To guarantee a safe and prosperous environment for farming and beyond, let's keep researching and putting these cutting-edge techniques into practice.

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WEED MANAGEMENT IN DIRECT SEEDED RICE

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Introduction

Direct-seeded rice is an alternative cropping technique that should require less water and labour than the classical method of transplanted-flooded rice. Weed competition is the major biological constraint in this resource-conserving production technique reducing the crop yield by 30–80%. Though manual weeding is considered to be the best, undependable labour availability and escalating labour cost have given impetus to the development and use of new chemicals for weed control. In contrast to this, chemical weed management offers economic and efficient weed control if applied at proper dose and stage. But, intensive use of herbicides may result in the development of resistant weed biotypes, crop phytotoxicity and public health hazard. Amidst these concerns, adoption of any single approach remains both insufficient and ineffective for sustainable weed management in direct seeded rice and the present situation emphasizes integrated weed management practices for direct seeded rice. The study attempts to identify various sustainable options of the weed management economically and effectively to reap the benefits offered by direct seeded rice.

Keywords: Direct-seeded rice, economics, sustainable options, weed management

Rice (Oryza sativa L.) is a primary food crop grown widely over 161 million ha in more than 100 countries of the World and provides income and employment for more than 100 million households in Asia and Africa. Increasing water scarcity, rising production costs and labour shortage are threatening food production in conventional transplanted rice system resulting in a drastic shift to direct-seeding of rice. Direct-seeded rice (DSR) production system is subject to greater weed pressure than conventional rice transplanting systems, in which weeds are suppressed by flooding and transplanted rice seedlings have a "head start" over germinating weed seedlings. Direct seeded rice (DSR) cultivation needs only 34% of the total labour requirement and saves 29% cost of the transplanted rice. Direct-seeding is practiced in two major ways viz. wet-seeding and dry-seeding. In wet-seeded rice, pre-germinated seeds are broadcast onto the puddled soil. However, in dry direct-seeding of rice (dry-DSR), non-pre-germinated seeds are sown into dry-ploughed, unpuddled dry or moist soil. Uncontrolled weeds decreased the yield by 96 per cent in dry DSR and 61 percent in wet DSR. Any delay in weeding will lead to increased weed biomass which has a negative correlation with yield. Integrated weed management approach based on a critical period of crop weed competition, involving different direct and indirect control measures, has been developed and has to be adopted to overcome weed problem in direct-seeded rice sustainably.

Weed flora in Rice

About 350 species have been reported as weeds of rice, of which grasses are ranked as first followed by sedges and broadleaf weeds. Different rice ecosystems and cultural practices mostly determine dominant weed species/group, rice-weed competition and eventually, the weed control strategy. Changes in crop establishment, from transplanting to direct seeding also resulted in marked changes in the composition of weed flora. Adoption of direct-seeding technology may result in weed flora shifts towards more difficult to control and competitive grasses and sedges. The major weeds associated with the direct-seeded rice (DSR) were listed in the Table 1

Table 1. Major weeds in direct seeded rice fields in India.

S.No.	Scientific Name	Family
1	*Echinochloa colona*	Poaceae
2	*Echinichloa crusgalli*	Poaceae
3	*Digitaria setigera*	Poaceae
4	*Eleusine indica*	Poaceae
5	*Echinochloa glabrescens*	Poaceae
6	*Ischaemum rugosum*	Poaceae

7	*Digitaria ciliaris*	Poaceae
8	*Oryza sativa* (weedy rice)	Poaceae
9	*Leptochloa chinensis*	Poaceae
10	*Paspalum distichum*	Poaceae
11	*Cyperus iria*	Cyperaceae
12	*Cyperus difformis*	Cyperaceae
13	*Cyperus rotundus*	Cyperaceae
14	*Fimbristylis miliacea*	Cyperaceae
15	*Monochoria vaginalis*	Pontederiaceae
16	*Ipomoea aquatic*	Convolvulaceae
17	*Sphenoclea zeylanica*	Sphenocleaceae
18	*Ludwigia octovalvis*	Onagraceae
19	*Ludwigia adscendens*	Onagraceae
20	*Eclipta prostrate*	Asteraceae
21	*Commelina benghalensis*	Commelinaceae

WEED MANAGEMENT OPTIONS IN RICE

Preventive Methods

Prevention of weed seed dispersal

Prevention, the most basic of all weed control methods, restricts introduction and spread of weeds. Prevention aims more at minimizing weed seed banks and check the entry of new weeds in crop fields to prevent further infestation. The key weed species of rice are often dispersed through natural means (animal, human, mechanical, etc.). Preventive measures compliment curative tactics like the use of herbicides by restricting weed dispersal and preventing weed seed bank build up.

Prevention of crop seed contamination with weed seeds

Rice seed contaminated with weeds is one of the major causes of weed infestation, especially in direct seeded rice. On average, 466 weed seeds/kg rice seeds including 314 weedy rice seeds, which is forty seven -fold higher than permitted national purity level were observed in Vietnam. An important rice weed, *Leptochloa chinensis* has reportedly been introduced in northern Italy through contaminated seeds. The prevention of weed seed contamination in DSR becomes more important than in TPR as a higher seeding rate is used per unit of the area under DSR.

Cultural methods

Stale seed bed Practicing

Stale seed-bed (SSB) after one and two irrigations with a successive application of herbicides reduced weed density by 44–68% and 77–85%, respectively, over a control in India. The weed seed bank depletion due to SSB provides a less competitive environment for rice during the initial stage.

Field preparation

The seedbed preparation under DSR, includes one or two deep ploughing through disc followed by a cultivator, 2–3 harrowing, breaking up big clods and land leveling. Good land preparation provides a weed-free seedbed, which reduces weed densities by up to 49%, saves labour for manual weeding.

Increasing crop competitiveness

The crop growth is favored by selection of cultivars, adjusting plant geometry, seed rate and spacing, would give an initial advantage for competing against weeds.

Seed priming

Higher and synchronized emergence of primed seeds can ensure vigorous crop stand with rapid canopy development giving rice plants a preliminary advantage over weeds. A robust seedling stand obtained from primed seeds enhanced rice competitiveness against weeds and improved tolerance to environmental stress.

Crop rotation

By its nature, crop rotation disrupts regeneration niches of weed species and prevents the build-up of adapted weed species. Rotating rice with mungbean was effective for weedy rice control because volunteer rice seedlings failed to survive in mungbean. Rotation combinations of 25 crops reduced weed density compared to monoculture.

Seeding density

Seeding density of crop determines solar radiation interception, canopy coverage and biomass accumulation which have a cumulative effect on its weed suppressive ability. Higher seeding rate develops a canopy rapidly and consequently suppresses weed more effectivety, and in contrast, the lower seeding rate results in sparse stands and encourage weed growth. Its is reported that *Echinochloa crussgalli* and *Leptochloa chinensis* densities were reduced at higher rice seeding rates of 200 kg/ha and 100 ka/ha, respectively.

Physical method

Hand weeding Hand weeding is very easy and environment-friendly but tedious and highly labour intensive, and; thus. is not an economically viable option for the farmers. It has been estimated that 150-200-labour-day/ha are required to keep rice crop free of weeds. Moreover, morphological similarity between grassy weeds and rice seedlings makes hand weeding difficult at the early stages of growth.

Mechanical weeding

Mechanical weeding had the advantage of economical, nonpolluting without residual problems and it is relatively safe for the operator. It has been reported that rotary weeder weeding had the advantage of 10.9% of increased crop yield/ha rather than using hand weeding.

Chemical method

Herbicides provide superior weed control and are more labour efficient than manual or mechanical methods of weed management. A list of some promising herbicides used in direct seeded rice field with their active ingredients, application time and target weed groups has been presented in Table 2.

Table 2. Promising herbicides used in direct seeded rice cultivation

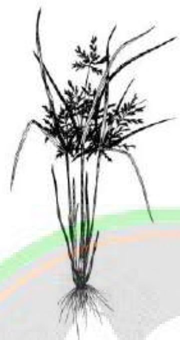
Herbicides	Time of Application (DAS)	Dose	Application	Targeted control
Pendimethalin	0-3	1000 g a.i/ha	Pre-emergence	Annual grasses and broadleaved weeds.
Oxadiargyl	3-5	100 g a.i/ha	Pre-emergence	Annual grasses, sedges and some broad leaved weeds.
Pyrazosulfuron	0-3	20 g a.i/ha	Pre-emergence	Broad leaved and sedges.
Bispyribac sodium	10-14	25-30 g a.i/ha	Contact herbicide for early & post	Broad spectrum of weed control except

			emergence application	*Leptocholoa chinensis* .
Chlorimuron+ metsulfuron	0-310-14	4 g a.i/ha	Pre-emergence and early post emergence	Broad leaved and sedges.
Bensulfuron methyl	6-10	300-500g a.i/ha	Pre-emergence and early post emergence under wet/standing water conditions	Effective against almost all annual and perennial broad leaved weeds and some sedges during.
Cyhalofop butyl	10-14	100 g a.i/ha	Early post emergence herbicide	Effective against E. crusgalli and L. chinensis until four leaf stage. Tank mixed with Sulfonyl urea gives wide spectrum of weed control.
Penoxsulam + cyhalofop butyl	6-10	12.5 g + 62.5 g a.i/ha	Early post emergence herbicide	Effective against E. crusgalli, L. chinensis, C. iria, F. miliacea and C. difformis under saturated condition.

Integrated weed management approach

Integration of diverse technologies is essential for weed management because weed communities are highly responsive to management practices and environmental conditions. Various weed control methods for DSR have been assessed, but complete reliance on one strategy fails to provide full control for weeds. A higher seed rate and fertilizer for stimulating initial growth, later on, limits the herbicide as an effective weed management approach. Under DSR, stale seedbed followed by retention of crop residues followed by applications of early and late post emergence herbicides can substantially reduce weed densities. Sequential application of pre and post-emergence application of pendimethalin and bispyribac-sodium herbicides integrated with hand weeding resulted in better yield and economics in DSR. Further, Integration of pretilachlor (PE) either with one hand weeding at 30 DAS or with brown manure through Sesbania aculeata or Sesbania rostrata provided desirable weed management during the critical growth period of DSR.

Leptochloa chinensis



Cyperus iria

Echinochloa crusgalli

Cyperus difformis

Eclipta prostrata

Echinochloa colona

Conclusion

Integrated approaches are suggested for sustainable weed control in direct-seeded rice, such as the use of clean certified seeds, higher seeding densities, cultivation of competitive variety, stale seed-bed preparation, crop rotation along with a rotation of herbicides with different mode of actions followed by manual weeding and rouging after mid-stage of rice growth. Need-based chemical weed management through herbicide, herbicide mixtures identification of new herbicides against a wide spectrum of weeds, and use of herbicide tolerant rice, would help in achieving a long-term and sustainable weed control in DSR. Judicious mix of more than one method is warranted to keep the weeds under control for higher productivity in direct-seeded rice cultivation.

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MINING OF SOIL POTASSIUM UNDER INTENSIVE CULTIVATION: A REVIEW

Article ID: AG-VO4-I06-15

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Abstract

Potassium mining or negative balance between the K input and output, results, when the crop K removal and K losses to other sinks becomes higher than the supply. A negative input output balance in the soil will eventually limit crop yield, facilitate nutrient mining and results in the depletion of soil K fertility. Crop residues contain a significant amount of K that is recycled back to the soil on decomposition. Experimental evidences suggest that restoring the fertility status of a soil is a much costlier process than maintain the inherent fertility status through external application of nutrients in a balanced proportion as per the need of the crop or cropping sequences.

Key words: Crop residues, Cropping sequences, Input -output balance, K removal

Introduction

The potassium (K) requirement of crops, by and large, is as high as that of N, causing its substantial removal from the soil through harvested plant parts, especially under intensive cultivation without adequate K input (Das *et al.* 2020). The N: P_2O_5: K_2O consumption ratio in 2019–2020 was 6.96:2.79:1 in India, and it has remained tilted towards N and P (more towards N between N and P) over the last many years despite the average crop uptake pattern hanging around 1.0:0.3:1.3 (FAI 2020). Apart from the inadequate application rates, the common practice of removing crop residues from fields further aggravates the problem of K mining in Indian soils, as crop removal is the most significant output in K balance equations (Sanyal *et al.* 2014).

Removing crop residues from fields accelerates nutrient depletion, especially K depletion (Goulding *et al.* 2021).

Negative K balance in agricultural fields is a threat to food security in India and most of the developing and several developed nations (Lu et al. 2017). Soil K depletion has been marked as one of the main reasons behind crop yield stagnation and poor nutrient use efficiency in present-day intensive cultivation. If allowed to go unchecked, soil K mining will eventually deteriorate soil health in general, soil K fertility in particular, and ultimately jeopardize agricultural sustainability as a whole. In the present article, an attempt has been made to briefly discuss the status of soil K mining in India under major crops and cropping systems, causes of mining in soil, and the strategies to be undertaken by today's researchers and farmers to mitigate the crisis of rapid K depletion and associated soil health deterioration.

Reasons behind soil K mining in India

Mining of soil K in agricultural lands occurs when K balance is negative, i.e., removal by the harvested portion of crops exceeds the external K input, including the K recycled back to the ground with crop residues (Sanyal *et al*. 2014; Majumdar *et al*. 2017). In India, the removal of K is more or less equivalent to uptake for field crops as their residues are mostly removed from the fields after harvesting. Crop residues and animal excreta (e.g., cowdung) generally find use as a source of energy for cooking and heating in rural areas, rather than recycling them back to the fields . Crop residues have plenty of other uses in rural households in India, prompting their removal from the crop fields (Sanyal *et al*. 2014). On top of that, K fertilization is nil or severely inadequate in many parts of the country, including the intensively cultivated areas . Though local recommendations advocate proper balance among N, P, and K fertilizers, most farmers opt for N only or N and P with little or no K fertilizer (Sanyal 2014a).

Soil K mining under major crops and cropping systems

Averaged over all crop groups of India, Tewatia *et al.* (2017) calculated a net balance (unit area basis) of − 42.2 kg K_2O ha^{-1} for 2015–2016. Negative K balance was highest for sugarcane followed by fruits and lowest for oilseed (Fig. 1). The negative balance for cereals was near the average of all crop groups since cereals account for the most significant portion of GCA in India (Anonymous, 2019)

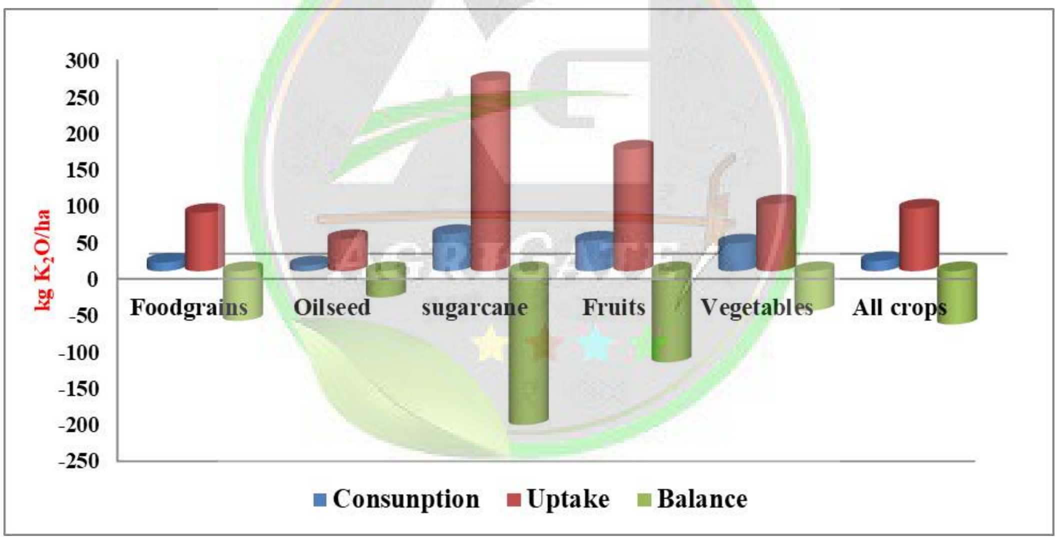
Consequently, cereal crops have the most significant impact on the K balance in Indian agriculture. On-farm studies (trials conducted at farmers' fields) on major cropping systems conducted under the aegis of AICRP-IFS across India indicated that K among the primary nutrients is the most neglected in the fertilization schemes followed by farmers (Table-1). Those studies recorded large negative K balances under farmers' fertilizer practices (FFP) irrespective of cropping systems. Interestingly, existing state recommendations (SR) were also not able to prevent soil K mining. However, for most of the cropping systems studied, K mining under FFP was slight to extensively higher compared with SR. Application of deficient secondary and micronutrients along with state recommended NPK (SR+M) caused greater mining of K due to an increase in yield and associated K uptake (Table-1)

Table-1: Nutrient use and removal at cultivator's field.

Cropping system/ locations	Treatment	Nutrient addition (kg ha^{-1})			Nutrient removal (kg ha^{-1})			Nutrient balance (kg ha^{-1})		
		N	P	K	N	P	K	N	P	K
Rice-wheat U.P. (24)	FFP	206.0	28.4	0.0	133	22.0	150	73	6.4	-150.0
	SR	220.0	48.0	74.7	186	35.0	160	34	13.0	-85.3
	SR+ M	220.0	48.0	74.7	204	40.0	174	16	8.0	-99.3
Rice-rice A.P. (24)	FFP	298.0	60.3	70.6	168	47.0	172	130	13.3	-101.5
	SR	240.0	52.4	66.4	185	52.0	189	55	0.4	-135.6
	SR+ M	240.0	52.4	66.4	199	56.0	202	41	-3.6	-135.6
Peralmillet-mustard Gujarat (18)	FFP	114.0	37.1	00.0	171	45.0	104	-57	-7.9	-104.0
	SR	130.0	39.3	54.0	193	51.0	116	-63	-11.7	-62.1
	SR+ M	130.0	39.3	54.0	200	54.0	122	-70	-14.7	-65.1
Peralmillet-wheat Gujarat (18)	FFP	130.0	34.9	0.0	129	28.0	65	1.0	6.9	-65.0
	SR	200.0	43.7	83.0	194	43.0	95	6.0	0.7	-12.0
	SR+ M	200.0	43.7	83.0	200	44.0	101	0.0	-0.3	-18.0
Maize-chickpea Karnataka (24)	FFP	80.0	38.0	0.0	138	26.0	133	-58	12.0	-133.0
	SR	110.0	32.8	20.8	142	28.0	169	-32	4.8	-148.3
	SR+ M	110.0	32.8	20.8	156	32.0	181	-46	0.8	-160.3

Rice-greengram W.B. (18)	FFP	52.5	26.6	34.0	130	22.0	129	-77.5	4.6	-95.0
	SR	100.0	34.9	66.4	138	26.0	161	-38.0	8.9	-94.6
	SR+ M	100.0	34.9	66.4	148	29.0	176	-48.0	5.9	-109.6
Maize-wheat H. P. (18)	FFP	50.0	14.0	21.6	678	17.0	53	-18.0	-3.0	-31.4
	SR	170.0	37.6	58.1	130	30.0	89	40.0	7.6	-30.9
	SR+ M	170.0	37.6	58.1	135	33.0	97	35.0	4.6	-38.9
Cotton-pearlmillet Gujarat (18)	FFP	202.0	37.8	0.0	287	46.0	85	-85.0	-8.2	-85.0
	SR	320.0	43.7	83.0	324	52.0	91	-4.0	-8.3	-8.0
	SR+ M	320.0	43.7	83.0	378	53.0	102	-58.0	-9.3	-19.0
Source: AICRP-IFS Reports (2011-12)										

Fig. 1: Potassium Mining Under Major Crops



Major causes of K mining

1. Inadequate K fertilization compared to crop removal over a very long period of time

Potassium (K) use has been inadequate over the past decades K consumption was 0.5 kg K_2O ha^{-1} 1965-66 which increased to about 12.0 kg K_2O ha^{-1} in 2015-16 which is 9% of the total per hectare NPK consumption in 2015-16. Crop uptake is much higher than the K addition through fertilizer leading to large K removal from the soil. According to recent estimates, the net annual K removal by crops was 10.3 Mt against K consumption of 1.7 Mt during 2015-16, leading to net negative balance of 8.6 Mt of K_2O at national level (Tewatia *et al.*, 2017) .As per hectare basis, the net negative balance is 34.2 kg and it varied from 14.7 kg in pulses to 121.2 in sugarcane. Such a large negative K balance is a major threat to soil health and agricultural sustainability.

The nutrient input : output ratio (Nutrient Depletion Factor)

It's provided a measure as to whether and to what extent nutrient uptake exceed the addition. it provides gross estimates of possible depletion. The K depletion factor calculated across 10 major rice –wheat growing regions of India showed an input : output ratio of more than 1.0 at all locations (Table -2). An NDF of more than 1.0 thereby suggesting nutrient mining at 4 of 10 locations for P_2O_5 while at all locations mining of K_2O and S occurred. Data pertaining to depletion of nutrients from the soil reserves indicates that K mining is the most severe. It is very likely that on a long term basis these soil contributions will decrease due to soil mining of nutrients.

Table-2: Nutrient Depletion Factor (NDF) and nutrient uptake from soil reserve under rice wheat system with BMPs

Location	Rice-wheat system yield (t ha-1)	Nutrient Depletion Factor			Depletion of soil nutrients from soil reserve (kg ha^{-1})		
		P_2O_5	**K_2O**	**S**	**P_2O_5**	**K_2O**	**S**
Sabour	13.8	1.74	1.86	1.2	88	261	42
Ranchi	10.4	0.73	1.09	2.04	63	205	41
Ludhiana	16.1	1.36	2.29	2.07	126	354	58
Palampur	9.8	1.7	1.83	1.35	74	226	36
R. S. Pura	1.2	.67	1.71	1.48	94	301	45
Faizabad	12.3	0.97	1.52	1.48	80	252	39
Kanpur	14.6	1.03	1.48	2.27	66	247	43
Modipuram	16.7	1.98	1.63	3.5	100	294	58
Varanasi	12.1	1.35	1.50	1.6	65	221	38
Pant nagar	12.4	0.77	1.45	2.02	67	220	42
Average	**13.1**	**1.2**	**1.60**	**1.9**	**82**	**258**	**44**
Normalized NDF when input = output		1	1	1	67	158	23

BMPs = Best management practices Sources : Tiwari *et al.* (2006)

2. Removal of crop residues

Crop residues contain a significant amount of K that is recycled back to the soil on decomposition. Crop residues containing 1% or more K, e.g., rice straw (~ 1.75% K), wheat straw (~ 1% K), sugarcane bagasse (~ 1.2% K), oat straw (~ 1.5% K) can serve as a sustainable alternative source of K in agriculture (Basak and Sarkar, 2017). After harvesting grain crops, around 50–70% of total biomass is left as residues, which would add a substantial amount of K therein if returned to the soil. However, decomposition and subsequent release of nutrients from straw are time-taking processes in the field, so the positive effects of straw-return on soil K status and crop yields may not be visible over short term periods. Nevertheless, over the long term, straw-return could alleviate soil K depletion under intensive cropping, enhance soil K status and increase crop yields (Zhao *et al*. 2014). Crop residues could be directly incorporated into the soil, converted to compost or biochar before soil application, or retained on the surface as a part of conservation agriculture to use them as K source (Katyal, 2020). However, crop residues have several uses namely fuel, cattle feed, thatching of roof in rural areas and as packing materials. Therefore, complete recycling of such residues in the field does not seem to be possible. Such recycling cannot replace the K completely which is removed from the field during the crop harvest. Buresh *et al.* (2010) suggested that the retention of rice residues in continuous rice-rice system is a must for maintaining a positive K balance. The K balance was found to be positive only at 100% residue retention. The K balance was negative at 15-40 % residue retention, which is the prevailing situation in India.

3. Perception of potassium – rich Indian soils

K supplying capacity of a soil depends on the parent materials of soil with K being present as a structural component of mica and feldspar, two major K bearing minerals. The structural K from these minerals especially mica, is partially released during transformation of these primary minerals to clay minerals by weathering. K status will be very low on primary minerals degradation. Further, the rate of K release from the K bearing minerals fails to keep pace with the k demand by growing crops, at the critical crop growth; some of the released K may be lost through leaching or may get re-fixed in the soil mineral. The above discussion suggests that even if the soil contains enough potassium, its release may not be adequate to meet the crop demand or the release of K from K bearing minerals in the soil may not synchronize with the crop demand

Conclusions

- K balance remained largely negative for a long in most states and all dominant cropping systems in India, primarily due to negligence towards K application through fertilizer or other sources.
- There is need to develop strategies and polices to boost K supplies and if this essential continuous to remain neglected in this country as in the past, future sustainability is of agriculture is likely to be constrained mostly by this nutrient.
- The key in promotion balanced fertilization is to make the K fertilizer affordable and accessible to the farmers.
- Application of adequate K input through either commercial fertilizer or alternative sources like crop residues, manures, and K-rich minerals, or their suitable combination, must be made to meet the crop demand under intensive cultivation to boost up crop yields, maintain soil health, and fetch more farm income in the long run.

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BIOLOGICAL CONTROL – SOIL SUPPRESSIVENESS TO PLANT DISEASE

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Abstract

Soil suppressiveness, categorized into general and specific types, stems from the microbial communities within soils, hindering plant disease development. General suppression relies on overall microbial biomass, boosted by organic matter like composts. Specific suppression involves certain microbial species combating specific pathogens. Mechanisms include antagonistic microorganisms, nutrient competition, induced plant resistance, antimicrobial compound production, and soil chemistry changes. Crucial for sustainable agriculture, soil suppressiveness cuts chemical reliance, saves costs, fortifies against disease outbreaks, and preserves the environment. Development hinges on factors like initial pathogen load, microbial dynamics, soil health, crop rotation, and management practices. Biological control agents—Trichoderma, Bacillus species, mycorrhizal fungi, predatory organisms, compost, plant extracts, and microbial inoculants—enhance suppressiveness. Understanding these mechanisms is vital for sustainable disease management, fostering reduced chemical usage, environmental health, and long-term agricultural productivity.

Keyword: - Suppressiveness, Antagonistic, Trichoderma, Bacillus, Mycorrhizal

Introduction

Soil suppressiveness refers to the soil's natural tendency to suppress or prevent the development of certain kinds of plant diseases. This phenomenon is caused by a combination of elements in the soil, including microbial communities, organic matter content, chemical qualities, and physical characteristics. Soils are rich supplies of bacteria that are hypothesized to assist plants suppress diseases by increasing plant health, inducing natural plant defense, producing antibiotics, competing with pathogens, or hyper parasitizing them. Suppressive soil is an appealing bio-control approach since it has the ability to be maintained over multiple seasons under ideal conditions.

Definition

Soil that suppresses crop disease due to the specific structure of its microbial community is known as disease-suppressive soil.

Suppressive soil can be of two types like

General soil suppression and

Specific soil suppression.

General soil suppression involves maintaining high microbial biomass in the soil to protect against various diseases. This relies on the quality and quantity of soil organic matter, such as composts, green manures, and cover crops, which provide nutrients to increase beneficial bacteria that colonize and protect plant infection sites.

Specific suppressive soil has a high concentration of certain microbial species that offer strong protection against particular pathogens. The treatment of wheat's take-all disease, caused by Guamanomyces graminis var. tritici, exemplifies this specialized soil suppression and is a key model for bio-control research.

Several mechanisms contribute to soil suppressiveness

Antagonistic Microorganisms: Beneficial microorganisms such as bacteria, fungus, and actinomycetes can directly combat plant diseases by competing for resources, producing antibiotics, or inducing systemic resistance in plants.

Nutrient Competition: Soil suppressiveness can also arise from nutrient competition, where beneficial microorganisms out compete pathogens for vital nutrients, thereby restricting their growth and spread.

Induced Resistance in Plants: Some microorganisms can induce systemic resistance in plants, making them more resistant to pathogen attack. This enhanced defense mechanism helps plants withstand diseases.

Production of Antimicrobial Compounds: Soil microorganisms generate diverse antimicrobial substances like antibiotics and volatile organic compounds, which hinder the proliferation of plant pathogens.

Changes in Soil Chemistry: Changes in soil pH, organic matter levels, and nutrient availability can also impact soil suppressiveness, directly or indirectly influencing pathogen survival and plant well-being.

Microbial Diversity: Greater microbial diversity in soil often corresponds with enhanced suppressiveness. Diverse microbial communities offer a wider array of antagonistic mechanisms against pathogens, contributing to soil health.

Needs of Soil Suppressiveness

Soil suppressiveness describes the innate capability of soil to restrain or manage the proliferation and impact of soil-borne pathogens, pests, or diseases. This phenomenon is vital for sustaining the vitality and yield of plants across agricultural, horticultural, and natural environments.

Implementing soil suppressive practices reduces the need for chemical pesticides, fungicides, and fertilizers, resulting in significant cost savings and enhancing the economic viability of farming operations. By leveraging natural disease and pest control mechanisms, soil suppressiveness promotes sustainable agriculture, maintaining soil health and biodiversity, and reducing environmental degradation for long-term ecosystem balance.

Soils with suppressive properties help crops withstand disease outbreaks, reducing crop damage and yield losses, ensuring stable food production and security. Soil suppressiveness encourages the growth of beneficial microorganisms, such as bacteria, fungi, and nematodes, which compete with pathogens, improving overall soil health and fertility. Maintaining soil suppressiveness ensures long-term agricultural productivity by fostering healthy soils with natural disease control, supporting consistent plant growth and yield stability. Reducing chemical pesticide and fertilizer use through soil suppressiveness mitigates environmental pollution and protects surrounding ecosystems, promoting cleaner water, richer biodiversity, and a balanced ecosystem.

Suppressive Soils in Plant Disease Management

The occurrence of disease suppressive soils has been extensively documented for various plant-pathogen systems globally, as listed in the table. Among these systems, soils suppressive to

Fusarium wilts caused by F. oxysporum or take-all of wheat caused by G. graminis var. tritici have been particularly well-studied across diverse geographic regions.

Sl. No	Pathogen involved	Reference
1	Cyst nematode Heterodera spp.	Kerry 1988; Westphal & Becker, 1999
2	Streptomyces scabies	Menzies, 1959
3	Fusarium oxysporum	Stotzky & Martin, 1963; Scher & Baker, 1980
4	Gaeumannomyces graminis var. tritici	Cook & Rovira, 1976
5	Phytophthora cinnamomi	Broadbent & Baker, 1974
6	Plasmodiophora brassicae	Murakami et al., 2000
7	Pythium spp.	Hancock, 1977
8	Rhizoctonia solani	Henis et al., 1978, 1979

How Long does it take for a Soil to Become Suppressive?

The time it takes for soil to become suppressive can vary widely depending on several factors, including the initial conditions of the soil, the type and quantity of organic residues introduced, environmental factors, and management practices. The duration will depend on the conditions and the return of organic residues. Natural suppressiveness is frequently associated with the physical properties of soils and is relatively independent of crop history.

Induced suppressiveness is wholly dependent on agricultural practices. Some soil-borne pathogens may be more persistent or adaptable to changes in soil conditions, requiring longer periods to achieve effective suppression.

Biological Control Agents uses in Soil Suppressivenesss

Biological control agents (BCAs), including microorganisms and macro-organisms, are essential for soil suppressiveness, actively targeting soil-borne pathogens, pests, and diseases. When specific nutrients are present, soil microbial communities grow and evolve into specialized networks. Studies show that soil amendments with green manure, stable manure, or compost effectively reduce diseases caused by soil-borne fungi like Pythium spp., Phytophthora spp., and Rhizoctonia solani.

T. atroviride T. hamatum T. harzianum

Some common biological control agents used to enhance soil suppressiveness:

Beneficial microorganisms

1. **Trichoderma spp.**: These fungi are well-known antagonists of various soil borne pathogens. They can colonize plant roots and outcompete pathogens for resources, as well as produce antifungal compounds.
2. **Pseudomonas spp.:** Certain species of Pseudomonas bacteria are effective bio-control agents against soil-borne pathogens. They produce antibiotics and enzymes that inhibit pathogen growth..
3. **Bacillus spp.:** Bacillus species are known for their production of antibiotics and enzymes that suppress pathogens. They can also enhance plant growth and trigger systemic resistance. Considered prominent bio control agents or bio pesticides, Bacillus species contribute to pathogen suppression through antagonism and competition.
4. **Mycorhizal fungi** Mycorrhizal fungi extend the effective root surface area of plants by forming a network of hyphae that can access nutrients beyond the root zone. By increasing nutrient uptake, especially for phosphorus and nitrogen, mycorrhizal fungi contribute to improved plant health and vigor, making plants more resilient to diseases. They produce glomalin, a glycoprotein that helps bind soil particles together, improving soil structure and stability. Enhanced soil structure promotes better water infiltration and retention, as well as aeration, which creates a healthier root environment and reduces plant stress, making them less susceptible to diseases.

   Mycorrhizal fungi compete with pathogenic microorganisms for space and nutrients in the rhizosphere. Mycorrhizal colonization can induce systemic resistance in plants against pathogens. Mycorrhizal symbiosis triggers the plant's defense mechanisms, leading to the production of defense compounds, such as phytoalexins and pathogenesis-related proteins, which enhance the plant's ability to resist diseases. Some mycorrhizal fungi produce antimicrobial compounds that inhibit the growth of soil-borne pathogens directly. Mycorrhizal colonization can increase plant tolerance to various stress factors, including biotic stress caused by pathogens. Certain mycorrhizal fungi produce allelopathic compounds that suppress the growth of competing microorganisms, including pathogens.

Predatory or Parasitic Organisms:-

1. **Predatory nematodes**: Certain nematode species, such as the bacterivorous or fungivorous nematodes, prey on soilborne pathogens, reducing their populations.
2. **Predatory mites**: These arthropods feed on soil-dwelling pests like root-feeding nematodes and small insects, helping to control their populations.
3. **Parasitic nematodes**: Some nematodes are parasitic to insect larvae and can be used as biological control agents against soil-dwelling pests like root maggots or cutworms.

Other Method

Compost and organic amendments can promote the growth and activity of beneficial microorganisms in the soil, enhancing soil suppressiveness. They also improve soil structure and fertility, indirectly contributing to disease suppression. Certain plant extracts and essential oils possess antimicrobial properties and can be used as natural fungicides or bactericides. When applied to soil, they can suppress soilborne pathogens and contribute to soil suppressiveness.

Conclusion

Soil suppressiveness is a crucial natural method for managing plant diseases by utilizing the interactions within soil microbial communities, organic matter, and soil chemistry. It provides a sustainable, long-term solution for plant disease control, minimizing the need for chemical inputs and promoting environmental health. Enhancing beneficial microorganisms, such as Trichoderma spp., Pseudomonas spp., Bacillus spp., and mycorrhizal fungi, is key to both general and specific soil suppressiveness. These microorganisms outcompete, antagonize, or directly inhibit pathogens through nutrient competition, antibiotic production, and inducing systemic resistance in plants. The use of biological control agents, predatory organisms, composting, organic amendments, and plant extracts further supports suppressive soils. By adopting these principles, farmers can achieve effective disease control, reduce crop losses, enhance soil fertility, and contribute to food security and environmental conservation.

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JACK- THE KING OF INDIA

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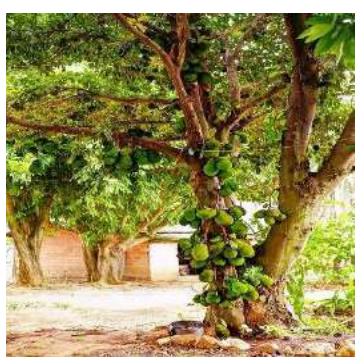
Introduction

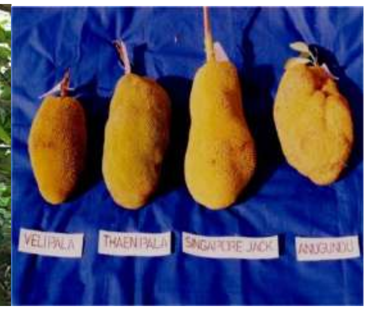
The jackfruit is indigenous to India. It is poor man's food in the eastern and southern parts of India. A rich source of vitamin A, C, and minerals, besides supplying carbohydrates. Tender jackfruits are used as vegetable and the skin of the fruit and its leaves are excellent cattle feed. Its timber is valued for furniture making since it is rarely attacked by white ants. The latex from the bark contains resin. Canning of flakes can be done. The jack is grown in Bangladesh, Ceylon, Burma and Malaya and also in Brazil. Assam has the largest area of 10,000 hectares followed by Bihar, Kerala and Tamil Nadu.

Varieties

Being a cross-pollinated and mostly seed propagated, its innumerable types of fruits differ widely in density of spines, rind, bearing, size, shape, quality and period of maturity. There are 2 broad groups of cultivated types—soft-fleshed and firm-fleshed. Rudrakshi has common pumello-sized fruits with smooth rind and less spines.








PKM-1 Jack

- Clonal selection from germplasm maintained at HC&RI, Periyakulam
- Regular and off season with cluster (3-4 fruits/cluster), bearing habit (106.6 fruits/tree/year)
- Bears twice in a year during Mar –May & Nov- Dec
- Large sized fruits (21.49 kg), high TSS (24.6 ^{o}Brix) and pleasant aroma
- Long and crispy flakes
- High yield (2.29 tonnes/tree; 237.36 t/ha /year)
- Harvesting starts from 4-5th year and economic yield from 8th year onwards.
- Flakes contain high calcium (32.74 mg/100 g), potassium (463.55 mg/100 g), iron (1.1 mg/100 g), zinc (2.18 mg/100 g), vitamin A (310.74 IU) and TSS (24.6 ^{o}Brix).
- Grown in tropical and subtropical regions
- Suitable for preparation of dessert, RTS, Jam, Jelly, Squash, Pickle, Chips, Noodles, Halwa and Seed powder incorporated cookies


PLR -1

- Clonal Selection from Panikkankuppam local
- Bears twice in a year (April-June & Nov-Dec)
- High yield (80 fruits/tree)
- Sweet carpels with attractive yellow colour
- Recommended for home gardens & High Density Planting
- Year of release – 1992.

PLR-2

- ❖ Clonal Selection from Pathirakkottai local
- ❖ High yield (107 fruits/tree) with medium tall trees
- ❖ Suitable for high density planting
- ❖ Vary sweet and non sticky carpels (TSS-20° brix)
- ❖ High palatability
- ❖ Good keeping quality
- ❖ High consumer preference
- ❖ Year of release – 2007

PLR-3 (2021) Gumless Jack

- ❖ Parentage: Selection from Pudhukoorapettai Local
- ❖ Duration: Perennial
- ❖ Season: June – December
- ❖ Yield:212 fruits/ tree/ year (1060 kg)
- ❖ Highest yield obtained: 300 Fruits / Tree
- ❖ Varieties compared and percentage of increase in yield over check: Almost similar to Palur.

PPI- 1

This variety was released from HRS, Pechiparai. Tree produces 105 fruits, each fruit weighs 17 kg, also bears in two seasons *viz*., April-June and November-December and produces high quality crisp carpels with more TSS and ascorbic acid content. The flakes are sweet and tasty with pleasant aroma.

Singapore or Ceylon Jack

Introduced in Tamil Nadu in 1948, precocious (2.5 to 3 years), fruit are medium size (7 to 10 kg), flesh sweet, crisp, carpels compact, yellow and firm with strong aroma.

Hybrid Jack (Singapore Jack x Velipala)

Fruits resemble Singapore Jack with bigger carpels and taste.

Research station	Varieties
Horticultural and Agro Forestry Research Programme (HARP), Ranchi	Khajwa, Swarna Monohar, Swarna Poorti
NDUAT, Faizabad	NJ-1, NJ-2, NJ-3 and NJ-15
HRI, Saharanpur	Safeda, Khaja, Bhusila, Bhadaiyan Handia
FES, Burliar	T-Nagar Jack
FES, Kallar	Velipala
Assam Agricultural University, Jorhat	Mammoth, Ever bearer, Rose Scented

Climate

It grows well in a warm, humid climate up to an elevation of 1,500m. In south India, it performs satisfactorily in arid and warmer plains. However, it cannot tolerate cold and frost. It grows in the arid region and up to an elevation of 1500 m, but quality gets affected at higher elevations (Samaddar, 1985).

Soil

Jackfruit can be grown on a wide variety of soils but it grows well in a rich, deep, alluvial and well-drained soil. It can also be grown on open textured or lateritic soil with sufficient nutrients. It is preferred in homesteads, as a shade-tree or as a mixed crop.

Propagation

Krishnaswamy (1990) found moisture content of seed to be that most guiding factor for germination and reported that the freshly extracted seeds of jackfruit had a moisture content of 62 per cent (0 day) showed 100 % germination. For seed propagation, soaking of seeds in 25 ppm solution of NAA for 24 hours resulted in the highest germination percentage as well as good seedling growth (Sinha and Sinha, 1968).

Planting

Vishal Nath *et al*. (2002, 2004) recommended 10 x 10 m spacing in square system under eastern Indian conditions.They also recommended that each pit should be filled with 20-30 kg well rotten FYM and 2 kg neem cake along with 100g of NPK mixture.

Training and pruning

Vishal Nath *et al*. (2002) recommended that initial frame of tree decides the productivity of plants in due course of time. Do not allow any lateral branches up to 1-1.5 m height after that 3-4 well spaced branches in all direction should be permitted. In aged trees, light to medium pruning can be given to remove overcrowded branches without affecting yield (Muthulakshmi, 2003).

Manures and fertilizers

The manures and fertilizers should be applied in two splits during May - June and September - October.

Manures & Fertilizers	**1 year old**	**Annual Increase**	**6th year and above**
FYM	10.000	10.000	50.000
N	0.150	0.150	0.750
P	0.080	0.080	0.400
K	0.100	0.100	0.500

In India, a fertilizer schedule for jackfruit has been developed at HARP, Ranchi (Vishal Nath *et al*., 2002). Application of 20-50 kg well rotten FYM, 100g urea, 200g SSP and 100g MOP to each plant of 1-2 years age during July month. As per age of the plant, this dose is enhanced and after attaining 10 years of age, a fixed dose of 1 kg urea (460g N), 2 kg SSP (320g P_2O_5) and 1 kg MOP (600g K) along with 50-80 kg well rotten FYM/leaf mould is applied to each plant during July after fruit harvest.

Farid (2007) reported that 20 years old trees with 15 g B/tree along the blanket dose of N-P-K-S-Zn *i.e*, 920:200:250:85:20 g/tree and 10 kg cowdung was optimum for increasing normal number of fruits and lowering the number of deformed fruits per tree.

Water management

Once in a week till the plant gets established. Thereafter irrigation is given as and when necessary. Vishal Nath *et al.* (2002) observed that imbalance in soil moisture after fruit set leads to initial fruit drop and flake formation stage leads to fruit cracking.

Harvesting and yield

Harvest season starts from February and extends to June. Fruits are harvested along with their footstalks. The yield commences from 5th year in grafts and 8th year in seedling trees. Yield varies from a few fruits during first year of bearing and it may be as high as 250 fruit after 15 years of age (Sharma *et al*., 1997).

Medicinal properties of jackfruit

The latex of this tree has anti-inflammatory properties. Hence it is recommended in inflamed abscesses and wounds. Poultice of jackfruit latex helps to reduce pain and swelling in abscesses and wounds.

Value added products

Ripe and unripe fruits could be effectively processed into canned, frozen and dried products, including nectar, juices and confectionery.

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STINGLESS BEES: GUARDIANS OF OUR ECOSYSTEMS AND ECONOMY

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Introduction

The carpenter bee, orchid bee, bumble bee, and genuine honeybee are all closely related to the stingless bees. They belong to the family Apidae. With a length of 4.0 to 5.0 mm, the stingless bee is the smallest member of the Apidae family of bees. Stingless bees, in contrast to Apis honeybees, have atrophied stings that do not sting, yet they will bite to protect their hive when it is disturbed. The centuries-old practice of beekeeping using stingless bees that is practiced all across the world is called meliponiculture. Despite the lack of research in these nations, stingless bees have also been kept for millennia in India, Sri Lanka, and Nepal.

Geographical distribution

Stingless bees are claimed to reside in most tropical and subtropical regions of the planet, including Australia, Africa, Southeast Asia, and tropical America. They are active throughout the year, though during the colder months they are less so. Up to 60 different species of stingless bees can be found in a single Neoptropic woodland, demonstrating significant regional and local variety. The common stingless bee species in the Indian subcontinent, *Trigona iridipennis*, is used in meliponiculture, where colonies are housed in tree logs, wooden boxes, and clay pots to collect tiny amounts of highly valued medicinal honey and other hive products like propolis and wax that are used for household and medicinal purposes.

Trigona iridipennis

Diversity of stingless bees

A sizable number of bees (about 600 species) that make up the Meliponini tribe are stingless bees. There are two tribes of stingless bees (subfamily Meliponinae): Meliponini and Trigonini. These tribes have a high number of genera and sub-genera. There are 374 recognised species within the 23 genera and 18 sub-genera that make up the tribe Meliponini. All Asian and African stingless bee species are members of the Trigonini tribe. This group includes the genera *Trigona*, *Plebeia*, *Tetragona*, and *Nanotrigona*. With 130 species and 10 subgenera, *Trigona* is the largest and most widely distributed genus. The genus *Melipona* has about 40 species of medium-to large-sized bees that are only found in the Neotropics. After *Trigona* was divided into nine smaller genera, all *Trigona* bees were grouped together under the *Tetragonula* genus. There are roughly 50 species in Africa, 300 in the Americas, 60 in Asia, 12 in Australia, and 4 in Madagascar that have been identified thus far. In the Neotropics, where up to 60 *meliponine* species can be found locally in a single forest, there is a high level of local and regional diversity. There are more than 200 kinds of stingless bees native to Brazil.

Nesting structure

Similar to honeybees, they are gregarious insects that reside in colonies. In nature, stingless bee colonies can have hundreds or thousands of workers. Their nests are constructed in dark places such as crevices in old walls, hollow logs, and tree trunks, where the entrance usually protrudes as an external tube. For nesting, they favour enclosed shelters over open ones. Entrance, Cerumen, Batumen, Involucrum, Storage Pots, and Brood Cells make up a stingless bee's nest. Cerumen is a mixture of wax and resin.

The stingless bee's wax has a greater melting point than honey bees' (*A. mellifera*) wax. When there is more wax present than resin, the nest's texture gets tougher. In addition, the waxy nest can be made into batumen by hardening it with mud. This offers superior insulation, particularly for exposed nests. In order to safeguard the interior of the hive, batumen and Cerumen are utilised. Involucrum, on the other hand, is the cerumen layer that surrounds the brood cells and shields the nest from parasites and predators.

Large trunk nests and underground homes within soils have exceptionally well-insulated interiors. Cell construction is the initial step in the creation of a new individual. More brood cells are introduced to the border of the nest or comb in situations where there are cell clusters. Around the spherical, horizontally comb-organized brood cells is the involucrum, a layer of waxy sheets that serves as insulation. Short pillars are used to connect the involucrum to the cavity wall externally.

In stingless bees, there is no interaction between the adult population and the developing larvae. Mass provisioning is used to feed stingless bee larvae as they grow, whereas royal jelly and bee bread are supplied to *Apis* spp. larvae gradually. Pupal broods are smaller and have a softer hue than larval broods, which are larger and darker. Both the males and the brownish workers are found in the same combs and were created in similar cells. Ellipse-shaped queen cells are typically seen towards the edge of combs. Unlike *Apis* honeybees, stingless bees store their pollen and honey in separate, spherical containers called "cerumen," which is a mixture of mud, wax, and resin or propolis.

The food storage pots are typically located at the top and bottom of the nest and are built one on top of the other or side by side. The walls of the honey and pollen pots are soft, thin, and dark brown, while the pots themselves are larger, spherical or oval. Generally speaking, the pollen pots are located nearer to the brood, although occasionally they are jumbled together. After they are filled, food pots are sealed. The way creatures that live underground build their nests.

The underground Lophotrigona canifrons of the Indian subcontinent are found in the messy, bushy woodlands that envelop shadow and block light from small trees and plants. It was discovered that the entrance tube leading to the nest was composed of a mixture of dirt, secondary roots, and cerumen. Scutellum was found to be covering the internal nest architecture.

Hive products

Bees collect floral nectar, which is a concoction of sugars and other trace elements that they then condense into honey. Honeybees produce a tasty, viscous fluid. It is harvested as nectar from additional floral nectaries, which are plant components other than flowers, and nectarines at the base of flowers. Honey produced by stingless bees is limited to species-specific varieties. Near the edges of the nest, stingless bees store their fragrant honey and pollen in clusters of tiny, spherical resin pots that they create independently using a mixture of wax, resin/propolis, and mud known as "cerumen." Their honey is also referred to as pot honey for this reason.

Stingless bee honey has a distinct flavour that combines a hint of fruitiness with a sour and sweet combination. The flavour, which is produced by plant resins that bees use to build their hives and honey pots, varies from season to season based on the flowers and trees that are visited. Stingless bee honey has a richer colour, a sharper flavour, and a higher concentration of phenolic chemicals. There are a lot of antioxidant flavanoids in *T. iridipennis* honey. Six hundred to seven hundred grams of honey are generated annually, which is a little quantity.

The University of Queensland's researchers found in 2020 that trehalulose, a sugar with a remarkably low glycaemic index (GI) compared to glucose and fructose, the two main sugars that make up conventional honey, is produced by specific stingless bee species in Australia, Malaysia, and Brazil. Such low glycemic index honey is beneficial to humans since it does not increase blood sugar levels, which would force the body to create more insulin. There is scientific evidence that this kind of honey has medicinal benefits for people as well.

Propolis

Honey bees use propolis in the construction of their hives and in the cleaning and disinfection of the colony's cavity. Bees without stings produce more propolis than honey bees do. *Tetragonula iridipennis* propolis has exceptional pharmacological properties. Propolis is gathered by *T. iridipennis* to fortify its nest, but people have also discovered that it possesses a variety of therapeutic benefits. Propolis has strong antiviral and antibacterial qualities.

Stingless bees in pollination of crops

Most eusocial bee species visit blooming plants and play a significant role in crop pollination, such as honeybees, stingless bees, and bumble bees. Because of a multitude of noteworthy traits, such as its ability to attract a large number of workers to visit rich resources, the honeybee, *Apis mellifera* L., is recognised as the principal pollinator of many crops. On the other hand, stingless bees (*Meliponini*) play a vital role in the pollination of many native plant species in tropical regions. Due to their small size, they can visit many types of blooms that have openings that are too small for other bees to penetrate. In the tropics, they are frequent visitors to plants that bloom.

Being true generalists, stingless bees collect pollen and nectar from a wide range of plants. A single species may receive flowers each year from up to 100 different plant species. According to recent studies, stingless bees effectively replace honeybees in the pollination of numerous greenhouse plants that are significant for both social and economic reasons, including watermelons, strawberries, and capsicums. Compared to other approaches, stingless bee pollination resulted in a higher fruit set and healthier fruits.

Conclusion

From the foregoing, it is clear that meliponiculture, or stingless bee keeping, is a sustainable practice that does not negatively impact the environment and yields valuable products with a high market value, such honey, propolis, pollens, and other products. Through pollination, a function these insects provide, this activity brings significant environmental benefits in the form of enhanced biodiversity and forest regeneration. Since pollination is essential to increasing agricultural crops' output, it has a significant economic value. Meliponiculture is a viable industry that ought to be made more widely known throughout the nation, particularly in rural regions where it may help farmers generate income and increase agricultural yields by providing pollination services.

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UNVEILING THE DEPTHS: HOW AN INDIGENOUS TECHNICAL KNOWLEDGE SHAPES MODERN FISHERIES

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Abstract

The process of the use of a wide variety of knowledge systems, this integration enables a holistic approach to problem-solving, addressing topics from aquaculture techniques to healthcare delivery and beyond. Traditional fishermen are naturally concerned that, as fishing becomes more capital intensive and fish aggregation technologies progress, Indigenous Technical Knowledge (ITK) may disappear. For the fishing sector to thrive sustainably over the long term, it is essential that these knowledge repositories, which are based on the firsthand experiences of indigenous people, be verified and documented. Solutions suited to the particular difficulties, cultural contexts, and environmental conditions faced by rural inhabitants are the result of collaborative efforts fusing scientific approaches and traditional wisdom.

Introduction

India is the world's second-largest producer of aquaculture fish and the third-largest producer of fish overall. Approximately 8.92% of the world's fish is produced in India. The nation is one of the 17 mega biologically rich countries in the world and is also home to over 10% of the world's fish biodiversity. Through the integration of scientific inquiry methods with the subtle understandings gained from generations of folk wisdom, these cooperative endeavors produce solutions that are not only precisely tailored to the particular difficulties encountered by rural communities but also intrinsically representative of their cultural and environmental settings.

Understanding Indigenous Technical Knowledge (ITK):

This integration makes it easier to solve problems holistically by utilising a wide variety of knowledge systems to handle problems ranging from the delivery of healthcare to agricultural practices and beyond. Innovations that are rooted in regional realities and customs are by their very nature more acceptable and approachable to rural clients, who are more inclined to adopt solutions that speak to their cultural heritage and lived experiences.

Local Ecological Knowledge and Resource Management:

a) Pond Construction

Site selection: - Fish farmers in the Assam hill district were said to have sought low-lying sites near their houses for their fish ponds. These ponds can be used for bathing, washing clothes, and cleaning kitchenware, in addition to being utilised for fish breeding. They decided against building dugout ponds in favour of embankment ponds due to cost considerations.

Soil quality: - To determine the soil's capacity for holding water, a mud ball is formed from the proposed pond site. If the ball stays in place, there is enough water in the soil to support the construction of a pond.

Outlet: - As outlet pipes, farmers used hollow bamboo pipes set at a certain height above the ground. The end of the bamboo that faces the ponds is blocked by stones and clay soil.

Protection of pond dyke: The pond's top is constructed broader than its bottom to better withstand the force of the water. In regions with heavy rainfall, a number of ponds are susceptible to erosion and deterioration. Farmers plant turf comprised of fodder grass together with vegetable and plantation crops like cucumbers, gherkins, and papayas.

b) Breeding: -

- In West Bengal, eggshells are hardened by farmers using water-immersed catechu and myrobalan nut extract. This prevents the release of immature hatchlings and increases the hatching rate.
- To prevent damage during transit, freshwater prawn stock in Tamil Nadu is wrapped in plastic tubes. Breeders of fish use bananas.
- leaves, teak leaves, and potato or carrot slices for laying eggs and raising larvae

Seed collection: - Murrel spawns, like as *Channa punctatus*, are gathered in Assam during the monsoon season using bamboo sieves, mosquito nets, or cloths for breathing in natural waters.

Seed transportation: - Bengal uses the age-old technique of transferring fry and fingerlings in hundis, clay, or aluminium pots. The water in these containers comes from the same source, and they are shaken on a regular basis. Transport duration is extended by management techniques such as partial water exchange, silt addition, and sediment removal.

Seed stocking: -

- **Weed fish eradication** – Mahua oil cake is used to kill the weedy fishes
- **Bird scaring** – using audio/ video tapes and some plastic things with coloured are for bird scaring in a few farms in Karnataka
- **Seed quality** - Farmers test seed quality by spinning water with a finger in a small container and observing their direction; seeds that are healthy swim in the opposite direction. In the case of Catla, Rohu, and Mrigal, a bigger head is mostly preferred because it will grow fast.

c) Fish feeding:

- Most of the farmers of Andhra Pradesh use the bag-feeding technique
- NaCl is used to promote Growth potential in carp farming
- Some agri by-products like fermented maize and poultry offal in feed have also been used

Holistic Approach of ITK Of Coastal Fishers

- When the sea is calm, fish availability is higher (Kancheepuram dt)
- When the sea is rough and blue in colour, there is less fish available (Cuddalore dt)
- Butterflies in a group can be observed before the cyclone it's them believes (Pullicat, Tiruvallur dt)
- More water currents are observed when a halo occurs around the moon (Pullicat, Tiruvallur dt)
- Presence of seagulls over the water surface indicates fish school (Kancheepuram dt)
- If the sea level increases, chillness will increase, so less fish catch (Nagapattinam dt)
- When sea snakes occupy the particular fishing ground, so no fish are caught because the sea is very rough
- During October to November, there will be a good catch of fish. It is a post-period of fishing ban season on the East Coast

- After rain, there will be a good catch of fish. The reason behind this is after rains, there will be a depression in DO for oxygen, so the fish will come to the water's surface
- During the summer months, there is an increased catch of squids (Kancheepuram dt)

Traditional Fishing Techniques and Tools:

Some traditional fishing techniques are

- **Pari** – These are crafted fishing baskets from natural bamboo splits. Fresh split bamboo
- **Katcha** – Katcha is a bamboo fishing basket with a conical form that resembles a pari and has no divisions on the inside. It is traditionally used for rice field fishing.
- **Ootha** It's also a conical-shaped basket constructed from slender bamboo strands.
- **Sorati** – Crabs are harvested from their nests in rice fields using this method. fields
- **Katta Maram** – It is composed of Matha tree timber and is lightweight.
- **Karai valai-** This traditional fishing net is composed of three particles: boya, purai, and stone, and is manufactured of coir

Challenges and Opportunities:

Earthquakes and Tsunamis

✓ A tsunami is a sequence of waves in the ocean that are brought on by landslides, volcanic eruptions, or abrupt disturbances. They dash onto shallow water, losing height and speed as they get smaller. They are usually 30 to 60 cm high. Massive breaking waves are how the tsunami appears, and the energy flux stays constant.

Prediction: A unique method of predicting earthquakes and tsunamis on the Andaman and Nicobar Islands is the odd barking of street dogs.

Heavy rain, flood and cyclone:

✓ 75% of India's rainfall falls between June and September during the monsoon season, resulting in significant downpours and extensive flooding. Eastern India's Himalayan rivers submerge catchments, upsetting people's livelihoods and causing infrastructure damage. The vulnerability of communities within the Himalayan Mountain ranges exacerbates the risk of flooding. The issue is made worse by sediment buildup, drainage blockages, and river floods that coincide with storm surges. The Deccan region, Brahmaputra, Northwest region, Central India, and Gangetic basins are among the locations that are prone to flooding.

Prediction: Black ants storing eggs and grains in safer places indicate rain. Screaming frogs, cocks spreading feathers, and termites in wet soil indicate rain. A red sky indicates 18 days of rain. Forests with lush vegetation indicate more rainfall. Snail climbing trees, earthworm crawling, ants shifting, and insects flying indicate cyclonic weather and heavy rain. Spreading lightning and thunder ensure rain. Redness after sunset indicates cyclonic storms within 7 days

Case Studies:

- ✓ **Case study in Chennai, southeast coast of India: -**

Given these circumstances, 200 fishermen in and around Chennai were surveyed using a standardised questionnaire to obtain primary data on Indigenous Technical Knowledge (ITK). Fishermen believed that overfishing and youth exploitation were more to blame than climate change for the recent drop in fish catch. Fishermen forecast climate variability, natural disasters, and fish availability using climatic data. Chennai fisherman preferred to temporarily evacuate their settlements in the case of hurricanes and sea erosion.

Ninety-one percent of fishermen watch and listen to television and newspapers for weather-related information. If the price is affordable, they would like to purchase weather-related insurance. In the previous 20 years, they did not report any significant disease outbreaks among them

- ✓ **Case study in Vypeen island of Ernakulam district**

The knowledge that an indigenous community has accumulated over centuries of living in a particular environment and whose scientific validity has not been demonstrated is known as indigenous knowledge (IK). ITKs may be the magic bullet needed to close the technological gap that is necessary for the fishing industry to survive. The knowledge components of many ITKs that are available in the fisheries sector are still localised and have not yet been widely distributed. In this regard, a pre-structured interview schedule was used to conduct a research study among 60 randomly chosen fishing houses in the Ernakulam district's Vypeen island. The study examined the many ITKs used in catch fisheries, such as fishing ground identification, timing of fishing, weather forecasting, fish shoals, and depth estimation.

Conclusion

The study found that a large number of ITKs with unique features that make them simple to use have been in use in the fishing sector for more than ten years. robustness and cost-effectiveness. The study found that compared to fisherman who utilize mechanized gear, traditional fishermen employ ITKs more frequently. Traditional fishermen are naturally concerned that ITKs might disappear in the future as a result of rising fishing-related capital expenditures and developments in fish aggregation technologies. For the fishing sector to thrive sustainably over the long term, it is essential that these knowledge repositories, which are based on the firsthand experiences of indigenous people, be validated and documented.

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SUCCESS STORY ON CROP DIVERSIFICATION WITH MORE REMUNERATIVE CROP : PAPAYA

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Introduction

In Chuda village, farmers are mostly growing cereals, pulses, oilseeds, vegetables and plantation crops. Narayanbhai is a small land holder of Chuda village of Surendranagar. Earlier, he was growing cotton, groundnut, cumin, wheat and vegetable crops in traditional way of farming. He was getting very low crop yield, hence earned less income. Due to such reasons, he would like to grow other economic crops for getting higher income. He heard about papaya crop which was earlier grown at nearby village of Chuda. To know the detail information regarding papaya cultivation, he comes in contact with KVK, Surendranagar.

Support by KVK

KVK, Surendranagar conducts various extension activities and training programmes for the farmers to improve their economic condition through farming. To know the details information about scientific cultivation of papaya, he visited KVK, Surendranagar and discuss with the KVK scientists about various queries related to farming. He regularly visited KVK through various programmes like trainings, meetings and other extension activities to satisfy the hunger of his knowledge about latest agricultural technology. He adopted the recommendations of agricultural university like selection of quality planting material, time of sowing, Integrated nutrient management, Integrated pest and disease management, right application of recommended fertilizers and irrigation in his farm.

Diversification through Papaya Cultivation

KVK, Surendranagar more emphasize on modern optional of agriculture to enhance the farmer's income. Assured irrigation after availability of Narmada canal water, Surendranagar District has vast scope of crop diversification. Papaya is one of the economically and commercially most important fruit crop of India. It is gaining popularity due to high yielding potential as well as year-round fruiting. Narayanbhai started to growing papaya in an area of 0.4 ha in the year, 2016.


Field of Papaya cv. Red Lady Taiwan - 786

He has grown 1000 plants of papaya var. Red Lady Taiwan – 786 and Madhu Bindu at a distance of 2 m x 2 m. He has adopted integrated approach for papaya cultivation to increase the production as well as getting higher net profit. Harvesting was done manually. After harvesting, papaya fruits were wrapped in newspaper to avoid bruising injuries during transport. Then, it was transported to local market. The details regarding interventions adopted by Narayanbhai is given below in Table 1.

- **Table 1. Interventions Adopted Through Technical Farming of Papaya: -**

Practices	Traditional farming	Technical farming
Soil Testing	-	Done
Seed Selection	Use of commercial variety Red Lady Taiwan - 786	Use of High yielding varieties Red Lady Taiwan - 786 and Madhu Bindu
Seed Treatment	-	Seed treatment with Thiram

Nutrient Management	Use of chemical fertilizers	Integrated nutrient management
Weed Management	Manually	Mechanized and manually
Pest & Disease Management	Use of chemical pesticides	Use of Integrated approach of pest and disease management *i.e.* physical, chemical and bio control methods

Outcome: -

Narayanbhai has invested Rs. 72,850/- in the year, 2016 for papaya cultivation. From the year 2016 to 2020, the detail information regarding cost of cultivation, production and income are given below in the Table 2.

Table 2. Cost of cultivation, Production and Income of Papaya: -

Particulars	**Year**				
	2016	**2017**	**2018**	**2019**	**2020**
Area (Ha)	0.4	0.5	0.4	0.8	0.4
Production (Kg)	30,600	40,360	46,540	67,320	21,560
Avg. Market Rate (Rs. /Kg)	11	8.5	8	12	19
Cost of Cultivation (Rs.)	72850	85300	88260	256750	63940
Gross Income (Rs.)	336600	343060	372320	807840	409640
Net Income (Rs.)	263750	257760	284060	551090	345500
B:C Ratio	**3.62**	**3.02**	**3.22**	**2.15**	**5.41**

Field Visit by KVK Scientist- Packaging through Wrapping of Newspaper

Impact

With the technical guidance of KVK, Surendranagar, he made significant progress towards crop diversification through papaya cultivation. Cultivation of papaya through scientific methods is more remunerative over the traditional method. He has earned more income by growing of papaya. Balanced use of fertilizers including, organic manures, micro nutrients and bio culture, fertilizer consumption was also reduced to 23 %.

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APPLICATIONS AND USES OF BIODEGRADABLE POLYMERS IN AGRICULTURE

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Abstract

The use of biodegradable materials in packaging, agriculture, medicine and other fields has become increasingly popular in India in recent times. Biocomposites, or materials made of biodegradable polymers, are particularly intriguing. Plastics are primarily composed of polymers, which are used in an increasing number of applications. Consequently, a great deal of research is being done on creating novel polymer composites using naturally existing components and changing conventional materials to make them more user friendly. Biodegradable polymer materials can contain a variety of biological components, the most popular being starch and fiber that have been derived from different kinds of plants.

Key Words: Biopolymer, Biodegradation, Applications and Uses

Introduction

In the agriculture sector, biodegradable polymers have become more popular in recent years. In recent years, biodegradable polymers have attracted a lot of interest as a potential replacement for conventional plastic materials in agricultural applications. The impact of plastic trash on land and waterways is lessened by these materials fast and safe environmental breakdown. The use of biodegradable polymers in agriculture has various benefits, including enhanced crop yields and soil health, in addition to reducing waste. Moreover, in the upcoming years, there will be a notable growth in the production of this kind of material.

Why do biodegradable polymers exist?

A polymer that can undergo total degradation under the influence of environmental microorganisms is known as a biodegradable polymer. When a plastic container reaches the end of its useful life and begins to break down as a result of various environmental factors, we say that it is biodegradable. Following biodegradation, this polymer yields compost, CO_2 and water, all of which are reabsorbed by the environment.

Origin

The packaging business uses a lot of biodegradable polymers that are derived from renewable resources. This indicates that the carbon atoms in their chains of molecules come from the natural world. This is the phenomenon usually known as possessing a "bio-origin·. The biopolymers used in the bioplastics industry often originate from biobased materials like sugar cane, corn or sugar beet.

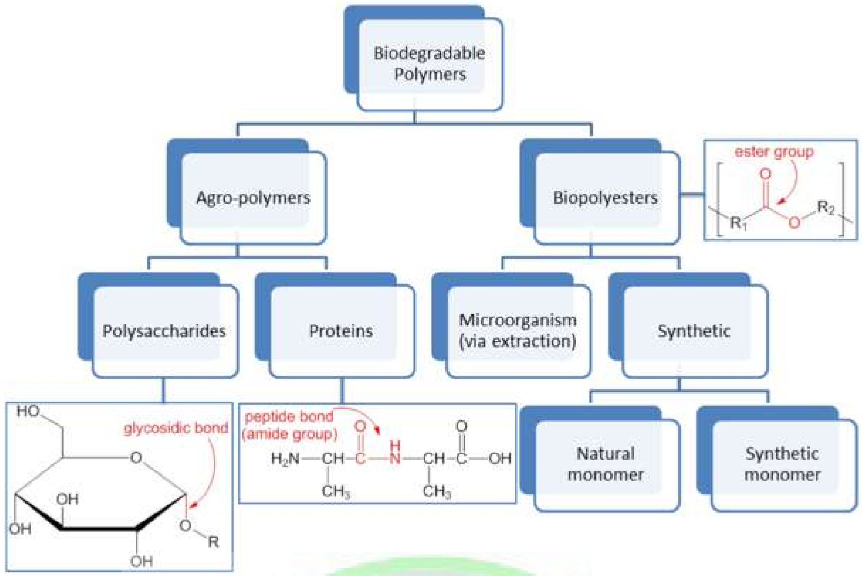
Qualities of biodegradable polymers

The majority of linkages in biodegradable polymers are ether, amide, or ester bonds. Biodegradable polymers can be broadly classified into two classes according to their synthesis and structure. Agro-polymers, or those made from biomass, are one of these categories. The other is composed of biopolyesters, which can be artificially produced from naturally occurring or manufactured monomers, or they can be generated from microorganisms.

Agro-polymers are composed of proteins, such as whey from animals or gluten from plants, and polysaccharides, such as starches found in potatoes or wood. Glycosidic linkages, which take a hemiacetal of a saccharide and bind it to an alcohol by losing water, are the building blocks of polysaccharides. Amino acids, the building blocks of proteins, have a variety of functional groups. By condensation reactions, these amino acids recombine to generate peptide bonds, which are made up of amide functional groups. Polylactic acid and polyhydroxy butyrate are two examples of biopolyesters.

There are different types of biodegradable polymers that can be classified, into three groups according to their origin.

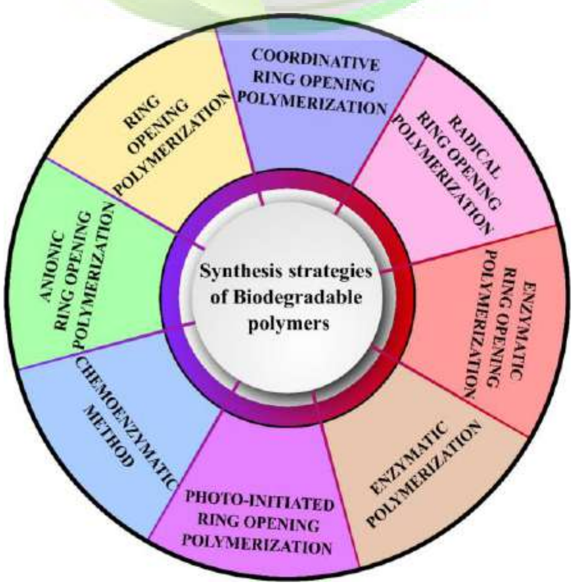
- Natural polymers such as starch, cellulose and proteins
- Modified natural polymers
- Synthetic polymers such as PLA



Examples

- Polylactic acid (PLA)
- Polyhydroxyalkanoate (PHA)
- Polybutylene succinate (PBS)
- Polyvinyl alcohol (PVA)
- Cellulose Acetate (CA)
- Polyglycolic Acid (PGA)
- Polymer Materials Based on Lignin

Strategies involved in the synthesis of biodegradable polymers



Biodegradable polymer uses

- **It is Easy to recycle biodegradable polymers:** These polymers not only decompose faster when discarded but can also be easily recycled using an organic method. Recycling helps to reduce landfill waste, and the recycled bio-waste can also be used as compost or as a renewable energy source for biogas production.
- **The amount of waste generated is reduced:** Biodegradable plastic degrades in a matter of months, depending on the material used to make it and the method of disposal.
- **Reduction in carbon Emission:** One of the most important benefits of using biodegradable polymers to produce plastic bags is the significant reduction of carbon emissions during the production process instead of conventional plastic.
- **Greenhouse gas emissions are reduced:** As the biodegradable polymer is used instead of conventional plastics, greenhouse gas emissions are reduced.
- **Reduced use of petroleum:** Oil is an essential component in the production of traditional polymer. When you consider the amount of waste generated during refining and even during the extraction of oil from the earth, it is no surprise that petroleum harms the environment.
- **They consume less energy during their manufacture:** Although the initial investment may be marginally higher, biodegradable plastics need less energy in the long run and require the reprocessing of fossil fuels to produce polymers.

Biodegradable polymer applications

There has been a recent push for research into creating materials that are more environmentally friendly and sustainable. In this regard, biodegradable polymers have emerged as one of the most effective substitutes for traditional plastics in achieving this goal.

Applications in Agriculture

There are many products in the agricultural sector in which biopolymers can play a role. Some of these applications can be films or tutors, where, as they are intertwined with the crops, we would avoid having to harvest them later on. Among the natural polymers utilized in controlled release systems include lignin, starch, chitin, cellulose, and alginic acid. Biopolymers are utilized in marine agriculture to create fishing nets and ropes. Using biodegradable materials in mulching and low-tunnel cultivation is a viable way to improve sustainability and ecologically friendly agriculture practices. Throughout their useful lives, agricultural films buried in the soil are subject to aging and degradation, therefore they must possess a few certain qualities.

Applications in Medicine

Biodegradable polymers are currently being used in orthopaedic and vascular surgery for surgical implants as well as simple membranes. Biodegradable polyesters are commonly used as porous structures in tissue engineering due to their high strength and adjustable rate of disintegration. These can also be employed as absorbable sutures or as implantable matrices for the controlled release of medications within the body. Gelatin is a naturally occurring polymer that is utilized in the production of biodegradable hydrogels as well as coatings and microencapsulation for different medications in biomedical applications.

Applications in Packing

Another significant application for biodegradable polymers is packaging. Biodegradable polymers are frequently utilized to decrease the amount of trash produced. Biopolymers have traits like low temperature and air permeability, among others. PLA Its permeability to oxygen and water vapor is medium. It is applied to packaging materials like bottles, cups, and films. Soft biodegradable packaging also uses PCL.

Applications in Other Fields

- **Automotive:** By using bioplastics and bio composites, the auto industry hopes to create lighter vehicles.
- **Electronics:** In electronics applications, PLA and kenaf are utilized as a composite. The Fujitsu business has already employed PLA to create a computer enclosure.
- **Construction:** The cushioning and paving stones of the carpet are made of PLA fiber. Because it is less flammable than synthetic fibers, it provides greater security.

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CARBON NANOTUBE AS STRATEGY FOR SUSTAINABLE AGRICULTURE

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Abstract

Carbon nanotubes are currently among the most extensively researched materials worldwide. They represent the most desirable material due to their electrical, mechanical and thermal properties. Investigations in this domain are uncovering an overabundance of unexpected findings across various fields such as material science, physics, chemistry and agriculture, thereby presenting numerous new opportunities for utilization. This article accentuates the basic properties, classification and comprehensive agricultural applications of carbon nanotubes, such as their role as plant growth regulators, biosensors, facilitators of seed dormancy and germination and tools for pesticide analysis.

Key Words: Carbon nanotubes, Agriculture, Seed dormancy, Plant growth, Biosensor.

Introduction

The agricultural sector is currently dealing with a wide range of issues that might threaten the sustainability of agriculture, including climate change, infectious crop diseases, deficient soil nutrients, lower crop yields, ignorance of genetically modified crops and a labour shortage. More extreme climatic circumstances, such as salinity, drought, hot and low temperatures are becoming more common as climate change conditions continue to grow. These variables can result in significant annual losses in global agricultural output, yield and quality.

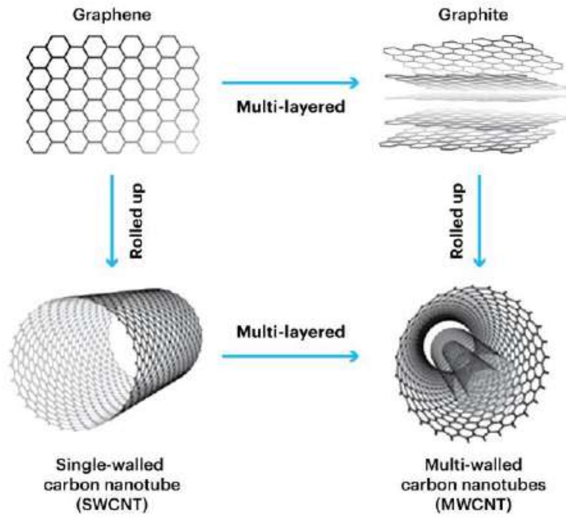
Climate change has increased the frequency and intensity of abiotic stresses, especially drought and high temperatures, which has led to large losses in important cereal crops including wheat, maize and barley. For example, it is known that two of the biggest barriers to agricultural productivity are drought and excessively salinized soil, together with the osmotic, oxidative and ionic stress that result from these conditions. In addition, biotic stressors like pests and diseases decreased agricultural productivity by roughly 20-30% annually, which is seen to be the most depressing obstacle to reaching global food security. Farmers have resorted to using agrochemicals excessively to manage crop losses and increase yields to solve these issues.

To safely and sustainably meet present and future food demands, innovative strategies that can increase the effectiveness of pesticide utilization while effectively shielding crops from environmental challenges are needed. With the potential to revolutionize conventional farming into precision farming, nanotechnology presents a promising avenue for sustainable agriculture. With careful monitoring of environmental factors and the implementation of carefully planned responses to each ecological condition, precision farming is a well-balanced method for raising agricultural output. To boost agricultural productivity through effective nutrient delivery, nutrient control, lowering mobile nutrient losses, creating slow-release fertilizers and enhancing the accessibility of poorly available nutrients, several researchers have recently concentrated on nanotechnology-based agriculture.

Nanomaterials engineering is a promising technique for improving crop productivity and the sustainability of current agricultural methods. Since they can penetrate plant cell walls, regulate plant growth, act as a medium for biosensors, and facilitate agricultural smart delivery, carbon nanotubes (CNTs) have garnered the most interest among the different kinds of carbon-based nanomaterials (CBNs) of farm applications. Because CNTs can act as a slow-release fertilizer and a growth promoting agent for plants, they are regarded as a new fertilizer. In agriculture, CNTs can serve as intelligent delivery systems for nano-encapsulated agrochemicals, which can be tailored to target particular components like pesticides and fertilizers and can be time and self-regulated.

Carbon Nanotubes Properties

A form of carbon having a diameter of nanometers and a length of micrometers, where the ratio of length to diameter is more than 1000 is known as a carbon nanotube (CNT). CNT is composed of encapsulated cylindrical graphitic sheets, also known as graphene, which are rolled into a seamless cylinder with nanometers in diameter.



Electrical Conductivity

Carbon nanotubes, or CNTs, have a high mechanical strength and are conductive both electrically and thermally. Electrically conductive continuous length webs can be created by drawing parallel arrays of multi-walled carbon nanotubes.

Strength and Elasticity

The strongest and stiffest materials discovered to date are carbon nanotubes, both in terms of tensile strength and elastic modulus.

Thermal Conductivity and Expansion

The carbon bond's rigidity aids in the transmission of vibrations throughout the nanotube, resulting in excellent heat conductivity. Because each carbon atom is connected to three other carbon atoms by strong covalent bonds, carbon nanotubes have an extremely high melting point. This also leaves a spare electron on each carbon atom, resulting in a sea of delocalized electrons within the tube, allowing nanotubes to conduct electricity.

Electron Emission

Carbon nanotubes have a very high melting point due to the strong covalent connections that bind each carbon atom to three other carbon atoms. Additionally, because of the additional electrons that each carbon atom possesses, a sea of delocalized electrons forms inside the tube, enabling nanotubes to conduct electricity.

Classification of CNTs

1. Single-walled carbon nanotubes
2. Multi-walled carbon nanotubes

Single-walled carbon nanotubes- it is represented as SWCNT. The single-walled carbon nanotubes exist in a 1-D structure. Some examples of single-walled CNT are armchairs and zig-zag single-walled carbon nanotubes.

The properties of Single-walled Carbon Nanotubes are,

- The diameter of Single-walled Carbon nanotubes is 2nm.
- The length of Single-walled Carbon nanotubes is around 2 micrometers.
- They exist in a one-dimensional structure. Therefore, it is also known as a nanowire.
- Electronics can be miniaturized by using a Single-walled Carbon nanotube.
- Their band gap varies from 0-2 electron volts (eV).
- They show conductivity like a semiconductor. Therefore, they exhibit both metallic and semi-conductivity behaviour.

Multi-walled Carbon Nanotubes- It is represented as MWCNT. It is composed of several nested carbon nanotubes. This type of nanotubes has two diameters, one is known as outer diameter and another one is known as inner diameter. An example of multi-walled carbon nanotubes is chiral multi-walled carbon nanotubes.

The properties of Multi-walled Carbon Nanotubes are given below,

- The outer diameter of multi-walled carbon nanotubes is around 2-20 nanometres.
- The inner diameter of multi-walled carbon nanotubes is 1-3 nm.
- The length of multi-walled carbon nanotubes is around 5-6 micrometers.

Carbon nanotube applications in Agriculture

Biosensor

A biosensor is a device that measures molecules in a solution containing analytes to be investigated quantitatively using a particular chemical. CNMs have strong physicochemical potentials, making them an ideal material for pathogen detection. Compared to commercially available sensors such as silicon, metal oxides, and others, CNT-based biosensors offer several advantages, including as high stability, fast reaction times, exceptional luminous properties, and high sensitivity (large surface area ratio).

Seed dormancy and germination

It has been reported that one potential way that nanoparticles assist in waking up dormant embryos and increasing seed germination is through CNTs' capacity to pierce the seed coat. The ability of carbon nanotubes to penetrate the seed coat has been hypothesised as a potential mechanism by which nanoparticles aid in the activation of genes enhancing seed germination due to the latent embryo. The capacity of carbon nanotubes to penetrate the seed coat has been hypothesised as a possible method by which nanoparticles assist in the activation of the latent embryo, resulting in improved seed germination.

Plant growth regulators

The utilization of nanotechnology in agriculture and food systems is becoming more popular due to its successful applications. At modest dosages, several kinds of nanoparticles have been demonstrated in studies to activate plant physiological systems. For instance, by triggering photosynthesis at the perfect concentration, TiO_2 nanoparticles were able to promote the growth of spinach plants. The advantageous effects of carbon nanotubes on plant growth and development have been reported by several research groups. Consequently, it has been noted that plants such as onions and cucumbers exhibit enhanced root growth in response to carbon nanotubes. Recent research has demonstrated that tomato plants can be stimulated to grow and that MWCNTs can affect the expression of genes related to cell division and plant development.

Pesticide analysis

Since carbon nanotubes have excellent adsorption properties, they are employed in extraction processes like solid-phase extraction (SPE) and solid-phase micro-extraction (SPME). One of the most widely used extraction technologies for pre-treating biological, food, and environmental samples is SPE technology. Several studies have demonstrated the potential of MWCNTs as an adsorbent for the pre-concentration of lead, nickel, and cobalt ions. Including insecticides with organophosphate (OP) and chlorophenols. The number of MWCNTs and the treatment conditions had an impact on the analyte recoveries, suggesting that by changing the sample conditions, they might be applied to other analytes and kinds of food samples. For accurate enrichment and sensitive detection of metal ions in a range of media, the nanoparticle-based SPE sorbent exhibits promise.

Nanofertilizers

The emergence of carbon-based nanofertilizers introduces a groundbreaking solution with substantial potential, encompassing a variety of benefits such as enhanced nutrient distribution, absorption, and overall botanical development. Carbon nanotubes (CNTs) represent one of the most extensively researched carbon-based nanofertilizers, recognized for their considerable aspect ratio, structural integrity, and distinctive chemical attributes. The utilization of CNTs in plants enhances nutrient distribution and absorption, leading to increased agricultural output. Another form of carbon-based nanofertilizer is Graphene, which exhibits the potential to enhance nutrient utilization efficiency and stimulate botanical growth.

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GLOBALIZATION AND ITS IMPACTS ON FISHERIES

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Abstract

Globalization is a historical process driven by human innovation and technological advancement, encompassing the movement of labour and technology across international borders alongside broader cultural, political, and environmental dimensions. Highlighting the globalization of information systems, it examines the dual nature of its positive and negative impacts. While economic globalization strengthens interdependence among nations, it also presents challenges such as destroying domestic markets, increased production costs, and issues like overexploitation of fish stocks and Illegal Unreported and Unregulated (IUU) fishing. Addressing these challenges requires a policy framework that balances the benefits of globalization with support for local economies and ensures equitable distribution of benefits. Specifically focusing on the fishing industry, measures to eliminate overexploitation, reduce subsidies, and enhance domestic market demand through tariffs and quotas are proposed to safeguard the welfare of stakeholders and promote sustainable development. This article explores the impacts of globalization on fisheries, mainly focusing on the negative effects of globalization because it is necessary to address these negative impacts to achieve sustainable development goals.

Introduction

Global integration, driven by technological advancements, transportation, and international cooperation, has created a highly interconnected world. This interconnectedness has facilitated the flow of goods, knowledge, and people, contributing to economic prosperity and lifting many out of poverty. Countries participating in the global economy benefit from specializing in their strengths, producing goods more efficiently, and making them more affordable, thereby improving living standards. Evidence shows that globalization grants access to a wider variety of goods and services, lowers prices, creates better-paying jobs, enhances health, and raises overall living standards. Global markets enable people to access larger and more diversified markets.

Fisheries are crucial for the livelihood and food security of poor households in low-income countries. The global market for fish and fish products has grown significantly, driving operators in the fisheries value chain to seek new opportunities, reduce production costs, and make profitable investments. This market evolution includes new products, production methods, fragmented and outsourced production processes, and changing value chains. As part of a global commons, fisheries require regional and international cooperation to ensure sustainable and responsible exploitation of fish stocks.

Globalization in fisheries involves economic integration, trade deregulation, macroeconomic policy convergence, changes in the role of nation-states, and the proliferation of supranational agreements and regulatory bodies. These changes impact human well-being, environmental conservation, equity, democratic decision-making, food security, and poverty alleviation. The impact of globalization on fisheries is complex, with differing opinions on its benefits. Some argue that the gains from fisheries exports balance the negative impacts on food security. This article delves into both the positive and negative effects of globalization on fisheries.

Impacts of globalization on fisheries:

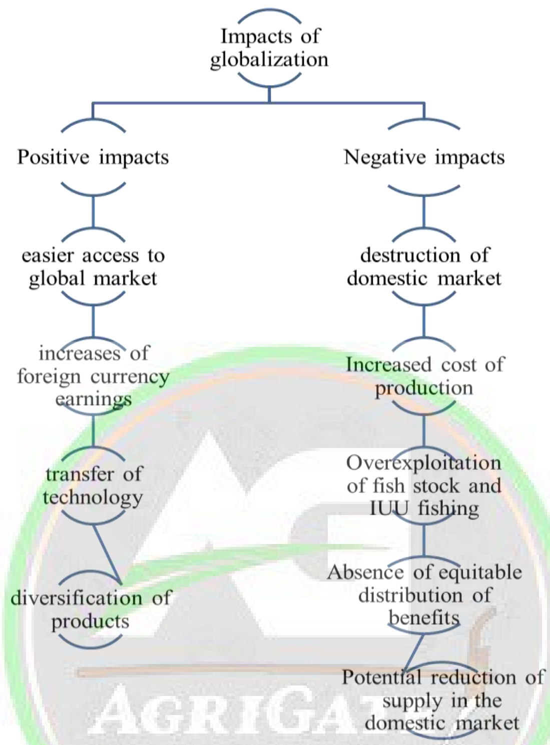
The emergence of globalization in the fisheries sector brings about both positive and negative impacts. On the positive side, it enhances the fisheries sector's contribution to various aspects of the economy, society, and politics. However, it primarily affects the resources of the particular area.

a) Positive impact includes:

- The access to overseas markets and diversification has led to higher incomes in the fisheries sector, including artisanal fishing. This is complemented by increased intra-regional trade and access to technological advancements.
- As incomes rise and populations grow, a demand for fish products is heightened, boosting foreign currency earnings and Gross Domestic Product (GDP) contributions.

- Local markets now feature better quality fish products, enhancing competitiveness internationally. Trade will be increasingly essential for redistributing global aquatic products and food security.

Figure 1: Impacts of Globalization



b) Negative impacts include:

i) Destruction of the Domestic market:

The global trade of fish and fishery products benefits the nation but also impacts the domestic market. The influx of fish and fishery products from global trade profoundly impacts the domestic market, altering consumer preferences with its diverse offerings. The allure of foreign products, often available at lower prices than their domestic counterparts, reshapes consumption patterns, exerting significant pressure on local industries. Domestic companies grapple with the formidable challenge of competing in a global market characterized by intense competition and price disparities. Consequently, the waning demand for domestically sourced fishery commodities precipitates a decline in local production levels, exacerbating unemployment woes within the domestic economy. This intricate interplay between international trade dynamics and domestic economic forces underscores the complexities of navigating the modern marketplace.

ii) Increased cost of production:

Fulfilling the requirements of imported countries, such as international standards and quality control, inevitably increases the cost of production for fish and fishery products. This includes investments in safety protocols, environmental compliance, and personnel training. Moreover, navigating complex regulatory frameworks and certification processes adds another layer of expense to the production cycle. Failure to meet these expectations risks exclusion from export markets and reputational damage. Thus, while globalization offers market expansion opportunities, it imposes significant financial strain on producers in this sector. Mitigating these effects requires comprehensive strategies to ensure equitable participation in the global economy.

iii) Overexploitation of fish stock and IUU fishing:

Due to the increase in global trade, the demand for fish leads to overexploitation of fishery resources and puts pressure on fish stocks due to globalization. Globalization has spurred population expansion and increased per capita consumption, leading to heightened demand for seafood. However, this demand has resulted in overfishing to satisfy global needs, putting immense pressure on marine ecosystems. Moreover, human-accelerated climate change exacerbates the strain on oceans, further impacting fish stocks. Consequently, despite depending on marine resources, the current level of fishing is unsustainable, necessitating global attention to address the problem of overfishing. Globalization exacerbates the challenge of illegal, unreported, and unregulated (IUU) fishing practices by facilitating the movement of illegally caught seafood across borders. The interconnectedness of global markets enables IUU fishers to exploit regulatory loopholes and evade detection, exacerbating the problem. Furthermore, the demand for cheap seafood in global markets incentivizes IUU fishing, driving overexploitation of fish stocks and environmental degradation. Without robust international cooperation and enforcement mechanisms, globalization perpetuates the cycle of IUU fishing, undermining efforts for sustainable fisheries management and posing threats to marine ecosystems worldwide.

iv) Absence of equitable distribution of benefits:

It is difficult for small countries to compete with global markets, increasing poverty within fishing communities. In the globalized marketplace, the lack of equitable distribution of benefits poses significant challenges for small countries, particularly in their ability to compete with larger, more economically powerful players. This disparity often results in small-scale fishing communities facing increased poverty levels. Globalization amplifies this issue by facilitating the dominance of larger corporations and nations in the market, leaving smaller players struggling to keep pace. As a consequence, these marginalized fishing communities find themselves unable to access the resources and opportunities necessary for sustainable livelihoods. Addressing this imbalance requires concerted efforts to create fairer trade policies and ensure that the benefits of globalization are distributed more equitably, thus safeguarding the welfare of all stakeholders involved in the fishing industry.

v) Potential reduction of supply in the domestic market:

Higher prices for tradable fish products in domestic markets may result in a potential reduction of fish supply from local fisheries to domestic market. Globalization often leads to higher prices for tradable fish products in domestic markets due to increased competition and the integration of global supply chains. As multinational corporations expand their operations, they may prioritize exporting to more lucrative international markets over supplying locally. This trend can result in a potential reduction of fish supply from local fisheries to domestic markets, impacting both consumers and local fishers. Additionally, the reliance on imported fish products may undermine the economic viability of domestic fishing industries.

Conclusion

In conclusion, while globalization has brought about significant advancements and opportunities, it has also introduced challenges, particularly in industries such as fishing. Addressing these challenges necessitates a nuanced approach that balances the benefits of globalization with the imperative to safeguard local economies, ensure equitable distribution of benefits, and combat harmful practices such as overexploitation and illegal fishing. We can foster sustainable growth in the fishing industry by implementing targeted policies.

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BIOFUEL PRODUCTION FROM MARINE MICROALGAE

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Abstract

Microalgae offer a promising renewable solution for sustainable biofuel production and bioproduct synthesis due to their adaptability and rich chemical composition. This overview explores their potential in producing biodiesel, bioethanol, biobutanol, and hydrogen gas, along with high-value bioproducts. Historical origins and recent advancements in microalgal biofuel production methods, including cultivation, harvesting, and downstream processing, are highlighted for their impact on cost-effectiveness and commercial viability. Integration with CO_2 mitigation and wastewater treatment enhances sustainability, while seawater-based cultivation addresses land constraints. Lipid-rich microalgae, particularly suited for biodiesel production, undergo lipid extraction and transesterification processes to yield high-quality fuel. Biogas and bio-hydrogen production further expand the microalgal biofuel portfolio. Economic and environmental considerations, such as energy inputs and land use implications, stress the importance of sustainable practices. Continued research and innovation are essential for fully realizing microalgae's potential as a sustainable biofuel source, fostering a cleaner energy future.

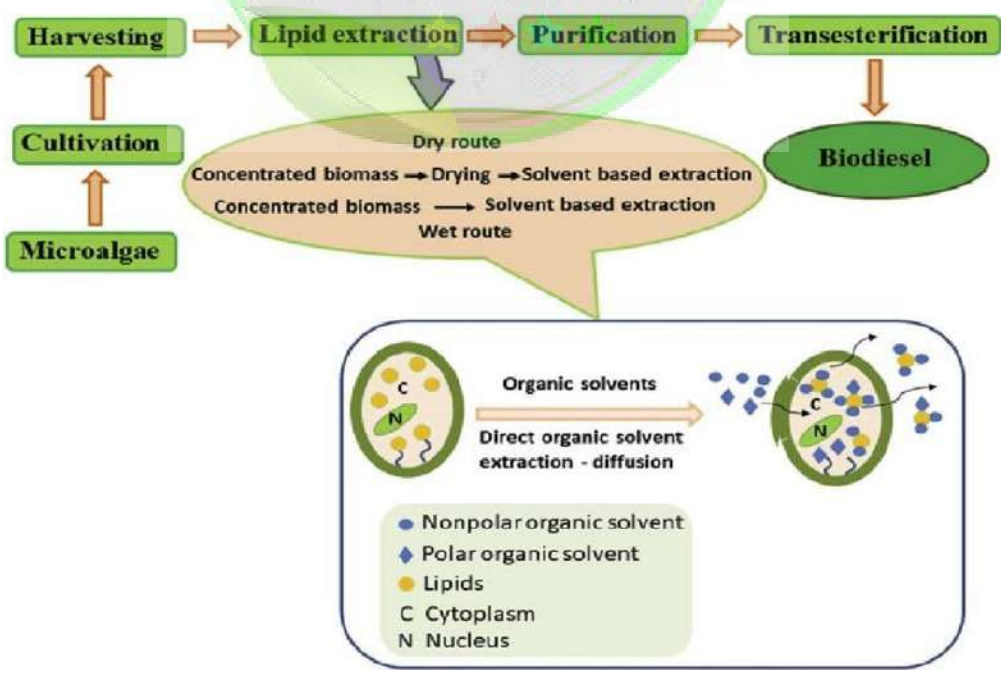
Introduction:

Microalgae as biomass can have a balanced mix of carbohydrates, protein, and lipids, or it can have a chemical composition that varies depending on the type of algae used. Marine algae are environmentally significant and have been utilized as food and medicine for ages. In addition to being food sources, a variety of marine algae species also yield extracts that find widespread usage in the dairy, cosmetic, pharmaceutical, and food industries. Algae can be utilized to produce hydrogen gas, bioethanol, butanol, and biodiesel. In 1955, Meier introduced the idea of using algae as fuel to produce methane gas from carbohydrate fractional cells. Oswald and Golueke expanded on this concept in 1960. These biofuels can be produced in conjunction with flue gas CO_2 mitigation, wastewater treatment, and high-value chemical synthesis. Moreover, marine microalgal species can be cultivated in seawater for microalgal farming purposes. It is anticipated that the utilization of microalgae cultivation in conjunction with downstream processing methods such as harvesting, drying, and thermochemical processing will increase the biofuel's economic viability.

Biofuel production:

Bio-oil from microalgae can be chemically transesterified into biodiesel or utilized directly as fuel. Other microalgae biofuels, including ethanol and methane, are produced as organic substrates that microorganisms may ferment in an anaerobic condition. According to the International Energy Agency's main scenario, the demand for these fuels rises by 56% globally to 79 million tonnes between 2022 and 2027. In fact, from 9% in 2021 to 13% in 2027, wastes and residues are predicted to be employed in the manufacture of biofuels.

Figure 1: Key steps of microalgae- based biodiesel production process



Lipid production:

Microalgae contains the lipids as shown in Table 1, which displays the microalgae's lipid content and FA profile. Carbohydrates can be transformed to ethanol and H_2, proteins to biofertilizer raw materials, and lipids to biodiesel. Plant and animal compounds that are structural esters of higher FAs are collectively referred to as lipids. However, given adverse environmental conditions, a large number of algae modify their lipid biosynthesis pathways to generate and accumulate neutral lipids (20–50% dw), primarily triglycerides. It is necessary to extract neutral lipids in order to produce biodiesel.

Some microalgae have an oil content that exceeds 80% of the dry weight of the algae. Algal cells can be thermochemically liquefied to yield microalgal oil, or they can be biologically converted to lipid or hydrocarbon. When it comes to getting energy out of these organisms, direct extraction of microalgal lipids seems to be a more effective way than fermenting algal biomass to make ethanol or methane (FAO).

Table 1 Composition of lipids of Selected Microalgae, % Dry Matter Basis (Raja *et al.*, 2013)

Species	**Lipid (%)**
Scenedesmus obliquus	12 – 14
Scenedesmusquadricauda	1.9
Chlorella vulgaris	14 – 22
Spirogyra sp	11 – 21
Tetraselmismaculata	3
Spirulina plantesis	4 – 9
Spirulina maxima	6 – 7

Products:

Fatty Acids:

Similar to other seed plants, the plastid produces the microalgae fatty acids, which are subsequently stored in triglycerides by means of a biochemical process that involves the plastid envelope and the endoplasmic reticulum. Then, using transesterification conversion processes, some fatty acids can be transformed into biodiesel. Long-chain polyunsaturated fatty acids (LC-PUFAs), including arachidonic acid, eicosapentaenoic acid, and docosahexaenoic acid, are particularly abundant in microalgae. Because of their high nutritional value, these LC-PUFAs are becoming more and more popular in the industries of cosmetics, medicine, and health food.

Biodiesel:

Triglycerides and a mono-alcohol (usually methanol or ethanol) react under the catalysis of alkali, acids, or enzymes to generate biodiesel through a process known as mono-alcoholic transesterification.

Biogas:

Encouraging the growth and cost-effective optimization of the complete biofuel production process requires the production of biogas. Anaerobic digestion, which turns organic material into biogas with the help of bacteria, requires a high moisture content and organic waste. For the purpose of producing biogas, both harvested biomass and residual biomass (after lipid extraction) are suitable feedstocks. The biogas that is produced is primarily composed of methane (55–75%) and CO_2 (25–45%), with trace amounts of other gases, like hydrogen sulfide (below the regulatory limit), also present.

Bio-hydrogen:

Hydrogen is a crucial fuel that finds extensive uses in heavy oil upgrading (such as bitumen), fuel cells, and coal liquefaction. (Wang Z *et al*., 2007). Various biological processes can produce hydrogen, such as the steam production of bio-oils, the dark and photofermentation of organic materials, and the photolysis of water, which is facilitated by specific microalgal species.

Economic Potential of biofuel:

The significant increase in transportation vehicles in recent years has led to an increase in fuel demand, and until 2040, the transportation sector's energy consumption is predicted to rise by 1.4% annually. Because of its outstanding characteristics, biodiesel produced from microalgae biomass has the potential to expand the fuel industry. Compared to terrestrial oilseed crops, microalgae have a faster rate of conversion of solar energy into biomass and oil, and they require a much broader range of water and land quality. The main issue with microalgal biofuels, meanwhile, is that they are more expensive than fuels derived from petroleum. The cost of microalgal biofuels is currently higher than that of petroleum fuel. Accordingly, new affordable techniques for producing biofuel from microalgae that is efficient are needed to promote the switch from the use of finite natural resources to renewable energy sources.

To ensure the economical generation of biodiesel from microalgae, three key elements must be taken into account: (i) the availability of feedstock, (ii) synthetic processing and extraction and (iii) quality of biodiesel from microalgae to meet the fuel standard requirements (Nagarajan *et al*., 2013). Some species, such as *Botyrococcus* sp., have the capacity to synthesize up to 90% of their dry weight in lipid. The resulting lipids are triacylglycerides (TAG), which are composed of both unsaturated and saturated fatty acids. Better choices are *Nannochloris* sp., *Dunaliella* sp., and *Chlorella* sp. because of their relatively high lipid productivity, which can be more than 50% by weight (Mata *et al*., 2010).

Growth factors including nutrition availability and environmental circumstances are the main determinants of the lipid content of microalgae. While other environmental parameters including temperature, pH, and salinity have been proven to affect the lipid production, it has been observed that microalgae under nitrogen starvation yield increased lipid output. The most widely utilized method for inducing lipid formation in microalgae is nitrogen deprivation.

Environmental Considerations of Biofuel:

Reduced emissions of carbon dioxide and sulfur dioxide are one of the many environmental benefits of biofuels. In comparison to terrestrial plants, the efficiency of CO_2 fixation by green algae, or chlorophytes, was found to be approximately 10–50 times higher. Biodiesel from microalgae does not contain any aromatics or other hazardous compounds that would affect the atmospheric air quality. Despite the presence of heavy metals, nitrates, and sulphates, flue gas has been found to be a more productive substitute for pure CO_2 in microalgae culture. Microalgae biofuel production is a sustainable and environmentally friendly technique, particularly when combined with wastewater or flue gas treatment.

Conclusion

Microalgae, comprising both prokaryotic and eukaryotic photosynthetic microorganisms, offer rapid growth potential owing to their simple structure. They've garnered attention for producing diverse biofuels like biodiesel, bio-oil, bio-syngas, and bio-hydrogen, suggesting sustainability in biofuel production. With judicious management of land and water resources, microalgal biofuels can feasibly meet escalating energy demands. Integrating microalgal farming with CO_2 mitigation and wastewater treatment, particularly in seawater environments using marine species, presents a viable option for populous coastal regions. Moreover, microalgae are prolific producers of novel bioproducts, finding applications across medicine, food, and cosmetics industries. Employing a biorefinery approach by combining microalgal farming with biofuel production is poised to enhance overall cost-effectiveness. Critical to this endeavor are ongoing technological advancements in photobioreactor design, biomass harvesting, drying, and downstream processing, which promise to streamline operations and drive commercial success in microalgae-based biofuel production.

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ARTIFICIAL INTELLIGENCE: THE FUTURE OF FARMING

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Introduction

Agriculture is crucial for economic sustainability and long-term growth. It has evolved from food production to processing, production, marketing, and distribution of crops and livestock products. As the global population grows, it's essential to review agricultural practices and introduce innovative approaches. AI can help improve crop yields and reduce the use of water, fertilizers, and pesticides. This can reduce the impact on natural ecosystems, increase worker safety, and keep food prices down. The application of

AI technologies will ensure food production keeps pace with the increasing population.Artificial Intelligence (AI) is rapidly becoming prevalent in areas like agriculture, where 30.7% of the world's population is engaged on 2781 million hectares of land. Agriculture faces challenges such as pest and disease infestation, inadequate chemical application, improper drainage, weed control, and yield prediction. AI techniques have been used to capture the intricacies of each situation and provide solutions best suited for that particular problem.

Applications of AI in Agriculture

Traditional farming involves various manual processes. Implementing AI models can have many advantages in this respect. By complementing already adopted technologies, an intelligent agriculture system can facilitate many tasks. AI can collect and process big data while determining and initiating the best course of action. Here are some common use cases for AI in agriculture:

Optimizing automated irrigation systems

AI algorithms enable autonomous crop management. When combined with IoT (Internet of Things) sensors that monitor soil moisture levels and weather conditions, algorithms can decide in real-time how much water to provide to crops. An autonomous crop irrigation system is designed to conserve water while promoting sustainable farming practices.

Detecting leaks or damage to irrigation systems

AI plays a crucial role in detecting leaks in irrigation systems. By analysing data, algorithms can identify patterns and anomalies that indicate potential leaks.

Machine learning (ML) models can be trained to recognize specific signatures of leaks, such as changes in water flow or pressure. Real-time monitoring and analysis enable early detection, preventing water waste together with potential crop damage.

AI also incorporates weather data alongside crop water requirements to identify areas with excessive water usage. By automating leak detection and providing alerts, AI technology enhances water efficiency helping farmers conserve resources.

Crop and soil monitoring

The wrong combination of nutrients in soil can seriously affect the health and growth of crops. Identifying these nutrients and determining their effects on crop yield with AI allows farmers to easily make the necessary adjustments.

While human observation is limited in its accuracy, computer vision models can monitor soil conditions to gather accurate data. This plant science data is then used to determine crop health, predict yields while flagging flag any particular issues.

In practice, AI has been able to accurately track the stages of wheat growth and the ripeness of tomatoes with a degree of speed and accuracy no human can match.

Detecting disease and pests

As well as detecting soil quality and crop growth, computer vision can detect the presence of pests or diseases. This works by using AI to scan images to find mold, rot, insects, or other threats to crop health. In conjunction with alert systems, this helps farmers to act quickly in order toexterminate pests or isolate crops to prevent the spread of disease.

AI has been used to detect apple black rot with an accuracy of over 90%. It can also identify insects like flies, bees, moths, etc., with the same degree of accuracy. However, researchers first needed to collect images of these insects to have the necessary size of the training data set to train the algorithm with.

Monitoring livestock health

It may seem easier to detect health problems in livestock than in crops, in fact, it's particularly challenging. Thankfully, AI can help with this. For example, a company called CattleEye has developed a solution that uses drones, cameras together with computer vision to monitor cattle health remotely. It detects atypical cattle behaviour and identifies activities such as birthing.

CattleEye uses AI and ML solutions to determine the impact of diet alongside environmental conditions on livestock and provide valuable insights. This knowledge can help farmers improve the well-being of cattle to increase milk production.

Intelligent pesticide application

By now, farmers are well aware that the application of pesticides is ripe for optimization. Unfortunately, both manual and automated application processes have notable limitations. Applying pesticides manually offers increased precision in targeting specific areas, though it might be slow and difficult work. Automated pesticide spraying is quicker and less labour-intensive, but often lacks accuracy leading to environment contamination.

AI-powered drones provide the best advantages of each approach while avoiding their drawbacks. Drones use computer vision to determine the amount of pesticide to be sprayed on each area. While still in infancy, this technology is rapidly becoming more precise.

Yield mapping and predictive analytics

Yield mapping uses ML algorithms to analyse large datasets in real time. This helps farmers understand the patterns and characteristics of their crops, allowing for better planning. By combining techniques like 3D mapping, data from sensors and drones, farmers can predict soil yields for specific crops. Data is collected on multiple drone flights, enabling increasingly precise analysis with the use of algorithms.

These methods permit the accurate prediction of future yields for specific crops, helping farmers know where and when to sow seeds as well as how to allocate resources for the best return on investment.

Automatic weeding and harvesting

Similar to how computer vision can detect pests and diseases, it can also be used to detect weeds and invasive plant species. When combined with machine learning, computer vision analyses the size, shape, and colour of leaves to distinguish weeds from crops. Such solutions can be used to program robots that carry out robotic process automation (RPA) tasks, such as automatic weeding. In fact, such a robot has already been used effectively. As these technologies become moreaccessible, both weeding and harvesting crops could be carried out entirely by smart bots.

Sorting harvested produce

AI is not only useful for identifying potential issues with crops while they're growing. It also has a role to play after produce has been harvested. Most sorting processes are traditionally carried out manually however AI can sort produce more accurately.

Computer vision can detect pests as well as disease in harvested crops. What's more, it can grade produce based on its shape, size, and colour. This enables farmers to quickly separate produce into categories — for example, to sell to different customers at different prices. In comparison, traditional manual sorting methods can be painstakingly labour-intensive.

Surveillance

Security is an important part of farm management. Farms are common targets for burglars, as it's hard for farmers to monitor their fields around the clock. Animals are another threat — whether it's foxes breaking into the chicken coop or a farmer's own livestock damaging crops or equipment. When combined with video surveillance systems, computer vision and ML can quickly identify security breaches. Some systems are even advanced enough to distinguish employees from unauthorized visitors.

Image-based insight generation

In the current world scenario one of the most dissertated areas in farming today is Precision farming. Imaging through drones can assist in rigorous field analysis, inmonitoring crops and scanning of fields. With a combination of Computer vision technology, drone data and IoT will ascertain that the farmers take rapid actions. Data fed from drone image could bring forth alerts in real time which would accelerate precision farming. Commercial drones makers like Aerialtronics have enforced IBM Watson IoT Platform and the Visual Recognition APIs for real time image analysis.

Optimizing AI for agriculture and agricultural processes

While the benefits of AI in agriculture are vivid, it can't function without other digital technologies already in place such as big data, sensors, and software. Likewise, other technologies need AI for them to work properly. In the case of big data, the data itself is not particularly useful. What matters is how it's processed and implemented.

Big data for informed decision-making

Combining AI wit allows farmers to get recommendations with big data analysts based on accurate, real-time information, thereby increasing productivity hence reducing costs.

IoT sensors for capturing and analysing data

IoT sensors together with other supporting technologies (AI drones, GIS, and other tools) can monitor, measure, and store training data on various metrics in real time. By combining these devices with AI, farmers can obtain accurate information quickly.

Intelligent automation and robotics for minimizing manual work

AI combined with autonomous tractors and IoT helps to solve the commonproblem of labour shortages. Robotics are also important — agricultural robots are already being used for manual tasks like produce picking. Robots are more advantageous for farm work purposes due to their ability to work longer hours, enhanced precision on top of reduced susceptibility to errors.

Challenges of AI in agriculture

Many people perceive AI as something that applies only to the digital world, with no relevance to physical farming tasks. This assumption is usually based on a lack of understanding of AI tools. Most people don't fully understand how AI works, especially those in non-tech-related sectors, leading to slow AI adoption across the agricultural sector. Although agriculture has seen countless developments in its long history, many farmers are more familiar with traditional methods. A vast majority of farmers are unlikely to have worked on projects that involved AI technology due to the following reasons:

Large upfront costs

While AI solutions can be cost-effective in the medium-to-long-term, there's no escaping the fact that the initial investment can be very expensive. With many farms and agribusinesses struggling financially, adopting AI may be impossible for the time being, especially in the cases of small-scale farmers and those in developing countries. However, the cost of implementing AI may drop as technologies develop. Businesses also have the opportunity to explore funding resources such as government grants or private investment.

Reluctance to embrace new technologies and processes

Unfamiliarity often makes people hesitant to adopt new technologies creating difficulties farmers to fully embrace AI, even when it offers undeniable benefits. Resistance to innovation alongside some reluctance to take a chance on new processes hold back the farming methods development as well as the sector's profitability in general. Farmers need to understand that AI is only a more advanced version of simpler technologies for field data processing. To convince agricultural workers to embrace AI, the public and private sectors should provide motivation, resources, and training. Governments must also develop the regulations needed to assure workers that the technology is not a threat.

Lack of practical experience with new technologies

Aspects of the agricultural industry differ in their technological advancement around the world. Some regions could leverage all the benefits AI, though there are some hurdles in countries where next-gen agricultural technology is uncommon. Technology companies hoping to do business in regions with emerging agricultural economies may need to take a proactive approach. In addition to providing their products, they must offer training and ongoing support for farmers and agribusiness owners who are ready to take on innovative solutions.

A lengthy technology adoption process

In addition to a lack of understanding and experience, the agricultural sector generally lacks the infrastructure needed for AI to work. Even farms that already have some technology in place may find it difficult to move forward. Infrastructure is also a challenge for AgTech providers and software companies. One of the main ways to overcome this is by approaching farmers gradually: for instance, offering the use of simpler technology first, such as an agricultural trading platform. Once farmers get used to a less complicated solution, providers can add additional tools and features.

Technological limitations

As AI is still developing, the technology will have constraints. Accurate models depend on diverse, high-quality data, which can be scarce in agriculture. For robots with sensors, limitations can make adapting to changing farming environments difficult. Overcoming these limitations requires ongoing research and analysis of data. Farmers should also remain involved with decision-making rather than entirely handing control over to AI. Monitoring AI decisions manually is likely to be useful during the early stages of adoption.

Privacy and security issues

There is still a general lack of regulations relating to the use of AI across all industries.

Particularly, implementing AI in precision agriculture and smart farming raises various legal questions. For example, security threats like cyberattacks and data leaks may cause farmers serious problems. It’s even conceivable that AI-based farming systems could be targeted by hackers with the aim of disrupting food supplies.

Future of AI in Agriculture

Global population is expected to reach more than nine billion by 2050 which will require an increase in agricultural production by 70% in order to fulfil the demand. Only about 10% of this increased production may come from unused lands and the rest should be fulfilled by current production intensification. In this context, the use of latest technological solutions to make farming more efficient remains one great necessity. Present strategies to intensify agricultural production require high energy inputs and market demands high quality food. Robotics and autonomous systems (RAS) are set to transform global industries. These technologies will have great impact on large sectors of the economy with relatively low productivity such as agro-food (food production from the farm to the retail shelf).

Conclusion

In AI and IoT Agriculture is considered important for human survival. Supporting current traditional agricultural practices with the latest IoT/ AI technology can improve performance, quality and productivity capacity. In addition, it has identified intelligent, sustainable agricultural sectors, namely human resources; plants; weather; soil; insects; pregnancy; agricultural products; irrigation / water; livestock; equipment; and fields. AI technology helps farmers to analyse soil / soil / plant life etc. and save time and allow farmers to plant the right crops in each season with the best yields. Direct planting can reduce water use, use land efficiently, and can be planted in urban areas on buildings. It can reduce the problems of unemployment. Allows predictions for next year's crop seasons / weather / weather / rain etc. AI-based forecasts allow pesticide / crop / crop suggestion in the right place at the right time before major disease outbreaks occur.

With so much untapped space in agriculture to intervene with automated response systems, there is a great opportunity for the agricultural industry to use emerging catboat technology to assist farmers with answers to all their questions and to provide appropriate advice and recommendations in their specific ideas. Farm-related problems. This encourages the growth of the AI market in agriculture.

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WORK-LIFE BALANCE: NAVIGATING THE MODERN ERA'S PROFESSIONAL AND PERSONAL DEMANDS

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Abstract

The modern era's relentless pursuit of productivity has placed immense pressure on individuals to balance their professional and personal lives. This article delves into the domain of work-life balance (WLB), highlighting its significance, challenges, and strategies to achieve an equilibrium that promotes both personal well-being and professional satisfaction. Drawing from contemporary research, the article examines the intricate relationship between WLB, job satisfaction, and organizational commitment, and explores how flexible work arrangements and supportive work environments can mitigate work-family conflicts. This synthesis underscores the necessity of WLB in enhancing overall life satisfaction and organizational efficiency.

Keywords: work-life balance, well-being, job satisfaction, work-family conflicts

Introduction

In today's fast-paced world, the boundary between work and personal life has become increasingly blurred. The advent of technology, changing family dynamics, and the rise in dual-income households have intensified the need for a balanced approach to managing professional responsibilities and personal obligations. The concept of work-life balance (WLB) is pivotal in this context, as it addresses the equilibrium required to fulfil both work and family roles without compromising either.

Work-life balance is defined as a flexible work arrangement that enables employees to meet their work obligations while also managing their personal lives effectively (Redmond, Valiulis, & Drew, 2006). Achieving this balance is crucial not only for individual well-being but also for organizational efficiency. Research indicates that individuals who perceive a balance between their work and life roles tend to be happier and exhibit better physical and mental health (Haar, 2014).

The positive correlation between WLB and job satisfaction is well-documented. Aryee, Srinivas, and Tan (2005) found that higher levels of WLB are associated with greater job satisfaction and organizational commitment. Similarly, Clarke *et al.* (2004) verified that better WLB is linked to higher marital satisfaction, suggesting that the benefits of WLB extend beyond the workplace into personal life.

Challenges in Achieving Work-Life Balance

Despite its importance, achieving WLB remains a significant challenge for many individuals. The primary hurdles include long working hours, inadequate childcare support, and the cultural expectation to be constantly available for work. Increased working hours have been shown to exacerbate the imbalance between work and home life (Sturges & Guest, 2004). Additionally, the lack of proper childcare arrangements can drastically increase family-work conflict (Frone *et al.*, 1992).

Women, in particular, face unique challenges in achieving WLB due to the dual pressures of career and household responsibilities. Schueller and Alexandra (2012) highlighted the persistent imbalance experienced by women as they attempt to juggle professional ambitions with traditional housewife roles. This often leads to the phenomenon known as the "glass ceiling," where women find it difficult to advance to leadership positions while managing family obligations.

Strategies for Enhancing Work-Life Balance

Organizations play a crucial role in fostering WLB. Implementing family-friendly policies and flexible work arrangements can significantly reduce work-family conflicts. For instance, allowing remote work and flexible scheduling can help employees better manage their personal and professional responsibilities (Peeters *et al.*, 2005).

Greenhaus, Collins, and Shaw (2003) proposed three strategies for achieving work-family balance: time balance, involvement balance, and satisfaction balance. Time balance involves equally dividing time between work and family; involvement balance ensures an equal psychological presence in both domains; and satisfaction balance focuses on deriving equal satisfaction from work and family roles. These strategies provide a comprehensive framework for individuals seeking to achieve WLB.

Moreover, supportive work environments that prioritize employee well-being can enhance job performance. According to the happy/productive worker hypothesis (Lucas & Diener, 2003), individuals with high psychological well-being tend to perform better at work (Wright & Cropanzano, 2004). Therefore, organizations that minimize work-life conflicts can create positive psychological capital among employees, fostering creativity and productivity (Hao *et al.*, 2015).

Conclusion

In conclusion, the modern era demands a reevaluation of how we manage work and personal life. Achieving work-life balance is not only beneficial for individual health and happiness but also essential for organizational success. By adopting flexible work arrangements, providing adequate support systems, and fostering a culture that values employee well-being, organizations can help employees navigate the complexities of modern professional and personal demands. As research continues to evolve, it is clear that the pursuit of WLB is a worthwhile endeavor that promises significant returns for both individuals and organizations.

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UNFOLDING TREASURE OF PEARL MILLET BY UNTANGLING ENIGMA OF GRAIN COLOUR

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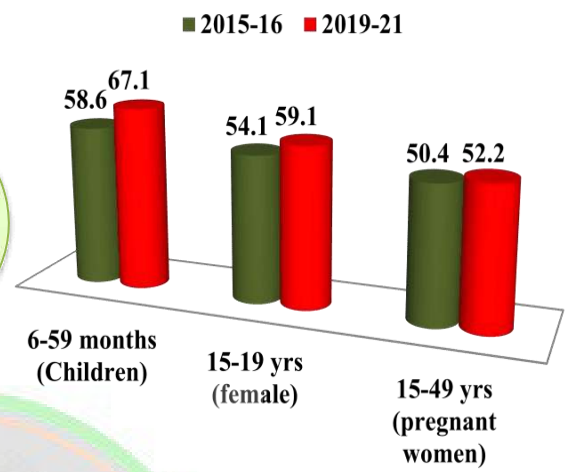
Introduction

Malnutrition is the sad part of the Indian growth story. In an effort to move closer to a "Malnutrition Free India" by the end of 2022, the Indian government proclaimed **2018** as the **"National Year of Millets".** The Indian Council of Agricultural Research (ICAR) has set minimum Fe and Zn levels for identification and release of national varieties of pearl millet. Additionally, the UN Food and Agriculture Organization (FAO) declared **2023** the **"International Year of Millets".** Pearl millet is a rich source of energy (361 Kcal/100g) which is comparable with commonly consumed cereals such as wheat (346 Kcal/100g), rice (345Kcal/100g) maize (125 Kcal/100g) and sorghum (349Kcal/100g) as per the Nutritive value of Indian foods. It has a better amino acid balance than sorghum, it is low in lysine, tryptophan, threonine and the sulphur-containing amino acids. Pearl millet contains various essential micro-nutrients needed by the body. It is rich in B-vitamins, potassium, phosphorous, magnesium, iron, zinc, copper and manganese.

The presence of omega-3 fatty acids in pearl millet as compared to any other cereal grain highlights its potential in prevention and treatment of cardiovascular diseases, diabetes, arthritis and certain types of cancer. Pearl millet is a gluten free grain and is the only grain that retains its alkaline properties after being cooked which is ideal for people with wheat allergies. One should remember that around 68 per cent of Indians live on under-$2 per day, and hence are on margins of poverty. Both anaemia and stunting are, to a large extent, consequences of diet deficiency in Fe and Zn. The data in NFHS 2019-21, show that among all age groups, the highest spike in anaemia was reported among children aged 6-59 months — 67.1 % (NFHS- 5) from 58.6 %

(NFHS-4, 2015-16). The data show that the number was higher in rural India (68.3 %) compared to urban India (64.2 %).

So, this age group of population needs more attention to get India ride off hidden hunger by improving their diet pattern, adding more nutritious stuff in their diet and enhancing their acceptability



It was reported that pearl millet grains have greater levels of the inorganic minerals Fe (22- 154 ppm) and Zn (19-121 ppm) than other staple cereals including wheat (10 ppm), rice (28 ppm), and maize (22 ppm). The pearl millet is part of a new "Green Revolution" with which biologists and nutrition experts hope to liberate the world from hunger and micronutrient- associated malnutrition. Due to its nutritional momentousness, it should not only be consumed by poor people, should also be included by rich in their diet. It is rich and cheap source of nutrition therefore can be considered as a possible alternative for food diversification; However rapid development of rancidity and its typical grey colour due to polyphenolic pigment present in the peripheral area of grains restricts its effectual use in domiciliary and food industry.

Self-sufficient Group

1. Self-capable of arranging food
2. Better accessibility of fruits, vegetables and milk
3. Supplements can be added in diet in case of any deficiency
4. Easily available
5. More conscious about balance diet
6. Comparatively less malnutrition and anaemic

Dependent

1. Mainly depends on ration provided by government
2. Cut down consumption of fruits, vegetables and milk due to low income.
3. Cannot afford supplements in their diet.
4. Sometime supplements are not available within their reach
5. Have little knowledge about balanced diet
6. Having more cases of malnutrition

It is like discounting the trove of nutrition due to outlooks just as migrant ignore cave of treasure due to its appearance. Earlier villagers put a lot of effort to reduce pearl millet flour colour. Villagers did not process their millet by a completely dry process. Following mortar and pestle dehulling, the grains were often soaked overnight in water containing tamarind pods or sour milk. This additional processing had a remarkable whitening effect; the original grey colour disappearedcompletely.

In modern era, no one prefers to eat pearl millet as they have not much time and they mostly depend on ready to use products. Children which are the most targeted group to improve the Global hunger index of India select their food generally on the basis of colour as they prefer light colour food more. So, the ultimate solution is for plant breeders to breed for varieties with light colour.

The new study is to look into the inheritance of cream grain colour of pearl millet so that this trait can be transfer to our commercial grown improved varieties using backcross method to increase consumption of pearl millet in daily diet of individual specially in mixed grain flour to enhance nutritional availability. In agricultural history also a lot of examples are there on grain colour importance like one of the revolutionary changes by Dr. M. S. Swaminanthan (1979). Dwarf Sonora 64 and Lerma Rojo 64A were satisfactory apart from their red grain colour, mutation was initiated at the IARI to alter the colour of the grain. This line of work resulted in Sarbati Sonora from Sonora 64 and Pusa Lerma from Lerma Rojo 64A, both possessing amber grains which is mostly accepted by Indians.

In this study, cream grain colour parent plant i.e., WGI- 100 was crossed with grey grain colour plant i.e., ICMB 13222. It was observed that F1 of this cross is cream grain colour indicating that cream grain colour isdominant to grey colour.

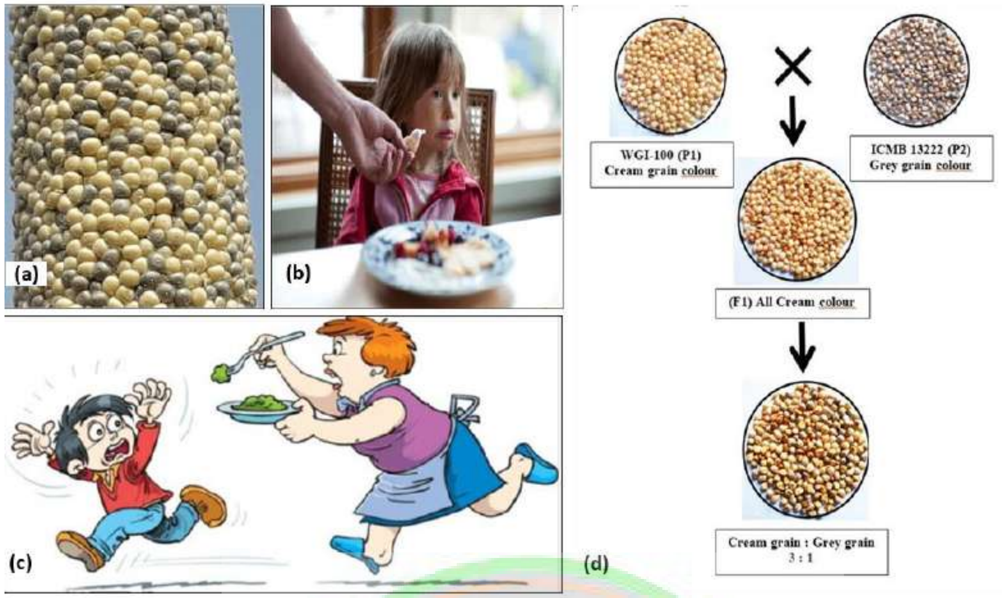


Fig: **(a)** Heterozygous panicle; **(b)** Picky eater child; **(c)** Mother wants their child to eat balanced diet but child do not prefer it due to colour; **(d)** Inheritance of Cream Grain Colour

Also, reciprocal cross shows same result representingthat no maternal inheritance is involved in grain colour pearl millet grain colour development. Then F1 plants were self-pollinated to obtain F2 plants. After self- pollinating F2 plants cream and grey colour grain were observed in 3:1 ratio suggesting that this cream grain colour is monogenic trait.

To confirm it, F2 generation was further proceeded by F3generation after selfing which leads to production of three types of plants homozygous cream, heterozygous and homozygous grey in 1:2:1 ratio. (Fig (d)).The new study also point out the location of gene on chromosomes along with markers associated with gene responsible for cream grain colour using SSR markers. The markers showing parents polymorphism was detected, and then bulk segregant analysis (BSA) was carried out to identify putative SSR markers linked to the target cream grain colour gene. Markers showing polymorphism between parents as well as cream and grey grain colour bulk segregents considered to be imputed markers. This imputed markers were used for genotypingof whole F2 mapping population (WGI-100 × ICMB 13222) to identify the marker linked to the trait of interest.

Although the cream grain colour lines are present butthey are low in performance, having high sugar content making it more vulnerable to insects, pathogens and birdsattack. Using molecular markers linked with the traits, rapid transfer of grain colour can be achieved in different

Advantage of cream grain colour in pearl millet

- More accepted and satisfied by consumer especially by children to combat hidden hunger, anemia, constipation, cancer, diabetes, celiac, diarrhea, weight loss, anti- allergic properties and non-communicable disease such as cardiovascular disease.

Fig (e)

- Correct anemic problem in women as it can be given to poor and pregnant women through Public distribution system.
- Favoured by industries as flour of this cream grain colour variety can be used to make different processed and bakery products such as biscuits, snacks, cakes, bread etc. Pearlmillet processed food give somewhat greyish tinge as shown in **Fig (e)** which is less preferred by processed food industries as well as their consumers.
- Pearl millet white colour flour can be mixed with wheat flour for daily consumption.
- Also increase in global temperatures and water deficit will be responsible for substantial reduction of crop yields resulting in price increase and major food securityconcerns. Pearl millet may be an alternative crop that exhibits great advantageous physiological characteristics when compared to other cereals as it is resistant to drought, low soil fertility, high salinity and high temperature tolerance.
- Can be added in mid-day meals besides rice and wheat to liberate India from micronutrient malnutrition and improve global hunger index.

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NANOTECHNOLOGY FOR PLANT DISEASE CONTROL

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Introduction

Nanotechnology stands as a captivating and rapidly progressing field with the potential to revolutionize various domains including science, technology, medicine, and agriculture. The transformation of macroscopic materials into nano-sized particles (1-100 nm) bestows them with novel characteristics, leading to distinct behaviors. These nanoparticles can be synthesized through diverse methods, primarily chemical and biological, with the former being more commercially prevalent. In agriculture, nanoparticles hold promise for crop protection, particularly in managing plant diseases. They can either exert direct effects on pathogens akin to traditional chemicals or serve as carriers for active ingredients such as pesticides or host-defense inducers, targeting specific pathogens (Khan and Rizvi, 2014).

1. History of Nanotechnology Timeline:

- 5th century: A Roman Cup (Lycurgus cup) made of nanosized gold clusters displayed varying colors depending on external or internal illumination.
- 1857: Michael Faraday provided insights into the optical properties of nanometer-scale metals.
- 1959: Richard Feynman delivered a seminal talk on nanotechnology titled "There is plenty of room at the bottom".
- 1974: Norio Taniguchi coined the term "Nanotechnology."
- 1982: Gerd Binnig and Heinrich Rohrer invented the scanning tunneling microscope.

- 1986: Gerd Binning, Calvin Quate, and Christopher Gerber invented the atomic force microscope.
- 1986: The first book on nanotechnology, titled "Engines of Creation: The Coming Era of Nanotechnology," was published.
- 1996: The Nobel Prize was awarded for the discovery of a new form of carbon: a molecule consisting of sixty carbon atoms (C_{60}).
- 2007: India launched the National Nano Mission.

2. **Nanoparticles come in various forms, each offering unique properties and applications:**

- **Metallic Nanoparticles:** Engineered metals at the nanoscale, shaped into cubes, spheres, bars, and sheets.
- **Fullerenes:** Pure carbon molecules composed of at least 60 atoms arranged in a spherical structure.
- **Carbon Nanotubes:** Graphene sheets rolled into single or multiple tubes, possessing remarkable strength and conductivity.
- **Quantum Dots:** Semiconductor nanoparticles that emit specific colors when illuminated by light, useful in imaging and displays.
- **Dendrimers:** Nanomaterials with tree-like structures extending from a central core, often used in drug delivery and diagnostics.
- **Nanoshells:** Concentric sphere nanoparticles with a dielectric core and a metallic shell, offering tunable optical properties.

3. **Characteristics of nanoparticles include:**

- Small size (1-100 nm) with high electrical and heat conductivity.
- Large surface-to-volume ratio, enhancing reactivity and facilitating targeted delivery.
- Strong affinity to target molecules or surfaces.
- Higher chemical reactivity and surface energy compared to bulk materials.
- Ability to alter chemical and physical properties based on size and shape (Garg *et al.*, 2008).

4. **Applications of nanotechnology in plant pathology**

Detection of plant disease

Nanotechnology presents promising applications in plant pathology, particularly in the detection of plant diseases. While current techniques are still in the developmental stage, researchers are exploring the potential of nanomaterials to overcome existing limitations in diagnostic tools. Nanoparticles, when reduced to nanoscale (1-100 nm), exhibit unique properties such as large aspect ratio, modifiable physical characteristics, strong affinity to targets (especially gold nanoparticles to proteins), structural integrity despite atomic granularity, and enhanced or delayed aggregation based on surface modification. Additionally, they demonstrate improved photoemission, high electrical and heat conductivity, and enhanced surface catalytic activity (Garg *et al*., 2008; McNeil, 2011; Shrestha *et al*., 2007).

Fluorescent silica nanoprobes show promise for rapid disease diagnosis. These nanoprobes, conjugated with secondary antibodies like goat anti-rabbit IgG, enable the detection of bacterial plant pathogens like *Xanthomonas axonopodis* pv. *vesicatoria*, which causes bacterial spot on solanaceous plants. Incorporating an organic dye, tris(2,2'-bipyridyl) dichlororuthenium (II) hexahydrate (Rubpy), into the core of circular silica nanoparticles results in fluorescence, rendering them photostable and facilitating effective disease detection.

5. Nanoparticles are synthesized through two primary approaches:

a) Top-down approach:

Nanoparticles are generated by reducing the size of a suitable starting material through physical and chemical treatments.

b) Bottom-up approach:

Nanoparticles are constructed from smaller entities, such as atoms, molecules, and smaller particles. In this method, nanostructured building blocks are first formed and then assembled to create the final particle.

6. Nanotechnology plays a vital role in managing plant diseases, with various nanoparticles being commonly employed for this purpose:

- Nanochitosan
- Nanosilver
- Nanosilica
- Nanosulfur
- Nanocopper
- Silica-silver
- Chitosan-silver

- Copper-chitosan

Nanosilver: Silver, in its nanoparticle form, demonstrates potent antimicrobial properties by inhibiting enzymes in microorganisms. Nanosilver has been extensively studied and utilized, particularly in combating diseases in agriculture. It also stimulates plant growth.

Silica-silver: Combining silica, which enhances plant stress resistance, with silver, known for its antimicrobial properties, resulted in nano silica-silver particles. These particles were highly effective against various fungal and bacterial pathogens, particularly at lower doses.

Nano copper: Nano-copper has proven effective in controlling bacterial diseases such as rice bacterial blight and mung leaf spot (Gogoi *et al*., 2009).

Nano iron: Studies are exploring the use of iron nanoparticles to target specific areas of diseased plants. Coating iron nanoparticles with carbon, researchers have tested their efficacy in treating infected parts of pumpkin plants.

Carbon nanotubes: Carbon nanotubes have demonstrated growth-enhancing effects on plants like tomatoes when present in the soil during growth. They likely facilitate water uptake and plant growth by entering germinating seeds (Khodakovsky *et al*., 2000).

7. Mechanisms of various nanoparticles in managing plant diseases:

A. Chitosan:

- Interacts with fungal membranes, altering permeability and causing cell death.
- Chelates metal ions, disrupting fungal growth by depriving essential nutrients.
- Penetrates cell walls, binds to DNA, inhibiting mRNA synthesis, and disrupting protein and enzyme production.

B. Silica:

- Enhances plant disease and stress resistance.
- Stimulates plant growth and physiological activity.

C. Copper Nanoparticle:

- Generates reactive hydroxyl radicals damaging biomolecules.
- Plays a crucial role in preventing and treating diseases in various plants.

D. Zinc Nanoparticle:

- Deforms fungal hyphae, inhibiting development and leading to cell death.

E. Silver Nanoparticle:

- Exhibits broad-spectrum antimicrobial activity through various mechanisms.
- Displays higher toxicity to microorganisms than mammalian cells.
- Adheres well to bacterial and fungal surfaces, acting as an effective fungicide.
- Stimulates plant growth.

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STRATEGY TO ENHANCING YIELD IN SUMMER SEASON TOMATO (*Solanum lycopersicum* L.)

Article ID: AG-V04-I06-29

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Introduction

Tomato is one of the most important vegetable crop grown all over the world. It is consumed either raw as a salad or cooked or processed forms like tomato sauce, tomato ketchup, tomato paste etc., tomato is considered as protective food due to it contains high amount of vitamins and minerals. The plant is generally much branched and has hairy, strongly odorous, feathery leaves. Tomato plants normally set fruits at 20 – 25˚C, if the temperature is more than the optimum means it will affect the fruit set and development.

Problems in summer season production of tomato

- High temperature during the reproductive phase will increase the flower drop.
- Due to the high temperature the fruit set will affected.
- It will affect the crop growth as well as reduce the yield.

Reason

- The high temperature leads to the formation of
  - ✓ Exerted stigma,
  - ✓ Burning of anther tip,
  - ✓ Dryness of stigmatic surface,
  - ✓ Low pollen dehiscence,
  - ✓ Poor pollen viability and
  - ✓ Poor pollen tube growth resulted in poor pollination and low fruit set.

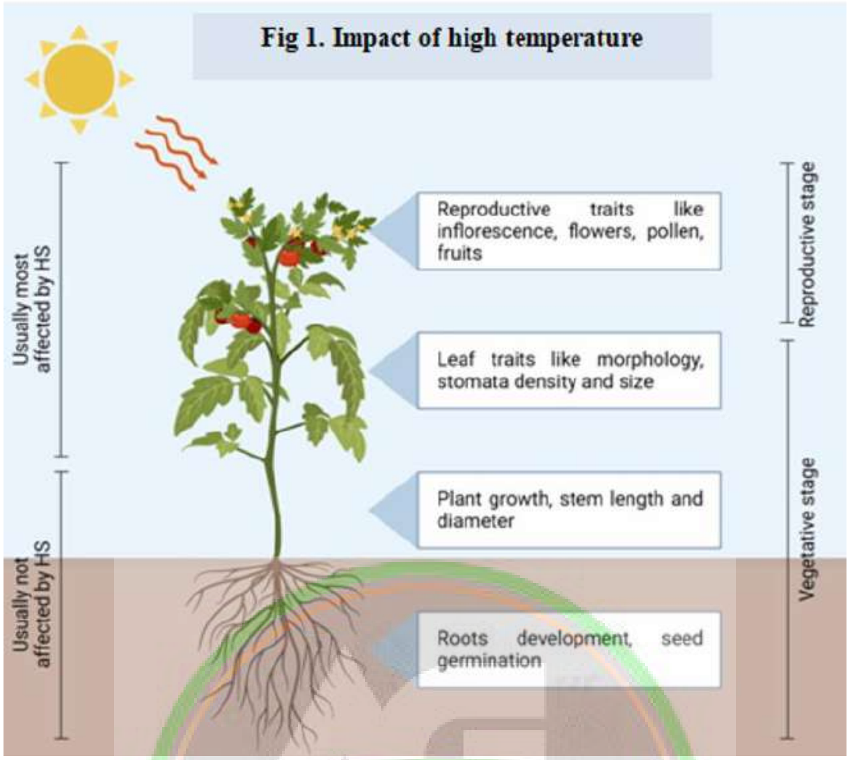

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Fig 2. Tomato Flower @ Optimum Temperature

Fig 3. Tomato Flower – Exerted

Fig 4.Tomato Flower - Burning of Anther Tip

Management

- Frequently irrigate the field, it will help to maintain the microclimate around the plants.
- Seedling soaking of IAA 50 ppm for 24 hrs and Borax 0.1% for 24 hrs.
- Foliar spray of Parachlorophenoxy Acetic Acid (PCPA) @ 50-100 ppm at flowering phase will increase the fruit set under high temperature.
- Seed soaking and foliar application of NAA 15-25 ppm at 30 Days After Transplanting will improve the fruit set.
- Foliar spray of Tomatotone (CPA 4-Chlorophenoxy acetic acid) will enhance the fruit set at high temperature.
- Soil application of Boron at 20-25 kg/ha or foliar spray of Borax 0.25%, it will increase the pollen viability, pollen tube growth as well as reduce the fruit cracking in summer tomato.
- Growing of hot set varieties like,
  - ✓ Philipine,
  - ✓ Punjab Tropic,
  - ✓ Pusa Hybrid 1,
  - ✓ Pusa Sadabahar,

- ✓ Pusa Ruby,
- ✓ Pusa 120,
- ✓ Sel 32,
- ✓ Punjap Chhuhara,
- ✓ HS 102,
- ✓ Co 3,
- ✓ Pusa Gaurav,
- ✓ Sioux and
- ✓ Pant T-2.
- ✓ Arka Ananya
- ✓ Anagha

- These varieties are withstand high temperature and sets fruits in that conditions also.

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SPEED BREEDING FOR CROP IMPROVEMENT AND FOOD SECURITY

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Abstract

Speed breeding technique is deemed as the future of plant breeding. Speed breeding refers to a quick generation advancement technology used for decreasing the time of seed to seed cycle, thereby shortening the otherwise traditionally long life cycle of a crop plant. With the use of this technology, up to 6 generations per year for photo insensitive crops and 2-3 generations per year for other crops have been obtained. This method manipulates the photoperiodic conditions and temperature requirements of crops grown in controlled poly houses. This method can accelerate crop breeding programmes and in use with other modern technologies like genome editing and high throughput genotyping platforms this technique can serve to breed new varieties at a much faster scale. This idea was originally conceptualized by NASA in order to grow food at a faster pace in space. Whether speed breeding can be applied to a particular crop or not can be checked by the help of Breeder's equation. The core recipe of speed breeding involves manipulation of light, photoperiodic regime, temperature, and humidity. This method has many applications like accelerated breeding, speeding up the process of genomic selection, boosting transgenic and CRISPR pipelines, and to study physiological traits of importance in crop plants.

Introduction

Speed breeding is a smart and fast generation advancement technology which serves to shorten the traditionally long breeding cycles, consequently accelerating the crop research programmes and cultivar development. This unique method was originally conceptualized by US

NASA in the 1980s for growing crops in space at a much faster rate.

In conventional plant breeding, after making crosses between desired parents, selection and screening for the desired traits along withgeneration advancement of the selected material is time consuming and thus 8-10 years are required for development of new variety. This slow improvement rate is attributed partly to the long generation times of crop plants. To increase productivity and stability of crops to meet the changing climatic conditions, there is need to fast-track research and also increase the rate of cultivar development. The time needed for generation of most crops poses a bottleneck in research and breeding programs thereby creating the need for technologies which accelerate plant development process and hence, generation turnover. This major problem can be conveniently overcome by use of speed breeding which involves quickening the breeding cycle from seed to seed by manipulating the photoperiodic conditions along with environmental conditions like soil media composition, temperature, spacing in the glass houses, all done to achieve rapid generation advancement.

First wheat variety which was developed through speed breeding was 'DS Faraday' by Lee Hickey. It has high protein content, tolerant to pre harvest sprouting and has milling quality. The speed breeding technique has mainly been used for purpose of research, but is now being widely adopted by the industries as well. Speed breeding in completely controlled and enclosed growth chambers can be used for accelerating plant studies and development, and can also complement in studying mutants and transformation studies.

Figure 1. 1st wheat variety 'DS Faraday' developed through Speed Breeding.

In comparison to plants grown in field, by using simple techniques of extended photoperiodic conditions (normally 22 hour light and 2 hour dark photoperiod) by using combination of light emitting diodes (LED) and metal halides in temperature controlled growth chambers results in rapid advancement of generations. This has been successfully used to achieve 6 generations per year in *Hordeum vulgare* (barley), *Triticum durum* (durum wheat), *Triticum aestivum* (spring bread wheat), *Cicer arietinum* (chickpea), *Pisum sativum* (pea) and 4 generations for *Brassica napus* (canola) as compared against 2-3 generations per year obtained through normal glasshouse conditions. The plants obtained through speed breeding have normal developmental process, can be easily crossed and have high seed germination.

Concept

Using controlled lighting and temperature control conditions plants complete their traditionally long breeding cycle in relatively shorter time by decreasing their time to flower and obtaining seed set, thereby increasing the number of generations obtained per year. For example in Arabidopsis thaliana, by manipulating the ratio of plant hormones and photoperiod along with the germination of immature seeds, 10 generations per year can be obtained by reducing the time to flowering to 20- 26 days. Similarly in case of barley (*Hordeum vulgare*) using the method of Single Seed Descent, by manipulating the photoperiod, temperature, soil fertility and using techniques of immature seed germination and embryo rescue 9 generations per year can be obtained by decreasing the flowering time to 24-36 days.

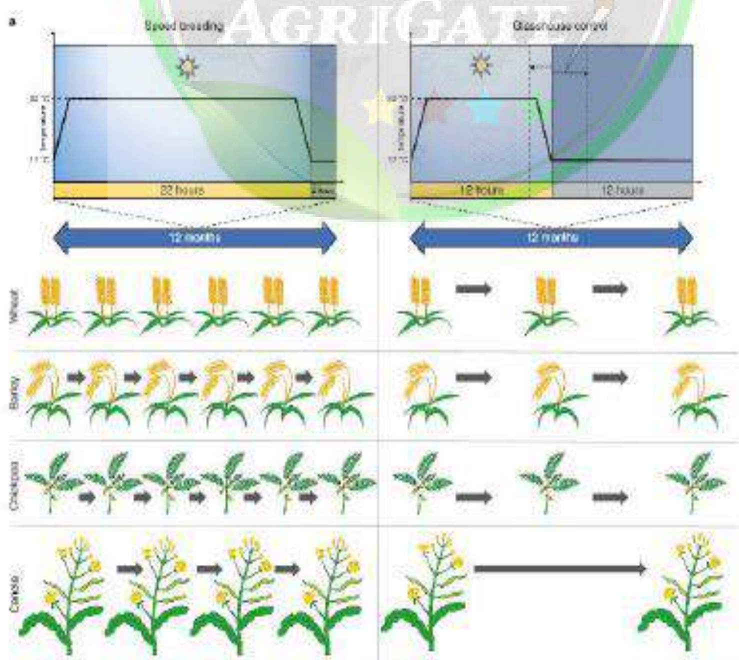

Figure 2. Comparison of number of generations of crops obtained per year through speed breeding (4-6 generations per year) versus glasshouse conditions (2-3 generations per year).

Innovation of Speed Breeding

The need for growing crops in lesser duration in space was first conceptualized by scientists in US NASA. This idea further inspired scientists in the University of Queensland and University of Sydney to engineer a platform for speed breeding.

Figure 3: Speed Breeding in environment controlled chambers.

Speed breeding takes the advantage of an artificial environment with increased duration of light to create the impression of longer daylight period to fasten the breeding cycles of the photo insensitive crops. This results in early reproduction of the crops by making use of continuous light. The speed breeding experiments in wheat have shown that comparison of quality and yield between plants grown under controlled conditions and those grown in regular glasshouse conditions was the same.

Breeder's Equation

Whether speed breeding can be applied to a particular crop or not it can be decided by the breeder's equation:

$$R_t = \frac{i r \sigma_a}{y}$$

Where,

R_t is genetic gain over time

i is selection intensity

r is selection accuracy

σ_a is genetic variance

y is years per cycle

The genetic gain over time increases with increase in selection intensity, selection accuracy and genetic variance and with decrease in years per cycle. An increase in selection accuracy increases phenotyping and reduces error.

Core Recipe of Speed Breeding

The main 'recipe' for setting up speed breeding conditions includes:

1. Light:

The preferable light for use in speed breeding is one covering the Photosynthetic ally Active Radiation (PAR) i.e. 400–700 nm with focus on red, far-red and blue range. This spectrum can be achieved by using Light Emitting Diodes (LEDs), or a combination of LEDs and halogen lamps. Photosynthetic Photon Flux Density (PPFD) of ~450–500 µmol/m2/s at plant canopy height is also recommended which can be adjusted at slightly lower or higher levels according to need of crop.

2. Photoperiodic regime: A photoperiod of 22 hour light and 2 hour darkness in diurnal cycle of 24 hours is ideal photoperiodic regime for speed breeding. Another alternative is continuous light but slight period of darkness is known to improve the health of plant.

3. Temperature: Ideal temperature for each crop should be applied. During photoperiod higher temperature should be maintained, while during dark period fall in temperature can help with stress recovery. Temperature has a major impact on the rate of plant development; therefore generation time can be accelerated by elevating temperature. However in some cases higher temperature may induce stress like conditions and affect performance of plant.

4. Humidity: Control over humidity even in controlled environment chambers is limited, but 60–70% RH is ideal for crop growth, this level can be modified according to type of crop. For crops more adapted to arid conditions, lower humidity level is recommended.

Figure 4. Temperature controlled glasshouses with supplemental lighting consisting of LEDs.

Procedure of Speed Breeding

A general procedure for low cost speed breeding in a homemade growth room design is as follows:

1. As an alternative to normally used Conviron BDW chamber, a room having insulated sandwich paneling fitted with seven LED light boxes (one light box per 0.65 m2) and a 1.5 horsepower inverter split system domestic air conditioner can be used.

2. The lightquantity of PAR at bench height should range from210–260 µmol/ m2s1& at 50 cm above the pot from 340–590 µmol/ m2 s1.The lights should be situated at a height of 140 cm above the bench. The room should be able to accommodate 90 pots of 20.3 cm.

3. Automatic wateringcan be achieved by using Irrigation Controller, having one solenoidper room and one spike dripper per 20.3 cm pot.

4. Thehumidity conditions should be ambient.

5. The lighting should be enriched in the blue, red and far-red part of the spectrum. It should be set to 12 hour

photoperiod and 12 hour darkness for4 weeks and then slowly be increased to 18 hour photoperiod and 6 hour darkness.

6. An air-conditioner can be used for regulation of temperature and set at 21°C during the photoperiod and 8°C in darkness.

Speed breeding approach is ideally realized using Single Seed Descent method, particularly for cereal crops. By increasing the sowing density in speed breeding, we can achive rapid cycling of many lines having healthy plants and viable seed. The plants grown under speed breeding reached anthesis in approximately half time as compared to those grown in same conditions under glasshouse conditions. The above described procedure has been used for speed breeding of wheat, barley, oat and triticale.

Harvesting of Immature Spikes

Under normal conditions 15 days are required for the storage of grains after harvest to decrease the moisture and attain natural ripening. This process is forgone in speed breeding where the harvest of plants is done just two weeks after anthesis when the spikes/pods are still green. They are then popped into hot air oven/dehydrator at 35°C for 3 days to fasten the maturity process artificially. The performance of the seeds obtained by such artificial drying is same as those obtained by normal drying except for the decrease in weight of such grains obtained by artificial drying. Such artificial drying accelerates the normal ripening process and this serves to save precious time and obtain faster seed to seed cycle, the core of speed breeding.

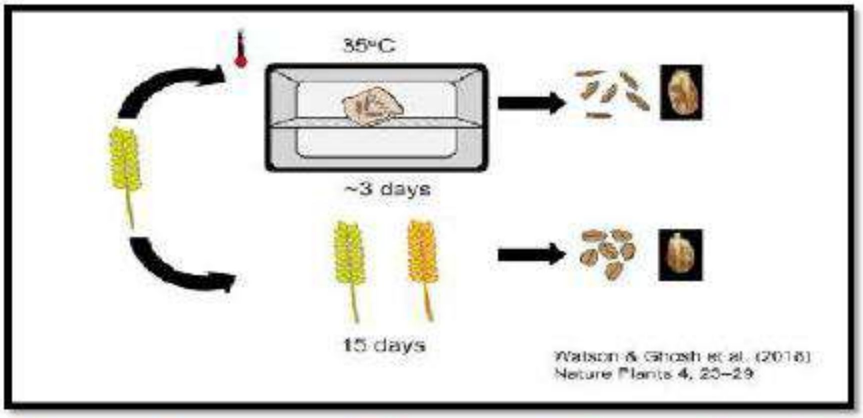

Figure 5. Comparison between normal seed ripening process (takes about 15 days) and harvesting immature spikes and their subsequent drying in dehydrator (takes about 3 days)

Applications of Speed Breeding

Applications of speed breeding are as follows:

1. Accelerating the crop improvement programmes by achieving upto 6 generations per year in photo insensitive crops and 2-3 generations in case of photo sensitive crops.
2. Speeding up the process of genomic selection.
3. An ideal method for generating large breeding populations.
4. For boosting transgenic and CRISPR pipelines.
5. It can be extended to study physiological traits of importance in crop plants.

Limitations of Speed Breeding

Some major limitations of speed breeding are:

1. The early harvest of immature seeds before completing normal ripening process interferes with the phenotyping of some seed traits.
2. There is no universal protocol of speed breeding because of diverse response of plant species to photoperiodic conditions.
3. Differential responses of various plant species when exposed to extended photoperiodic conditions.
4. Initial investment of setup is high.

Conclusion

With the ever increasing population, by 2050 farmers will have to increase food production by 60-80% to feed the potential 9 billion people. Another main issue which arises is that breeding programmes should be in tandem with the changing climatic conditions and to achieve rapid results in both these respects, speed breeding is the way to go. Speed breeding in combination with modern crop breeding technologies, including genome editing, genomic selection and high throughput genotyping, can be a great asset in accelerating the rate of crop development. Speed breeding can serve to enhance the plant growth by accelerating research program in terms of reducing the breeding cycle of plant. In India, particular success has been seen in case of wheat in speed breeding which can be extended to other crop varieties, and similar facilities can be set up for the faster development.

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MANAGEMENT STRATEGIES OF NEWLY DETECTED PEST FALL ARMY WORM, *SPODOPTERA FRUGIPERDA* IN MAIZE

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Introduction

The fall armyworm (FAW) *Spodoptera frugiperda* (Smith) is one of the devastating insect pests belonging to the family Noctuidae and falls in the Lepidoptera order. The scientific name of fall Armyworm, *Spodoptera frugiperda* is derived from the feeding habits of the larval life stage, *frugiperda* meaning "lost fruit" in Latin, as the pest can cause damage to crops resulting in severe yield loss. The Native to the tropical and subtropical region of America. It has invaded many African and Asian countries and caused huge economic losses. Incidence of FAW reported in India during May 2018 on maize. It is a polyphagous pest (Baudron *et al*., 2019) causing damage to economically important cultivated cereal crops such as maize, rice, sorghum, cotton and various vegetable crops and eventually impacts on food security (FAO, 2017; CABI, 2018; Bateman *et al*., 2018). The FAW feeds on leaves stem and reproductive parts of plant species (Tefera *et al*., 2019).

This pest is a dangerous pest. It could migrate from country to country with a high potential further spread because of its natural distribution capacity, sporadic, migratory behaviour and trans-boundary trade. It has also a number of generations per year and the moth could fly up to 100 km per single night. The early emergence in crop life cycle, voracious feeding habit, large-scale aggressive behaviour, high fecundity, fast migration, wide host-range and irreparable nature of crop damage make FAW as a key pest on maize. In this regard, present article we discuss the damage symptoms, life cycle and Management strategies of the fall armyworm *Spodoptera frugiperda* (Smith). It could be helpful to create the awareness about new pest fall armyworm identification and its management practices among the farmers.

Host range:

In addition to maize (major host), FAW can eat more than 80 plant species including rice, sorghum, cotton, sugarcane etc.

Life Cycle:

The life cycle is completed in about 30 days during the summer, but 60 days in the spring and autumn, and 80 to 90 days during the winter.

Egg

The egg is dome shaped; the base is flattened and the egg curves upward to a broadly rounded point at the apex. The number of eggs per mass varies considerably but is often 100 to 200, and total egg production per female averages about 1500 with a maximum of over 2000. The eggs are sometimes deposited in layers, but most eggs are spread over a single layer attached to foliage.

Fall armyworm egg masses. D Visser ARC-VOP Roodeplaat

Larva

There are six instars in fall armyworm. Young larvae are greenish with a black head, the head turning orangish in the second instar. In the third instar, the dorsal surface of the body becomes brownish, and lateral white lines begin to form. In the fourth to the sixth instars the head is reddish brown, mottled with white, and the brownish body bears white sub-dorsal and lateral lines. Elevated spots occur dorsally on the body; they are usually dark in colour, and bear spines. The presence of four black spots arranged in square shape on dorsal aspect of the penultimate abdominal segment is another important mark to differentiate it from other cutworms. The face of the mature larva is also marked with a white inverted "Y". Duration of the larval stage tends to be about 14 days during the summer and 30 days during cool weather.


Pupa:

Pupation normally takes place in the soil, at a depth 2 to 8 cm. The larva constructs a loose cocoon, oval in shape by tying together particles of soil with silk. If the soil is too hard, larvae may web together leaf debris and other material to form a cocoon on the soil surface.

Adult:

The adult moths, with their distinct wing patterns a combination of earthy tones with noticeable markings - are nocturnal in their habits. They have a wingspan of about 32-40 mm. The adults live for about 10 to 21 days, with their primary objective being reproduction (Chhetri LB *et al;* 2019).

Damage Symptom:

Young larvae initially consume leaf tissue from one side, leaving the opposite epidermal layer intact. By the second or third instar, larvae begin to make holes in leaves, and eat from the edge of the leaves inward. Feeding in the whorl of corn often produces a characteristic row of perforations in the leaves (shot holes). Larval densities are usually reduced to one to two per plant when larvae feed in close proximity to one another, due to cannibalistic behaviour. Larvae also will burrow into the growing point (bud, whorl, etc.), destroying the growth potential of plants, or clipping the leaves. In maize, they sometimes burrow into the ear, feeding on kernels.

Management strategies for Fall Armyworm in Maize

A. Preventive Methods

I. Monitoring Installation of pheromone traps @ 5/acre in the current and potential area of spread in crop season and off-season.

II. Cultural control

1. Summer ploughing in deep to expose pupae of FAW to predatory birds, heat etc.
2. Control is largely achieved in the northern and central India through a winter kill by exposing larvae and pupae within the upper soil surface.
3. Clean and weed free cultivation to destroy the alternate hosts and balanced use of fertilizers.
4. Early, synchronized sowing of maize to reduce the availability of crop for increase of population of FAW and further outbreak.
5. Intercropping of maize with suitable pulse crops of particular region. (eg.Maize + pigeon pea/black gram /green gram).
6. Sowing of 3-4 rows of trap crops (eg. Napier) around maize field and spray with 5% NSKE or azadirachtin 1500 ppm as soon as the trap crop shows symptom of FAW damage.
7. Apply charcoal, soil, ash, local plant extract on the whorl of maize, as an ITK.

III. Mechanical control

1. Mass trapping of male moths using FAW specific pheromone traps @ 15/acre and light trap @ 1 number/ha at early stage of crop.
2. Application of Sand + lime in 9:1 ration in whorls in first thirty days of sowing.
3. Hand picking and destruction of egg masses and neonate larvae in mass by crushing or immersing in kerosine water.
4. Application of dry sand in to the whorl of affected maize plants soon after observation of FAW incidence in the field.

B. Curative Methods:

I. Biological control

1. Augmentative release of egg parasitoid *Trichogramma pretiosum* or *Telenomus remus* @ 50,000 per acre at weekly intervals or based on trap catch of 3 moths/trap.
2. The infestation level is at 5% damage in seedling to early whorl stage and 10% ear damage, then use following entomopathogenic fungi and bacteria: *Metarhizium anisopliae*, 8 *Nomuraea rileyi*, *Beauveria bassiana*, *Verticilium lecani* (1 × 10 cfu/g) @ 5g/litre whorl application.

3. Apply Azhadirachtin 1% EC @ 10,000 ppm or neem oil @ 5 mL/lit. as oviposition deterrent on one week after sowing.

4. Erect bird perch @ 25-50 numbers/ha to attract predatory birds during early stage of the crop (up to 30 days) on feeding various larval stages of FAW.

5. Earwings (Dermaptera: Forficulidae), Lady bird beetles, Spiders, Ants and Asian bugs

two species are currently recognized to play a significant role as FAW eggs predator in maize crops (Firke *et al* 2019).

II.Chemical Control:

1. First Window (seedling to early whorl stage):

Spray 5% NSKE /Azadirachtin 1500ppm @ 5ml/l of water.

2. Second window (mid whorl to late whorl stage):

To manage 2nd, 3rd and 4th instars larvae having more than 10% foliar damage the following chemicals may be used upto early tasselling stage: Spinetoram 11.7% SC or Chlorantraniliprole 18.5% SC or Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC.

3. Third Window (8 weeks after emergence to tasseling and post tasseling):

Insecticide management is not cost effective at this stage. Bio-pesticides as recommended above to be applied.

Conclusion

The fall armyworm (FAW) *Spodoptera frugiperda* (Smith) is one of the devastating insect pests belonging to the family Noctuidae. Since it is an invasive pest in India, identification of the pest seemed to be difficult due to lack of reference materials or type specimens. The pest is rapidly spreading in India due to little characteristic behaviour like voraciousness, fast and rapid flying capacity, more 80 alternate hosts etc. IPM is most important method of pest management to manage *Spodoptera frugiperda* at below ETL. To achieve such freedom from FAW in other parts of country, periodical awareness training, workshop and FFS to maize growers are highly required. A collective and integrated action could be recommended that can play a vital role for management of the fall armyworm.

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CYBORG INSECTS: BLENDING SCIENCE FICTION WITH CUTTING-EDGE TECHNOLOGY

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Abstract

For decades, the morphology and intelligence of insects have influenced the design of robots. Cyborg insects represent a novel concept in the integration of living organisms and technology. While the idea of insect cyborgs may seem like science fiction, it is a recent development centered on using electrical stimuli to control insect movement. These hybrid insect-computer robots, or cyborgs, signify the future of compact, highly mobile, and efficient devices. While cyborgs are often associated with human-machine interfaces, the exploration of cyborg insects is equally intriguing and presents fewer ethical concerns regarding experimentation boundaries. Cyborg insects offer versatile applications spanning agriculture, search and rescue, environmental monitoring, surveillance, reconnaissance, and medical fields. By merging their innate abilities with advanced technology, they provide innovative solutions to diverse challenges across various domains.

Keywords: Cyborg insects, cybernetics, technology, Internet of things, Agriculture

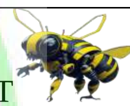
Introduction:

Scientific and technological progress has propelled humanity to new heights, with one notable achievement being cyborg technology. In the mid-1940s, Norbert Wiener introduced the concept of cybernetics, focusing on control and communication in animals and machines. Little did Wiener know that fifty years later, cybernetics would become widely known, profoundly impactful, and transformative. While cyborg insects have received less attention, they present equally intriguing advancements, with fewer ethical constraints on experimentation and development. The term "cyborg" originates from the fusion of "cybernetics" and "organism."

(Silja et al., 2022). Cyborgs are depicted as hybrids of living being and machine, blending robotic and bionic implants. In 1960, Manfred Clynes coined the term, recognizing the potential of enhancing biological functions artificially for humans.

To make cyborg insects work, scientists use sensors and actuators, like other robotic systems. They initially created wireless sensors for insects to collect data for biology studies, which helped them understand how insects' brains function and influence their behavior. Now, researchers are taking it a step further by adding actuators to control the insects' movements and eventually creating biobots. This means more than just collecting data; it involves guiding insects to perform specific tasks by controlling how they move (Tohoku University,2023). Despite their small size, these cyborg insects are being used in various fields, showing how technology and nature can come together to create new opportunities. This article delves into the integration of cyborg insects, merging elements of science fiction with cutting-edge technology.

Cyborg vs Robot

 CYBORG	ROBOT 
A cyborg is a fusion of both machinery and living organisms	A robot is an automated machine that lacks biological life.
It is a considerably complex entity.	Robots can vary in complexity, ranging from simple to highly intricate designs.
Cyborgs are not limited to humans but are also applied to other living organisms, including insects, animals and birds.	A robot is an automated machine equipped with advanced technologies, often designed to operate with minimal human intervention.
Cyborgs consist of both mechanical and biological components, blending elements of both.	A robot doesn't necessarily need to imitate or replicate human beings.

How Cyborg Insects Function?

1. **Attachment:** Scientists secure a 3D-printed mount onto the insect's dorsal surface, linking it to a secondary structure housing electronic parts, such as a printed circuit board functioning as a microcontroller.

2. **Electrode Implantation**: Minute electrodes are inserted and anchored within the insect's antennae, activating neurons associated with motor functions. By triggering these neurons, scientists can regulate the cyborg's actions; for example, activating the right antenna prompts leftward movement, and conversely, activating the left antenna induces rightward movement.

3. Communication: Employing a two-way radio and a chip antenna, the cyborg transmits data regarding its environment, position, and nearby auditory cues. Computer algorithms can interpret this data to coordinate groups of cyborg insects for search-and-rescue operations.

4. Sound Capture: Singular or tri-directional microphones affixed to the backpack capture sound and ascertain its origin. Subsequently, algorithms analyse the sound to discern if it emanated from humans, prompting the cyborg to investigate further if needed.

5. Power Supply: A compact three-volt lithium-polymer battery energizes the backpack, weighing a mere half gram. It can be detached for recharging, or alternatively, a petite solar panel can be affixed atop the backpack to replenish a drained battery within two hours.

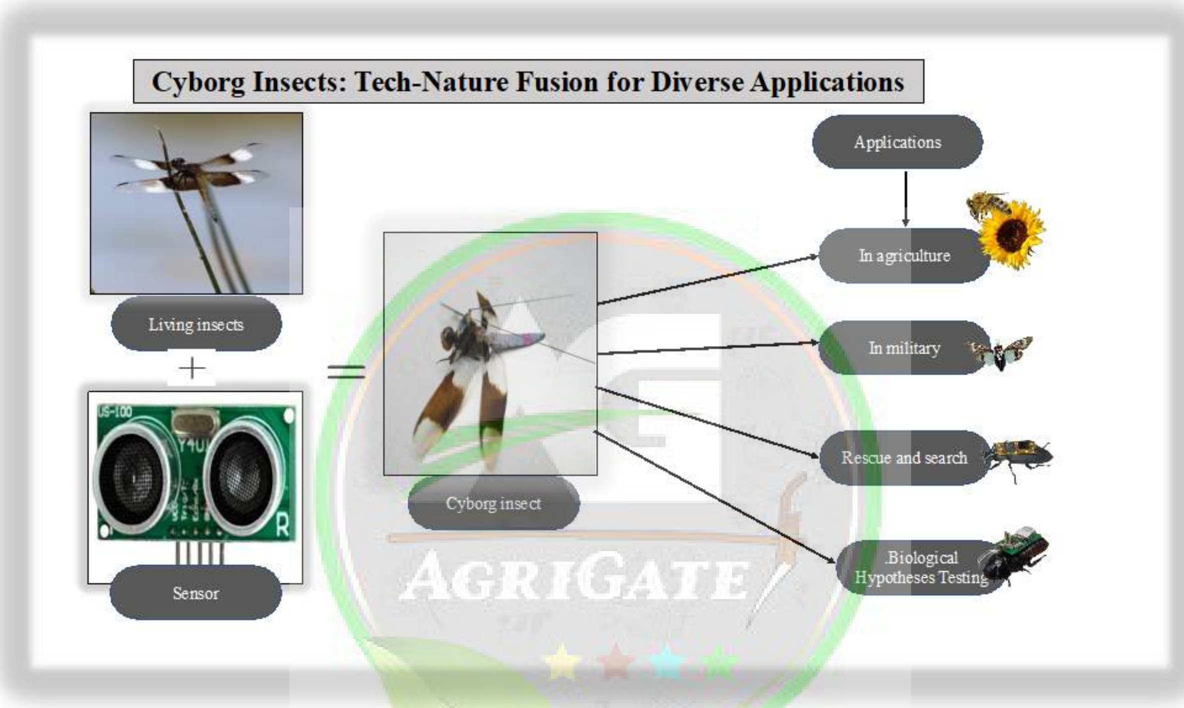
Applications:

Cyborg insects find utility in the following domains:

1. **Agriculture:** Cyborg insects have many uses in agriculture. For example, they can help with pollination by being directed to specific areas of crops. This is important for getting the most out of crops. Engineers at Draper, in Cambridge, Massachusetts, are working on a project called DragonflEye. They're trying to create dragonflies that have been changed using technology. They want these dragonflies to be able to carry things, do surveillance, or even help bees with pollination. The project is being done with the Howard Hughes Medical Institute (HHMI) at Janelia Farm(Ackerman, 2015). Additionally, cyborg insects can help control pests. They have sensors that can find pests early, so farmers can stop them before they cause too much damage. They can also be used to monitor things like soil moisture and temperature, helping farmers make better decisions about watering and fertilizing crops. Lastly, cyborg insects can even help with weed control by finding and removing specific types of weeds, which means less need for chemicals or manual labour.

2. **As spy(military applications):** The military and spy world no doubt would love tiny, live camera-wielding versions of Predator drones that could fly undetected into places where no human could ever go to snoop on the enemy. Instead of attempting to create miniature robots as spies, researchers are now experimenting with developing insect cyborgs or "cybugs" that could

work even better. Using insects as weapons is not new; it dates back to ancient times and includes tactics like releasing bees or crop-eating insects during the Cold War. Before gaining control over insect movement, their sensing abilities were utilized for tasks like detecting landmines. This technology could potentially be combined with tracking backpacks. The modern use of unmanned aerial vehicles (UAVs) in warfare has also been influenced by insects, as seen in the term "drone."



3. **Search and Rescue**: Cyborg insects are often suggested as useful tools for search and rescue operations. They can be deployed in various scenarios, such as locating lost individuals in large outdoor areas like mountains or navigating through collapsed buildings to find survivors trapped under debris. However, it's important to note that search and rescue technology can also be used for other purposes, including surveillance, policing, or military operations. Articles discussing the potential of cyborg insects in search and rescue highlight their role in both national security and saving lives. However, it's recognized that the current level of development in this field, with a success rate of around 50%, is not sufficient. Significant improvements are needed to make these technologies more effective and reliable for their intended purposes(Drew, 2023).

4. **Biological Hypotheses Testing**: cyborg insects can help scientists understand how insects fly. For example, researchers are studying why beetles stretch out their legs while flying, which

slows them down. Unlike flies and honeybees that use their eyes to steer, beetles rely on other senses. By attaching sensors to beetles and studying their flight patterns, scientists discovered that the beetles' legs are important for steering and controlling their landing. This information not only helps us understand how insects move but also gives us ideas for designing small flying robots.

Conclusion

The creation of cyborg insects is an amazing example of how biology and technology can come together to solve problems in a variety of disciplines. Cyborg insects demonstrate the promise of using creative engineering to harness nature's powers, from increasing environmental monitoring and weed management to revolutionising agriculture through pollination assistance and pest control. Initiatives such as DragonflEye show how cutting-edge technology can be radically improved by combining it with live things, opening the door for further developments in everything from surveillance to agriculture. Cyborg insects have the potential to address important issues and pave new paths for scientific research and technological advancement as this field of study develops.

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A NEW BEE SPECIES: *HOPLITIS ONOSMAEVAE*

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Introduction

Bees are essential for pollination, playing a vital role in maintaining biodiversity and boosting agricultural productivity. Discovering new bee species is significant for understanding ecological dynamics and supporting biodiversity conservation. Recently, a new species within the Megachilidae family, *Hoplitis onosmaevae*, has been identified, providing deeper insights into the rich diversity and complex relationships within the bee world.

Taxonomy and Morphology

The newly identified species, *Hoplitis onosmaevae*, is part of the Megachilidae family, renowned for its leaf-cutter and mason bees. Members of this family are characterized by their solitary nature and distinctive nesting behaviors. The species name, onosmaevae, honors the plant genus Onosma, closely associated with these bees.

Morphologically, *Hoplitis onosmaevae* exhibits several unique features that set it apart from other species in the genus. These bees have a robust body structure covered with dense hair, which is particularly effective for pollen collection. Their mandibles are notably strong and adapted for cutting leaves and petals, a common trait within the Megachilidae family. Moreover, the species displays distinct coloration patterns on their thorax and abdomen, which serve as important identification markers. These physical traits not only aid in the identification of *H. onosmaevae* but also highlight the evolutionary adaptations that have enabled these bees to thrive in their specific ecological niches.

Habitat and Distribution

Hoplitis onosmaevae has been discovered predominantly in arid and semi-arid regions, where Onosma plants are abundant. These plants are essential for the bees, serving as both a primary food source and a preferred nesting site. The close association between *H. onosmaevae* and Onosma plants underscores the importance of specific plant-bee interactions in maintaining ecosystem balance and biodiversity.

Currently, the known distribution of *H. onosmaevae* is limited to specific regions. However, ongoing research may reveal a broader geographical range. Understanding the habitat requirements and distribution patterns of *H. onosmaevae* is crucial for developing effective conservation strategies. These efforts are vital not only for the preservation of this new species but also for the protection of the broader ecological communities in which they are embedded.

Ecological Significance

The discovery of *Hoplitis onosmaevae* highlights the intricate relationships that exist within ecosystems. As a pollinator, *H. onosmaevae* plays a crucial role in the reproductive processes of Onosma plants. This relationship facilitates gene flow and helps maintain plant diversity within their habitats. The mutualistic interactions between *H. onosmaevae* and Onosma plants are vital for the stability and resilience of these ecosystems.

Furthermore, the presence and population dynamics of *H. onosmaevae* can serve as important indicators of environmental health. Changes in their populations may reflect shifts in habitat quality and the availability of floral resources. Monitoring the health and stability of *H. onosmaevae* populations can provide valuable insights into broader ecological changes and help identify potential environmental threats.

Conservation Implications

The identification of *Hoplitis onosmaevae* underscores the urgent need for targeted conservation efforts. Protecting the habitats where these bees and their host plants thrive is essential for their survival. Effective conservation strategies should focus on preserving natural habitats, promoting sustainable land-use practices, and enhancing floral diversity through habitat restoration initiatives.

In addition to habitat protection, raising public awareness about the importance of pollinators can foster community involvement in conservation efforts. Educational programs and citizen science initiatives can play a significant role in monitoring bee populations and their habitats. These programs not only provide valuable data for researchers and conservationists but also engage the public in meaningful conservation activities.

Conclusion

The discovery of *Hoplitis onosmaevae* enriches our understanding of bee diversity and highlights the complex interdependencies within ecosystems. As research continues to uncover and document biodiversity, the importance of conserving pollinators and their habitats becomes increasingly evident. Future research and conservation efforts will be crucial in ensuring the survival of this newly identified species and the ecological communities it supports.

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A QUICK INSIGHT TO SPEED BREEDING IN PULSES

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Introduction

Pulses, defined as legumes that yield dry seed for human use, are agronomically valuable plants, both in the food system and in the field. Pulses form an important component of the human diet, provide animal feed, and replenish soil fertility through biological nitrogen fixation. However, breeding pulses is a slow process as conventional pulse breeding is time consuming requiring selection of complementary parental genotypes with desired traits, followed by crosses and a series of selection and advancement of superior progenies to release cultivars. These, conventional breeding procedures can take more than 6-7 years to develop and 3-5 years to release a variety. Furthermore, continuous field selection and early rapid generation advancement require skill and expertise in phenotyping, as well as production resources to manage a large number of segregating populations before yield and economic traits can be evaluated once homozygous or genetically stable breeding populations have been created. In this context, speed breeding emerges as a technology that allows for reducing generation cycle time and accelerate genetic gain.

Speed Breeding and its Application

The speed breeding concept was inspired by NASA's efforts to grow crops in space, using an enclosed chamber and an extended photoperiod. Speed breeding can be defined as a suite of techniques that involves the manipulation of environmental conditions under which crop genotypes are grown, aiming to accelerate flowering and seed set, to advance the next breeding generation as quickly as possible (Wanga et al. 2021). The method saves breeding time and resources through rapid generation advancement. Applications of SB include the development of biparental and more complex mapping populations, pyramiding traits, hastening backcrosses, phenotyping adult plant traits, mutant studies, and genetic transformation experiments. Recent research has shown the power of combining emerging techniques, such as gene editing, high-throughput phenotyping and genotyping, genomic selection (GS), and MAS, with SB for accelerating crop improvement. Furthermore, the cost and space requirements for producing a large number of inbred lines can be minimized by planting them at high plant densities.

Speed Breeding in Pulses

Several speed breeding systems have been developed in pulses. Watson et al. (2019) demonstrated a considerable reduction in the breeding cycle time by taking up to 6 generation in a year of rabi season legumes such as chickpea and field pea. Samineni et al. (2020) developed a protocol for increasing the number of generation cycles per year in chickpea (*Cicer arietinum* L.). The mean total numbers of generations produced per year were respectively 7, 6.2, and 6 in early-, medium-, and late-maturing accessions. Mobini and Warkentin (2016) achieved up to five generations within a year in pea, using a hydroponic system with in vivo embryo rescue. For speed breeding of pigeon pea, Saxena et al. (2019) employed early maturating photoperiod-insensitive genotypes, and showed its potential to deliver new early maturing cultivars with the successful reduction of up to 4-5 years. Lulsdorf and Banniza (2018) developed a system that achieves six generations per year and can be applied in combination with screening for disease resistance in lentil. Mobini et al. (2020) reported significantly reduced time to first seed and increased pollen viability in plants exposed to cold treatment. Increased pollen viability also showed a significant positive correlation with seed set. The growing numbers of examples of speed breeding signifies its utility in accelerating breeding programs especially through rapid generation advance.

Conclusion

Pulses are crucial to provide affordable protein to growing human population worldwide. Speed breeding can improve genetic gains in pulse breeding programs by increasing the number of plant generations in a year, subsequently reducing the length of the breeding cycle. It is important to note that, as with any breeding technology, speed breeding has limitations and can only be used to accelerate those parts of a breeding or research programme that would benefit from accelerated generation advancement. Speed breeding must therefore be integrated with other breeding techniques as well as cost-effcient high-throughput genotyping and phenotyping to speed up the generation, testing and commercial release of orphan crop varieties. The SB protocols are now available for small- or broad-scale adoption and further modifications based on local needs/innovations. The SB protocols can, thus, be progressively improved and combined with modern breeding techniques to realize their potential for the identification and transfer of genes critical to crop resilience and adaptation. However, the adoption of speed breeding in many developing countries, especially in public plant breeding programmes, is limited by the lack of trained plant breeders and plant breeding technicians, and a lack of the requisite infrastructure. But the results of speed breeding for enhancing generation turnover in pulses breeding programs are encouraging, and enhanced adoption of these modern approaches will be crucial to improve the rate of genetic gain in pulses.

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APOMIXIS- AWAY FROM MIXING

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Introduction

Apomixis, derived from two Greek word "APO" (away from) and "mixis" (act of mixing or mingling). It refers to the occurrence of an sexual reproductive process in the place of normal sexual processes involving reduction division and fertilization. In other words apomixis is a type of reproduction in which sexual organs of related structures take part but seeds are formed without union of gametes. Seeds formed in this way are vegetative in origin. When apomixis is the only method of reproduction in a plant species, it is known as obligate apomixis. On the other hand, if gametic and apomictic reproduction occurs in the same plant, it is known as facultative apomixis. The first discovery of this phenomenon is credited to Leuwenhock as early as 1719 in *Citrus* seeds. Apomixis is widely distributed among higher plants. More than 300 species belonging to 35 families are apomictic. It is most common in Gramineae, Compositae, Rosaceae and Rutaceae. Among the major cereals maize, wheat and pearl millet have apomictic relatives.

Types of apomixis

1.Recurrent Apomixis

An embryo sac develops from the MMC or megaspore mother cell (archesporial cell) where meiosis is disturbed (sporogenesis failed) or from some adjoining cell (in that case MMC disintegrates). Consequently, the egg-cell is diploid. The embryo subsequently develops directly from the diploid egg-cell without fertilization. Somatic apospory, diploid parthenogenesis and diploid apogamy are recurrent apomixis. However, diploid parthenogenesis / apogamy occur only in aposporic (somatic) embryo-sacs. Therefore, it is the somatic or diploid aposory that constitutes the recurrent apomixis. Such apomixis occurs in some species of *Crepis*, *Taraxacum*, *Paa* (blue grass), and *Allium* (onion) without the stimulus of pollination. *Malus* (apple), and *Rudbeckia* where pollination appears to be necessary, either to stimulate embryo development or to produce a viable endosperm.

2. Non -recurrent Apomixis

An embryo arises directly from normal egg-cell (n) without fertilization. Since an egg-cell is haploid, the resulting embryo will also be haploid. Haploid parthenogenesis and haploid apogamy, and androgamy fall in this category. Such types of apomixis are of rare occurrence and they do not perpetuate.

3. Adventive Embryony

Embryos arise from a cell or a group of cells either in the nucellus or in the integuments, e.g. in oranges and roses. Since it takes place outside the embryo sac, it is not grouped with recurrent apomixis, though this is regenerated with the accuracy. In addition to such embryos, regular embryo within the embryo sac may also develop simultaneously, thus giving rise to poly-embryony condition, as in *Citrus, Opuntia.*

4. **Vegetative apomixis**

In some cases like *Poa bulbosa* and some *Allium, Agave* and grass species, vegetative buds or bulbils, instead of flowers are produced in the inflorescence. They can also be reproduced without difficulty. However, Russian workers do not group this type of vegetative reproduction with apomixis.

Now, different apomictic phenomena in each of the recurrent and non-recurrent apomicts are considered in relation to the development of the embryo sac or embryo.

Development of apomictic embryo sac

1. Apospory:

It involves the development of embryo sac either from the archesporial cell or from the nucellus, or from other cell: It is of two types:

(i).Generative or haploid apospory*:* If the embryo sac develops from one of the megaspores (n), the process is called generative or haploid apospory. Since it cannot regenerate, as it is haploid and fertilization fails, the process gives rise to non-recurrent apomicts.

(ii) ***Somatic or diploid apospory****:* When diploid embryo sac is formed from nucellus or other cells, the process is termed as somatic or diploid asopory. Since it regenerates without fertilization, it is recurrent.

Development of apomictic embryo

1. Parthenogenesis:

This refers to the development of embryo from egg-cell without fertilization, e.g. in some cases in com, wheat, tobacco. This is also of two kinds:

(i) ***Haploid parthenogenesis****:* The embryo develops from egg-cell without fertilization in a haploid embryo-sac produced by generative apospory. It is non-recurrent in nature. (ii) (ii).***Diploid parthenogenesis****:* The embryo develops from egg-cell without fertilization in a diploid embryo-sac arising from somatic apospory. It is recurrent type.

2. Apogamy

This is related to the development of embryo not from the egg-cell but from any one of the synergid or antipodal cells within the embryo sac, without fertilization. This is haploid or diploid. In the haploid apogamy, the embryo arises from any cell other than the egg-cell without fertilization in haploid embryo -sac formed by generative apospory. By virtue of its haploid nature, it is also non-recurrent apomixis. Whereas in case of diploid apogamy, embryo develops from any cell other than the egg-cell without fertilization in a diploid embryo-sac developed by somatic apospory. It is recurrent type.

3. Androgamy

It is the development of embryo neither from egg cell nor from synergids or antipodals, but from one of the male gametes itself, inside or outside the embryo-sac. Since it is haploid, it is non-recurrent apomixis.

In another phenomenon, i.e. parthenocarpy, seedless fruits are formed from ovary without fertilization. Normally, fertilization stimulates the ovary to become enlarged and form fruit. But in case of parthenocarpy, such stimulation may be received even from incompatible pollination.

Genetics of apomixis: Crosses between amphimicts and apomicts belonging to the same species, segregate for the two types of individuals in advanced generations. This suggests that apomixis is a genetically controlled phenomenon in plants. Stebbins (1958) states that, as a rule, the apomictic condition is recessive to sexuality, although polyploid apomicts show tendency towards dominance. However, this recessiveness is not usually due to a monogenic difference. Since there is frequent reversion of apomicts to normal sexuality or sterility or some abnormal genetic behaviour in crosses involving in apomict and an amphimict or involving two apomicts of diverse origins, it appears that a successful apomictic cycle is the result of an interaction of many genes which tend to break on hybridization. It is only in the relatively simple types of apomixis, like adventive embryony and vegetative reproduction that simple genetic beheaviour can be expected.

Advantages of apomixis in plant breeding:

The two sexual processes, self-and crossfertilization, followed by segregation, tend to alter the genetic composition of plants reproduced through amphimixis. Inbreeding and uncontrolled out breeding also tend to break heterozygote superiority in such plants. On the contrary, apmicts tend to conserve the genetic structure of their carriers. They are also capable of maintaining heterozygote advantages generation after generation. Therefore, such a mechanism might offer a great advantage in plant breeding where genetic uniformity maintained over generation for both homozygosity (in varieties of seIfers), and heterozygosity (in hybrids of both seIfers and outbreeders) is the choicest goal. Additionally, apomixis may also affect an efficient exploitation of maternal influence, if any, reflecting in the resultant progenies, early or delayed because it causes the perpetuation of only maternal individuals and maternal properties due to prohibition of fertilization. Maternal effects are most common in horticultural crops, particularly fruit trees and ornamentalplants.

Thus, in short the benefits of apomixis, insofar as their utility in plant breeding is concerned, are:

1. Rapid multiplication of genetically uniform individuals can be achieved without risk of segregation.
2. Heterosis or hybrid vigour can permanently be fixed in crop plants, thus no problem for recurring seed production of F 1 hybrids.
3. Efficient exploitation of maternal effect, if present, is possible from generation to generation.
4. Homozygous inbred lines, as in corn, can be rapidly developed as they produce sectors of diploid tissues and occasional fertile gametes and seeds.

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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.

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

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

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.

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POPULAR RICE LANDRACES OF INDIA

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Introduction

India has a broad spectrum of Rice landraces cultivated by the traditional farmers of different states, over several generations, thereby conserving the enormous genetic diversity in Rice. These landraces are potential sources for cultivar development of improved varieties through conventional and modern breeding strategies. There are numerous rice landrace varieties suitable for different duration (*viz.*, extra early, early, medium, long, extra long and very long durations), different cropping pattern (*viz.*, mixed cropping, plantation cropping, alley cropping as well as bund cropping) different cultivation conditions viz., direct dry sowing, direct wet sowing, transplanting, delayed transplanting), different ecosystem (*viz.*, alkalinity, salinity, sodicicity, shade condition, sandy soil condition, deep water and mountainous soil condition), resistance to many pest (viz., stem borer, BPH, WBPH, leaf folders) and diseases (viz., blast, smut, rice tungro virus), for different dishes (for plain rice, Idli making), special purpose (for puffed rice, flaked rice, briyani rice, special festive dishes,) different coloured rices (*viz.*, black rice, red rice, purple rice, yellow rice and white rice) and for special utility purposes (*viz.* for thatching, long straw for animal feed, soil conservation on slopy lands).

Further rice landraces are rich in slow release carbohydrates, balanced amino acid composition protein, good faty acids, sufficient vitamins and minerals and especially rich in many phytofactors specific to each type of landrace. As such below is a tabulation of most popular rice landraces presently cultiated in Tamil Nadu as well as elsewhere in other states of India. This information might be very useful for Rice breeders who are interested in improving yield and quality improvement.

Sl. No.	Traditional variety	Duration	Special feature	Popular in states
1	Aanai Komban	140-150	It helps in easy digestion, relieves constipation, helps the body get rid of excess fluid, and strengthens the nerves. The rice does not get spoil for a long time, so it can be used as a snack on trips.	Tamil Nadu
2	Abhaya	120-125	Good for digestion and has anti-inflammatory properties.	Andhra Pradesh
3	Adukku nel	60-70	High in healthy fats, high in iron, iron, magnesium, zinc, calcium, and phosphorus. This rice promotes blood growth and bone strength. Strengthens body muscles., Yield - 4t/ha.	Tamil Nadu
4	Amaravati	130-140	Good for digestion and has anti-inflammatory properties.	Andhra Pradesh
5	Ambemohar	135	It is rich in iron, lime, zinc, ash, and magnesium minerals.	Maharashtra
6	Arcot Kichali Samba	145	Its rice is rich in nutrients and has a high immune system. Cattle love to eat their hay. Excessive milk secretion. You can make food, biryani, and multi-course meals in it.	Tamil Nadu
7	Arikalu	120-130	High iron content and is good for diabetics.	Telangana
8	Arupatham Kuruvai	90-100	It cures anaemia due to its high iron content. It is rich in fibre, which relieves constipation. It also cures nervous diseases. Yield - 4.10t/ha.	Tamil Nadu
9	Arupatham Samba	115-120	It cures anaemia due to its high iron content. It is rich in fibre, which relieves	Tamil Nadu

Sl. No.	Traditional variety	Duration	Special feature	Popular in states
10	Athur Kichilli Samba	135-145	Old rice is disease resistant. This rice can be cooked for pregnant women to secrete breast milk and maintain health. Drought tolerant.	Tamil Nadu
11	Balamani	130-140	Rich in antioxidants and good for digestion.	Tamil Nadu
12	Bhatta	140-150	Good for digestion and has anti-inflammatory properties.	Odisha
13	Bhavani Samba	130-140	Increases digestion and rejuvenates and energizes the body, reducing sugar and bad cholesterol. Rich in iron and B vitamins.	Tamil Nadu
14	Bora Saul	150-160	Rich in minerals and used in traditional medicine.	Assam
15	Chak Hao	120-140	Used in Manipuri cuisine and has antioxidant properties.	Manipur
16	Champa Shashti	135-145	Rich in antioxidants and good for digestion.	Odisha
17	Chennellu	120-130	High iron content and is good for diabetics.	Andhra Pradesh
18	Chilakamma Sannalu	125-130	Good for digestion and has anti-inflammatory properties.	Andhra Pradesh
19	Chinnar	145-150	Excretes waste. Cleanses the blood and bowels. Cures joint pain. Rice is rich in minerals including iron, zinc, and potassium. It is rich in calcium.	Tamil Nadu
20	Chittimutyalu	130-140	Good for digestion and has anti-inflammatory properties.	Andhra Pradesh
21	Dagad Phool	120-130	Good for digestion and has anti-inflammatory properties.	Maharashtra

22	Dehradoon Basmati	120-125	Aromatic and used in making biryani and pulao.	Uttarakhand
23	Dubraj	130-140	Good for diabetics and has anti-inflammatory properties.	Madhya Pradesh, Chhattisgarh
24	Gandhakasala	120-130	Good for digestion and has anti-inflammatory properties.	Andhra Pradesh, Telangana
25	Garudan Samba	150-160	Makes the body strong. It is rich in iron and reduces anaemia. Heals kidney infections, and heals the body.	Tamil Nadu
26	Gobindobhog	130-140	Aromatic and used in making sweets.	West Bengal
27	Gotan	125-135	Rich in antioxidants and good for digestion.	Rajasthan
28	Ilupai Poo Samba	125-135	Rich in iron, old rice is immune-boosting. Stabilizes bones. It has high immunity due to the high number of antioxidants. Relieves joint pain and paralysis. Since it is herbal rice, it can be cooked and eaten with other rice. Drought tolerant.	Tamil Nadu
29	Indrayani	120-130	Aromatic and used in making biryani and pulao.	Maharashtra
30	Jaya	120-130	Good for digestion and has anti-inflammatory properties.	Tamil Nadu
31	Jeerakasala	130-140	Used in Ayurveda for treating fever and urinary tract infections.	Kerala, Tamil Nadu
32	Jyothi	120-130	Rich in antioxidants and good for digestion. Blast tolerant.	Andhra Pradesh
33	Kaar Arisi	120-130	It gives the body vigour and strength and is an excellent remedy for diabetes, rheumatism, and skin diseases.	Tamil Nadu
34	Kaivarach	140-150	Contains many mineral salts including calcium, magnesium, zinc, potassium, and	Tamil Nadu

	Samba		iron. Rice is rich in folic acid and antioxidants needed for fetal development. Eliminates nerve-related problems.	
35	Kala Jeera	130-140	Rich in antioxidants and good for digestion.	West Bengal, Odisha
36	Kalo Mota	120-130	Rich in antioxidants and good for digestion and blast tolerant.	UP, Haryana and Assam
37	Kalanamak	115-120	It contains more than forty types of bios- and mineral nutrients. Improves brain nerve function, kidney function, skin diseases, blood purification, and cancer removal and prolongs life. Suitable for pregnant women. Causes sattvic character. Buddha is said to have eaten. Drought tolerant.	Uttar Pradesh
38	Kandasali	120-125	It is medicinal rice. Gives blood development and hormonal balance in girls. Best medicine for thyroid problems. It removes toxic waste from the body and makes the endocrine glands work smoothly.	Tamil Nadu
39	Karunguruvai	120-130	Natural Viagra to strengthen the body. Over time, pregnant women are given proper fertility and healthy delivery. As it releases sugar slowly, it is good for diabetes. Siddha doctors use elephant feet to cure disease.	Tamil Nadu
40	Karuppu Kavuni	145-150	It is a remedy for dog bites.	Tamil Nadu
41	Karuthakaar	135-140	Cures leprosy, diabetes, jaundice, and haemorrhoids.	Tamil Nadu
42	Kattu Ponni	130-140	Since rice is rich in fibre, it can relieve constipation. It is rich in calcium which strengthens the bones. Being easily digested, it gives strength to the elderly.	Tamil Nadu
43	Kattuyanam	130-140	High in protein and good for diabetic	Tamil Nadu

44	Kichilli Samba	135-140	Increases immunity. You will get wealth and physical strength. It helps mothers to secrete breast milk and strengthen their bodies. The variety is suitable for daily cooking and eating by people of all ages. Controls sugar. Root-knot nematode tolerant.	Tamil Nadu
45	Kothamalli Samba	135-140	The vital nutrients of this rice support blood clotting in case of injuries in the body. Rice is ideal for diabetes control, obesity reduction and body nutrition.	Tamil Nadu
46	Kottara Samba	145-150	Increases immunity. Brain development and intelligence will improve. Puberty women can increase their body strength if they eat this rice regularly. Reduces bad cholesterol.	Tamil Nadu
47	Kudavazhai	115-120	Provides excellent relief from diseases such as blood pressure, diabetes, constipation, stomach ulcer, digestive disorder, and chronic stomach pain.	Tamil Nadu
48	Kullakar	105-110	Facilitates secretion of breast milk, excretion of body waste, cures blood pressure, diabetes, constipation etc. Drought tolerant.	Tamil Nadu
49	Kuzhiyadichan	115-120	This rice is good for breastfeeding and controlling diabetes. Saline Tolerant.	Tamil Nadu
50	Lachkari Kolam	135-140	Rich in antioxidants and has anti-inflammatory properties.	Chhattisgarh
51	Madumazhingi	135-140	If people who are doing a lot of physical work eat this rice, they will get rid of fatigue and get the necessary nutrients for the body. Flood tolerant.	Tamil Nadu
52	Mangal Ponni	135-140	Rice is a herbal herb with high immunity. Heal's tumours and heals. Removes waste and beautifies our mane.	Tamil Nadu

53	Manoharibhog	120-130	Aromatic and used in making sweets.	West Bengal, Odisha
54	Mappillai Samba	150-160	It increases digestive power, soothes mouth and stomach ulcers, strengthens nerves, and increases sperm production. Good for diabetes. Flood tolerant.	Tamil Nadu
55	Mashuri	130-140	Good for diabetics and has anti-inflammatory properties.	Karnataka
56	Matta Rice	120-140	Rich in antioxidants and good for digestion.	Kerala
57	Mudhgoji	120-130	Rich in antioxidants and good for digestion.	Karnataka
58	Muttira sannam	135-140	Immunity-boosting herbal rice. This rice is good for lack of brain development. Increases memory power.	Tamil Nadu
59	Mysore Malli	130-135	Porridge made from its rice is anti-inflammatory. Its old rice is watery, flavourful and nutritious. This rice is used as an easily digestible food for children.	Tamil Nadu
60	Njavara	150-180	Used in Ayurvedic medicine to treat neurological disorders.	Kerala, Tamil Nadu
61	Pachari	120-130	Low glycaemic index and good for diabetics.	Kerala
62	Palakkadan Matta	120-140	Used in traditional Kerala cuisine.	Kerala
63	Perumkari	135-140	Good for digestion and has anti-inflammatory properties.	Kerala
64	Perumkathai	140-150	Used in Ayurvedic medicine to treat arthritis and gout.	Tamil Nadu
65	Perunachi	130-140	Rich in antioxidants and good for digestion.	Tamil Nadu
66	Pokkali	150-180	Rich in minerals and used in Ayurvedic medicine, salt resistant and flood tolerant.	Kerala

67	Poongar	120-130	Rich in antioxidants and good for digestion.	Tamil Nadu
68	Rajamudi	135-140	High in fibre.	Karnataka
69	Rakthasali	135-140	Siddha doctors use Rakthasali as a medicine to balance rheumatism, pithama and kapha doshas, this rice is used to improve blood circulation and to agitate the blood. Drought tolerant.	Tamil Nadu
70	Rangpuria	125-130	Good for digestion and has anti-inflammatory properties.	West Bengal
71	Rasagadam	135-140	Rice is the first food for infants and is highly immune and reactive. Digests quickly and strengthens the digestive system. Strengthens the nervous system and helps cure anaemia. Flood tolerant.	Tamil Nadu
72	Salem sanna	120-130	Controls diabetes due to its high nutrient content. Rich in iron, calcium, and magnesium minerals. You can eat this rice to get the best results. Better skin health.	Tamil Nadu
73	Sali Rice	120-130	Aromatic and used in making biryani.	Maharashtra, Gujarat
74	Samba Mahsuri	120-130	High iron content and good for diabetics, 4-5t/ha.	Tamil Nadu, Andhra Pradesh
75	Samudri	125-130	Rich in antioxidants and good for digestion.	Maharashtra
76	Seeraga Samba	125-135	It has high immunity. It is highly reactive and can prevent cancer. It helps in regular heart movement, removes bad cholesterol, relieves constipation, and improves digestion. Leaf folder resistant.	Tamil Nadu
77	Sempalai	100-105	Herbal rice with high medicinal value. Rice is loved by children. Easy to digest. Rice is ideal for body nutrition.	Tamil Nadu

78	Shyama	125-130	Rich in antioxidants and good for digestion.	West Bengal
79	Singinni kaar	110-115	It is a medicinal herbal rice. Prevents diabetes. Relieves joint pain. Strengthens bones. By giving this porridge to weak patients, they will get stronger and recover.	Tamil Nadu
80	Sita Ashoka	125-130	Used in Ayurvedic medicine to treat female reproductive disorders.	Uttar Pradesh, Bihar
81	Sivappu Kavuni	140-150	Royal families have been using it for medicinal reasons for a long time. It is herbal rice rich in potassium, magnesium and zinc.	Tamil Nadu
82	Sonamasuri	130-140	Low glycaemic index and good for diabetics.	Andhra Pradesh
83	Soora kuruvai	105-110	Rice helps to strengthen the weak bones of the newborn mother. Drought tolerant.	Tamil Nadu
84	Swarna mashuri	135-140	Easily digestible rice. Nutritional food for the elderly. Excellent food for skin diseases. The best rice for body strength. Flood tolerant.	Andhra Pradesh
85	Thanga samba	150-160	It is a cure for skin diseases. Increased immunity. Skin manifestations including acne will disappear. Drought tolerant.	Tamil Nadu
86	Thavalakannan	130-140	Good for digestion and has anti-inflammatory properties.	Tamil Nadu
87	Thengai Poo Samba	120-125	Rich in iron, calcium, potassium, zinc, and magnesium minerals. As this rice is easily digestible, it can be used as baby food. Saline tolerant. Cyclone tolerant.	Tamil Nadu
88	Thirupathi saram	110-120	The rice cooked in this rice will not spoil for a long time. When travelling abroad, tamarind rice can be tied to a banana leaf and used for several days.	Tamil Nadu

89	Thooyamalli	125-135	This rice contains a moderate amount of soluble fibre. Rich in iron, magnesium, and zinc. Old rice is disease resistant. Its juice tastes like fresh water.	Tamil Nadu
90	Tulaipanji	130-140	Good for digestion and has anti-inflammatory properties.	West Bengal, Odisha
91	Tulsi vasanai samba	145-150	Strengthens the lungs. It cures colds and emaciated people should eat this rice regularly for a period.	Tamil Nadu
92	Vadan samba	140-150	As it is easily digested, children are fed with its porridge. Adolescent girls are given pudding for balanced body development. Its porridge cures jaundice and dysentery.	Tamil Nadu
93	Vaigundam	130-140	Rich in antioxidants and good for digestion.	Tamil Nadu
94	Valan samba	140-150	Cleanses the bowels, beautifies the skin, relieves bile, and stomach problems, karapan and manth. Rich in iron, magnesium, and zinc. Pudding can be given to adolescent girls during menstruation to strengthen their bodies.	Tamil Nadu
95	Vanapadi	130-140	Good for digestion and has anti-inflammatory properties.	Kerala
96	Varappu Kudaijan	110-115	It cures anaemia due to its high iron content. It is rich in fibre, which relieves constipation. It also cures nervous diseases.	Tamil Nadu
97	Vasanai Seeraga Samba	110-120	Easily digestible, prevents gastric disturbances and stimulates appetite. Cures rheumatism. Stomach ulcers, loss of eyesight and discharge of water from the body resolve.	Tamil Nadu
98	Vellai chitirai kaar	115-120	Packed with vitamins and minerals and rich in fibre, this rice is a delicious rice that is perfect for everyone, from children to adults, to gain strength and nutrition. Saline	Tamil Nadu

			tolerant. Drought tolerant.	
99	Vellai Kolam	130-140	Rich in antioxidants and good for digestion.	Tamil Nadu
100	Vellai Kuruvai	100-105	It is easily digestible, relieves constipation, strengthens the nerves, and flushes out the bad water secreted in the body.	Tamil Nadu
101	Vellai milagu samba	160-165	It Stimulates appetite, cures headaches, strengthens the digestive system, relieves arthritis, and helps remove toxins from the body.	Tamil Nadu
102	Wada Kolam	125-130	Rich in antioxidants and good for diabetics.	Chhattisgarh
103	Wynaad Kaima	120-130	Rich in antioxidants and good for digestion.	Kerala

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CROP WILD RELATIVES AND THEIR IMPORTANCE

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Introduction

Crop wild relatives (CWRs) are wild plant taxa closely related to crops, offering genetic diversity for crop improvement. Despite their potential recognized by **Nicolai Vavilov** in the 1920s, their importance for future food security remains underestimated. Predicted climate change, including temperature rise, altered rainfall, and pest outbreaks, will impact agriculture significantly. Adapting agriculture through planting adjustments or variety shifts can only partially address these challenges. To meet future needs, plant breeders require genetic diversity from germplasm, landraces, and especially wild relatives. CWRs, with their broader biodiversity, are crucial for breeding resilient crops. Recognizing them as vital gene sources is essential for developing high-yield, stress-tolerant varieties.

GLOBAL DISTRIBUTION AND CONSERVATION OF CROP WILD RELATIVES:

Latest estimates report that there are between **50,000-60,000 crop wild relatives** in the wild. **10,739** of these are important plant genetic resources for food and agriculture (PGRFA) and **700** of these, representing less than 0.26% of the world flora, are the most important in terms of global food security and the ones requiring urgent conservation measures.The distribution of crop wild relatives is mostly correlated with the diversity of flora within a country. The greater the diversity of plant species, the greater the number of CWR occurring within a country. Many developing countries, located within centres of plant diversity and centres of crop diversity, contain large numbers of important crop relatives.

IMPORTANCE OF CWRs:

Crop Wild Relatives (CWR) play a pivotal role in safeguarding global food security and agricultural sustainability. These wild plant species, closely related to cultivated crops, harbour a rich genetic diversity that holds immense potential for crop improvement. Their genetic resources offer valuable traits such as resistance to pests and diseases, tolerance to environmental stresses, and enhanced nutritional content. By incorporating genes from CWR into crop breeding programs, scientists can develop resilient varieties capable of adapting to changing climates and evolving agricultural landscapes. Moreover, the conservation of CWR contributes to the preservation of ecosystem services, supports cultural traditions, and sustains the livelihoods of communities dependent on wild plants. With the escalating challenges posed by climate change and population growth, the conservation and utilization of Crop Wild Relatives emerge as essential strategies for ensuring future food security, promoting biodiversity, and fostering sustainable agricultural practices worldwide.

Genetic Diversity

Crop wild relatives are valuable genetic resources as they possess a wide range of traits that are essential for crop improvement. These traits include resistance to pests and diseases, tolerance to environmental stresses such as drought, heat, and salinity, as well as unique nutritional qualities. The genetic diversity present in CWRs provides breeders with a rich source of genes to incorporate into cultivated crops, thus enhancing their adaptability and resilience to changing environmental conditions and evolving pests and diseases.

Adaptation to Climate Change

With the increasing threats posed by climate change, such as rising temperatures, erratic rainfall patterns, and extreme weather events, there is a growing need for crops that can thrive under such conditions. Crop wild relatives, which have evolved in diverse habitats and climates, harbour genes that confer tolerance to various environmental stresses. By tapping into the genetic diversity of CWRs, breeders can develop climate-resilient crop varieties that are better equipped to withstand the challenges posed by climate change, thereby ensuring food security for future generations.

Pest and Disease Resistance

Pests and diseases pose significant threats to crop production, leading to yield losses and economic hardships for farmers. Crop wild relatives have co-evolved with pests and pathogens over millions of years, developing natural resistance mechanisms to combat these threats. By crossbreeding cultivated crops with CWRs, breeders can introduce genes conferring resistance to pests and diseases, thus reducing the reliance on chemical pesticides and fungicides. This not only promotes environmentally sustainable agricultural practices but also helps farmers mitigate the economic risks associated with crop losses due to pest and disease outbreaks.

Nutritional Quality

In addition to traits related to agronomic performance, crop wild relatives also harbor genes associated with nutritional quality. Many CWRs exhibit higher levels of vitamins, minerals, antioxidants, and other beneficial compounds compared to their cultivated counterparts. By incorporating these genes into breeding programs, breeders can develop crop varieties with enhanced nutritional profiles, thus addressing malnutrition and improving public health outcomes, especially in regions where access to diverse and nutritious foods is limited.

Conservation and Sustainable Use

Despite their importance, many crop wild relatives are currently under threat due to habitat loss, deforestation, climate change, and unsustainable land-use practices. Conservation efforts aimed at preserving the genetic diversity of CWRs are therefore essential to ensure their continued availability for future generations. This involves the establishment of protected areas, in situ conservation measures, and the creation of gene banks to store seeds and other genetic material. Additionally, sustainable use practices, such as participatory plant breeding and community-based conservation initiatives, can help empower local communities and indigenous peoples while safeguarding the genetic resources of CWRs.

UTILIZATION OF CWRs FOR CROP IMPROVEMENT:

Despite valuable genes in Crop Wild Relatives (CWRs), their full potential remains largely untapped due to genetic bottlenecks and insufficient genetic information. Plant breeders typically focus on specific CWRs for desired traits rather than exploring broader genetic diversity. Challenges like cross incompatibilities, limited accessibility to CWR resources, and underutilization hinder their exploitation. Efforts primarily target a few food crops, with issues such as infertility in progeny and inadequate conservation further impeding progress. However, international collections and online portals offer valuable resources for researchers aiming to harness CWRs for crop improvement.

Table 1: CWRs of some important cereals utilized in breeding for biotic and abiotic stress tolerance

CWR of cereals	Traits	Utilization
Triticum monococcum	Heat tolerance, Salt tolerance, Powdery mildew resistance	Controlling thermal tolerance through heat shock protein (HSP) gene Sodium extrusion mechanism Mapping of Pm resistance markers
Oryza rufipogon	Blast resistance	Blast resistant gene Pi33 introgressed in rice var. IR64
O. longistaminata	Bacterial blight resistance, drought tolerance	Xa21 gene transfer from wild to variety IR72
Hordeum spontaneum	Severe salt and dehydration stress, aluminum tolerance, Fusarium resistance	*Hordeum spontaneum* x two-rowed malting barley population
H. marinum	Salt tolerance	Salt tolerant amphiploid production
H. bulbosum	Resistance to powdery mildew and leaf rust; leaf scald	Advanced back cross population of wild x cultivated
O. glaberrima	Weed competitiveness, drought tolerance and high yield	NERICA (NEw RIce for AfriCA)

Useful Gene Sources from Alternative CWRs

Advancements in genome-assisted breeding, along with next-generation sequencing, facilitate the evaluation of alternative crop genomes for stress tolerance mechanisms. *Arabidopsis thaliana* served as a model plant, aiding in the exploration of new gene resources within alternative crop genomes. For instance, *Brachypodium distachyon,* a diploid wild grass with a fully sequenced compact genome, proves valuable for drought tolerance in wheat and barley due to its close phylogenetic relationship. Similarly, *Haynaldia villosa L. harbors* genes enhancing resistance to various diseases in wheat. Other examples include *Elytrigia elongata* for salt tolerance and *Leymus chinensis* for stress tolerance genes transfer to wheat and barley.

Table 2: CWRs of Alternative Crop Species Utilized in Breeding for Climate Resilient Agriculture

CWR	Traits	Utilization
Agropyron elongatum	Rust resistance	Marker validation in wheat for leaf rust resistance
Agropyron cristatum	Drought and cold tolerance	Antioxidant mechanism activation for drought tolerance; Fructan biosynthesis for cold tolerance
Agrostis stolonifera	Drought tolerance	QTL detection for drought tolerance
Brachypodium distachyon	Cold and drought tolerance	Fructan accumulation under low temperature (CBF3 genes); osmoprotectan sugar biosynthesis
Elymus repens	Fusarium head blight resistance	Wheat introgression line production
Leymus chinensis	Fusarium head blight resistance, salt tolerance	Wheat-Leymus introgression lines, induction of salt stress tolerance genes
Sporobalus stapfianus	Drought tolerance	Leaf specific desiccation gene

MAXIMIZING THE UTILIZATION OF CROP WILD RELATIVES VIA ADVANCED BIOTECHNOLOGY AND MOLECULAR BREEDING APPROACHES:

Omics technologies, encompassing genomics, transcriptomics, proteomics, and metabolomics, offer comprehensive insights into regulatory genes and vital traits in Crop Wild Relatives (CWRs). High-throughput sequencing has amplified SNP discovery, aiding trait association studies. Phenotypic-genotypic integration validates known genes and uncovers novel loci governing agronomic traits in CWRs. These methods dissect complex traits like drought tolerance, exemplified by dehydrin and Asr gene families in wild barley and tomato. Metabolic pathways from CWRs, like terpenoid biosynthesis in wild tomato, can enhance cultivated species' resistance. While metabolomics elucidates gene actions, cost and heritability limit its application. Genetic modification, including cisgenesis and genome editing, promises trait enhancement in CWRs without transgenic risks, advancing crop improvement efficiently.

Conclusion

Utilizing genetic diversity within crop wild gene pools is crucial for addressing challenges from modern agriculture and climate change. Intensive pre-breeding efforts, combined with marker-assisted evaluation of major genes, can widen the genetic base of crops and identify desirable chromosomal segments. Despite past struggles with linkage drag, advancements in DNA sequencing, particularly de novo and resequencing methods, efficiently explore genetic variation in CWR. Genomics-assisted breeding facilitates introgression of favorable traits from wild species into cultivated crops, overcoming compatibility barriers. Collaboration between plant breeders and genetic engineers is essential for developing new cultivars. Strategies for efficiently utilizing these wild gene pool resources are actively pursued, assuming a rich reservoir of beneficial alleles for crop improvement.

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MICROPROPAGATION IN NEEM

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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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IMPACT OF ON-FARM TRIALS & FRONT-LINE DEMONSTRATIONS IN ADOPTION EXTENT AND HORIZONTAL SPREAD OF MULTI-DISEASE RESISTANCE TOMATO CULTIVATION IN TRIPURA

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Introduction

Tomatoes can be grown in Tripura in a variety of well-drained soils, including sandy loam, clay, black, and red soil. Sandy loam soils with high organic matter and a pH of 6.0–7.0 are ideal for cultivation. Tomatoes are sensitive to frost and low temperatures, so the ideal soil temperature for cultivation is 15–17°C.

The majority of the farmers from North & Dhalai District, Tripura grow a different kind of vegetables during *Rabi* season following paddy during *Kharif* season. Among the vegetables tomato (*Solanum lycopersicum*) is one of the most important and popular vegetable crops mostly grown by farmers. Although several varieties of tomato are cultivated by the farmers the expected yield of the crop is not been achieved so far because of the crop damage caused by bacterial wilt, early and late blight, and leaf curl diseases which reduces the crop loss.

Initial status / Practice of farmer before KVK intervention

- Cultivation of local varieties
- High incident of bacterial wilt, leaf curl & blight disease of available varieties
- High cost of hybrid seed from Pvt sector varieties
- Low yielded varieties

KVK Intervention & Extension tool

OFT/ FLDs, Training, IIHR NEH Scheme, Linkage with IIHR for seed procurement. With high incidents of bacterial wilt, leaf curl, and late blight problems farmers lose interest in growing tomatoes in their fields. Farmers contacted KVK Dhalai Scientists and then went for trials and demonstrations of tomato varieties Arka Samrat and later on Arka Rakshak and Arka

Abhed since 2015 and subsequent years. The performance of those varieties was excellent compared to local and other private-sector varieties.

Crop : Tomato

Farming Situation : Irrigated farming

Title of OFT : Varietal evaluation Tomato

Nos of trails – 3

Problem diagnosed : High incident of bacterial wilt, leaf curl

Severity of problem (%) : 22.7

Technology: Varietal evaluation of Tomato variety Arka Rakshak

Remark for recommendation for FLD – recommended for FLD

Training for adoption of technology

Technology performance:

	Arka Abhed	**Arka Rakshak**	**Arka Samrat**	**Local**
Size fruit (g)	98.38	95.98	95.21	98.32
crop duration (Days)	144	132	135	146
Bacterial wilt incidence (%)	0.0	0.0	0.0	9.56
TLCV incidence (%)	0.0	0.0	0.0	17.93
Late blight incidence (%)	0.0	1.1	2.8	6.1
Yield (mt/ha)	65.84	59.02	55.90	41.10
B:C ratio	4.8:1	4.0:1	3.75:1	3.0:1

KVKs contribution by FLDs -

Year	Tech Dissemination	Schemes	Nos of Villages	Area (ha)
2015-16 to 2017-18	**Popularization of triple disease resistance Tomato varieties**	FLDs (ATMA & ICAR),	9	24.0

Productivity, technology gap, technology index and extension gap in tomato under FLD

Yield (mt/ha)			**% Increase in yield**	**Extension gap (mt/ha)**	**Technology gap (mt/ha)**	**Technology index (%)**
Potential	**Demonstration**	**Local check**				
70.00	**54.70**	**45.20**	**21.02**	**9.5**	**15.30**	**21.85**

FLDs, in different villages conducted by KVK

Comparative C:B analysis of tomato under FLDs and farmers practice

Gross Cost (Rs/Ha)		**Gross Return (Rs/Ha)**		**Net Return (Rs/Ha)**		**B:C Ratio (GR/GC)**	
Demo.	**Local check**	**Demo.**	**Local check**	**Demo.**	**Local check**	**Demo.**	**Local check**
94,500	**105000**	**547000**	**452000**	**452500**	**347000**	**5.7:1**	**4.3:1**

Impact of Front Line Demonstration (FLDs) on horizontal spread of tomato

Variety	Area (ha)		Change in area (ha)	Impact (% Change)
	Before demo	After demo		
Arka Abhed Arka Rakshak Arka Samrat	11	**29**	18	163.64

Impact

After receiving the higher yield he cultivated a larger area as a demonstration and received a better price in the market as those are also good quality and shelf life. Other farmers are very much interested in this technology as it is resistant to mainly bacterial wilt, leaf curl, and cultivating every year. More than 100 nos of farmers are now cultivating IIHR tomato varieties in that village and nearby villages. Farmers every year make contact with KVK and give a request letter to KVK for procuring the variety and on their payment basis seeds are procured from the IIHR Seed section. KVK provides seeds every year on IIHR NEH component schemes and even on a payment basis also due to high demand received from the farmers.

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ROLE OF POLLINATORS IN VEGETABLE CROP ECOSYSTEM

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Abstract

Pollinators play a crucial role in the vegetable crops ecosystem, facilitating the process of pollination and ensuring the production of fruits and seeds. Various vegetable crops, including cucurbits, brassicas, and solanaceous plants, rely on insect pollination for optimal quality fruit and seed set. The multifaceted contributions of pollinators to vegetable crop ecosystems, includes enhancing yield, promoting genetic diversity, and maintaining ecosystem stability. Various types of pollinators including bees, syrphids, moths, butterflies, flies, and beetles contribute to the pollination and increasing yields through their foraging activities. However, factors such as habitat loss, pesticide use, and climate change pose significant challenges to insect pollinators, thereby impacting vegetable seed production. Implementing sustainable agricultural practices that prioritize pollinator conservation, such as reducing pesticide applications and creating pollinator-friendly habitats, is crucial for maintaining and enhancing vegetable seed yields. Collaboration among stakeholders, including farmers, researchers, and policymakers, is essential for promoting the resilience and sustainability of vegetable seed production systems in the face of ongoing environmental changes.

Key words: Vegetable, Entomophily, Pollinator, Seed Production, Honey Bees

Introduction

Vegetables hold significant importance in Indian agriculture and nutritional security due to their high productivity, nutritional value, short growth duration, economic viability, and role in generating employment both on and off the farm. India is blessed with diverse agro-climatic conditions, allowing for the cultivation of a wide variety of vegetables throughout distinct seasons (Singh *et al*., 2021). India's vegetable biodiversity is extensive, and the country serves as either the primary or secondary centre of origin for many vegetable varieties (Negi *et al*., 2020). Vegetables serve as crucial sources of essential nutrients like proteins, vitamins, minerals, dietary fibres, micronutrients, antioxidants, and phytochemicals in the daily diet. Beyond their nutritional value, they also possess various potential phytochemicals with properties such as anticarcinogenic and antioxidant effects, including flavonoids, glucosinolates, and isothiocyanates (Butnariu and Butu, 2015).

As world's second-largest vegetable producer only after China, India contributes substantially to global vegetable production. In 2023-24, India produced 209.39 million metric tonnes of vegetables in an area of 11.24 million hectares (APEDA, 2024). However, the average productivity of important vegetables is low as compared to the world average (Vanitha *et al*., 2013). The successful production of any crop in terms of good quality and high productivity depends upon many factors and pollination is one of them and it is reported that the pollinators enhance the reproduction and genetic diversity of around 80% of the plant species (Negi *et al*., 2020). Major vegetable grown in India includes potato, onion, cucurbits, crucifers, tomato and brinjal where majority are cross pollinated and relies on insect pollination for fruit and seed production.

Table 1. Predominant insect pollinators of various vegetable crops

Crops	**Pollinators / Visitors**
Asparagus	Honey bees
Bitter gourd	Small wild bees
Beet	Thrips, syrphid fly, honey bees, solitary bees and hemipteran insects
Brinjal	Bumble bees, carpenter bees and honey bees
Carrot	Apidae, Ichneumonidae, Psammocharidae, Sphecidae, and Vespidae families of the Hymenoptera Bombyliidae, Sarcophagidae, Stratiomyidae, Syrphidae, and Tachinidae families of the Diptera
Cucumber	Honey bees

Coriander	Honey bee
Lettuce	Honey bee, flies, wild bees and butterflies
Muskmelon	Honey bees, ants and thrips
Okra	Honey bees and bumble bees
Onion	honey bees, small syrphid flies, halictid bees, drone flies, lady bird beetles, moths and butterflies
Peppers	Honey bees and other bees
Parsnip	Honey bee, other wild bees, beetles and dung flies
Pumpkin and squash	Honey bee, wild bees, cucumber beetles, scarab beetles, meloid beetles, flies and moths
Watermelon	Honey bees, bumble bee, and different species of bees
References; Pushpalatha *et al*., 2024; Paschapur *et al*., 2022; Hanif *et al*., 2022; Magwira, 2021; Njoroge *et al*., 2010	

Insect pollinators in vegetable production system

The pollination requirements for vegetable species vary widely and depend on pollination mechanism of plant *viz*., self or cross-pollination to facilitate fruit and seed set. For entomophilous crops, insect pollinators are crucial for qualitative and quantitative fruit and seed production and the scarcity of natural pollinators significantly hinders the output. In many vegetable crops, such as brinjal (*Solanum melongena*), tomato (*Lycopersicon esculentum*), chilli (*Capsicum annum*/ *C. frutescens*), onion (*Allium cepa*), carrot (*Daucus carota*), cabbage (*Brassica oleracea*), cauliflower (*B. oleracea*), cucumber (*Cucumis sativus*) and radish (*Raphanus sativus*) etc pollination is performed mainly by honey bees (*Apis* sp. and bumble bee) (Thakur *et al*., 2016) and it significantly increases the yield of the crop. It is reported that there was 93, 17-19 and 43 per cent increase in the yield of onion, cotton and mustard seed yield when pollinated by honey bees (Raghumoorthi *et al*., 2016)

Table 2. Per cent yield increase in various vegetables due to pollinators

Vegetable	Per cent yield increase (%)	Vegetable	Per cent yield increase (%)
Asparagus	12-405	Cucumber	10
Brinjal	27	Onion	354-9878
Cabbage	100-300	Radish	100-300
carrot	9-135	Tomato	64
Yankit *et al*., 2018; Khalifa *et al*., 2021; Reddy *et al*., 2022; Singh *et al*., 2023			

Effect of pollinators on fruit and seed of a vegetable

- Increases the per cent flower set and seed set
- Increases fruit size, shape and weight
- Increases the germination percentage of the seeds
- Increases the nutritional content or the fruit and/ or seeds

Major threats to the pollinators

- **Habitat Loss, degradation and fragmentation-** Urbanization, agricultural expansion, and deforestation lead to the destruction and fragmentation of natural habitats, reducing the available nesting sites, foraging grounds, and floral resources for pollinators (Dar *et al*., 2017; Loose *et al*., 2005; Sidhu and Joshi, 2016).
- **Pesticide Use-** Insecticides, herbicides, and fungicides used in agriculture can be toxic to pollinators. They can kill insects directly or affect their behaviour, such as navigation and foraging abilities, leading to declines in pollinator populations (Tolon and Duman, 2003; Yue *et al*., 2018).
- **Monoculture Farming-** Large-scale monoculture farming reduces floral diversity, limiting the availability of food sources for pollinators. Additionally, it exposes pollinators to higher risks of pesticide exposure due to the intensive use of agrochemicals (Varah *et al*., 2020).
- **Climate Change-** Changes in temperature, precipitation patterns, and seasonal shifts can disrupt the synchrony between flowering plants and their pollinators. This can lead to a mismatch in timing, affecting the availability of food resources for pollinators (Goulson, 2003; Green, 2016).
- **Disease and Parasites-** Insect pollinators are susceptible to various diseases and parasites, including mites, fungi, and viruses. These pathogens can weaken individual insects and entire colonies, leading to population declines (Heid, 2015; Mullin *et al*., 2010).
- **Invasive Species-** Invasive plant species can outcompete native plants, reducing the diversity of floral resources available to pollinators. Similarly, invasive insect species may compete with or prey upon native pollinators, further impacting their populations (Watanabe, 2008).
- **Conservation strategies of pollinators:**

Conservation of pollinators is crucial for maintaining ecosystem health, biodiversity, and food security. Here are some strategies for conserving pollinators:

- **Habitat Restoration**- Protecting and restoring natural habitats, such as meadows, grasslands, and forests, provides essential nesting sites, foraging grounds, and floral resources for pollinators (Dar *et al*., 2017).
- **Creating Pollinator-Friendly Landscapes**- Designing urban and agricultural landscapes with diverse, pollinator-friendly plants can support healthy pollinator populations. Planting native wildflowers, shrubs, and trees provides essential food and habitat for pollinators (Senapati *et al*., 2017).
- **Reducing Pesticide Use**- Implementing integrated pest management (IPM) practices and using alternative pest control methods can minimize pesticide exposure to pollinators. Choosing organic farming practices and selecting less toxic pesticides can also help protect pollinators (Sponsler *et al*., 2019).
- **Promoting Sustainable Agriculture**- Encouraging agroecological practices, such as crop rotation, polyculture, and the use of cover crops, can enhance biodiversity and provide a more diverse and stable food supply for pollinators (Tolera and Ballantyne, 2020).
- **Conserving Native Plant Species**- Protecting and conserving native plant species ensures a diverse and abundant supply of floral resources for pollinators. Establishing native plant gardens and restoring native plant communities can support local pollinator populations (Kearns and Inouye, 1997).
- **Raising Awareness and Education**- Educating the public about the importance of pollinators and the threats they face can foster appreciation and support for pollinator conservation efforts. Outreach programs, workshops, and educational materials can help raise awareness and promote pollinator-friendly practices (Martins *et al*., 2016).
- **Policy and Regulation**- Implementing policies and regulations that protect pollinator habitats, restrict the use of harmful pesticides, and promote sustainable land management practices are essential for ensuring long-term pollinator conservation (Hall and Steiner, 2019).

Conclusion

As essential contributors to the fertilization process, pollinators ensure the development of high-quality seeds across a diverse range of vegetable crops. Their diligent foraging activities not only enhance seed yields but also promote genetic diversity within vegetable populations, fostering resilience to environmental challenges. However, the sustainability of vegetable seed production is threatened by various factors, including habitat loss, pesticide use, climate change, and agricultural practices that diminish pollinator habitats. To safeguard the invaluable contributions of insect pollinators, concerted efforts are needed to implement sustainable agricultural practices, preserve and restore pollinator habitats, and raise awareness about the importance of pollinator conservation. By prioritizing pollinator-friendly strategies and fostering partnerships between farmers, researchers, policymakers, and communities, we can ensure the continued prosperity of vegetable seed production systems. Embracing the pivotal role of insect pollinators not only secures our agricultural productivity but also contributes to the preservation of biodiversity, the enhancement of ecosystem resilience, and the promotion of global food security.

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SPEED BREEDING – A NOVEL RAPID GENERATION ADVANCEMENT METHOD IN PLANT BREEDING

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Introduction

The concept of speed breeding technique was originally developed by NASA in the eighties to help grow crops in space. This can hasten the process of developing new crop varieties. Now many Indian plant scientists are showing interest in exploring the concept of speed breeding. Scientists hope speed breeding will accelerate agricultural research and increase food production to meet the demands of a rising population. Speed breeding technology is an indoor plant growing technique. It shortens harvest time (2-3x faster) of crops like wheat and barley. Speed breeding is also known as accelerated breeding and rapid breeding system. This technique uses artificial light and temperature conditions to speed up the crossing and breeding of new crop varieties.

MAIN FEATURES

1. Techniques Involved

'Speed breeding' technology involves indoor techniques such as glass house, green house and poly house for growing plants under controlled conditions to grow several generations of selected plants.

2. Environment Used

Speed breeding uses an artificial environment with enhanced light duration to create longer daylight regimes to speed up the breeding cycles of photo-insensitive crops. Speed breeding in controlled environment growth chambers can accelerate plant development for research purposes, including phenotyping of adult plant traits, mutant studies and transformation. The use of supplemental lighting using light emitting diodes (LEDs) in a glasshouse environment allows rapid generation cycling through single seed descent (SSD) and plant density can be scaled-up for large crop improvement programs. Protocols suitable for speed breeding in glasshouses and growth chambers with low cost have been developed. Speed breeding uses enhanced LED lighting and day-long regimes of up to 22 hours to optimise photosynthesis and promote rapid growth of crops. It speeds up the breeding cycle of plants: for example, six generations of wheat can be grown per year, compared to two generations using traditional breeding methods. Speed breeding

uses an artificial environment with enhanced light duration to create longer daylight regimes to speed up the breeding cycles of photo-insensitive crops.

It uses supplemental lighting to aid photosynthesis rate in intensive regimes of up to 22 h per day in a glasshouse environment that allows rapid generation cycling through single seed descent and potential for adaptation to larger-scale crop improvement programmes.

3. Integrated Approach

There is great potential for integrating speed breeding with other modern crop breeding technologies, including high-throughput genotyping, genome editing and genomic selection, accelerating the rate of crop improvement. Speed breeding approach is being carried at ICRISAT with crops like pigeon pea, millets, sorghum and groundnut. These crops are important for food and nutrition security in many countries in Africa and Asia.

4. Ways of Speed Breeding

Speed breeding can be carried out in numerous ways, one of which involves extending the duration of plants' daily exposure to light, combined with early seed harvest, to cycle quickly from seed to seed, thereby reducing the generation times for some long-day or day-neutral crops.

5. Rapid Technique

Speed breeding leads to rapid generation advancement of segregating populations resulting in rapid development of improved cultivars. Conventional breeding takes a longer time for the development of crop varieties with a minimum of 8-10 years of breeding cycles. The main problem of conventional breeding is the inability to complete more generations in lesser time. A recent report on speed breeding mentions that up to six generations per year could be achieved for bread wheat, durum wheat, barley, pea and chickpea, and four generations for canola.

LIMITATIONS

1. The speed-breeding technique has largely been used for research purposes, but is now being adopted by the industries as well. Speed breeding as a platform can be combined with several other technologies such as marker-assisted selection, genomic selection, CRISPR gene editing, etc. to get to the end result faster. With the success of speed breeding particularly in wheat crop, India can also initiate such facilities for quick development of new crop varieties.
2. Speed breeding in the case of photo-insensitive crops like wheat, barley, chickpea and pea greatly reduces the generation time and helps in achieving six generations per year, but for the photosensitive crops like soybean, speed breeding is not suitable to speed up the breeding cycles.
3. The enhanced light provided in the speed-breeding facility will not allow the plants to bear flowers in case of photosensitive crops. Therefore, alternative approaches have to be followed to speed up the breeding cycles in such crops.
4. Speed breeding involves greenhouse and poly house facility, which is used for advancement of Fl to F2 and important individual plant selections during off-season (November-February). The few of selected segregating material is also advanced to shorten the varietal development programme.
5. A crop variety may perform well in an artificial environment, where temperature, water supply, and light regimes are easily regulated, but if it doesn't thrive out in the field, where the vast majority of our crops are grown, then it's practically a dud. New wheat varieties must be productive out in the elements for farmers to take them on.
6. Expensive: It is considered that developing speed breeding protocols for crops is expensive. We need a lot of investment. It would require huge expenditure to build controlled environments for speed breeding.
7. Adoption: It would be difficult to convert all breeders from conventional breeding to the speed-breeding regime.

ADVANTAGES

Speed breeding can be carried out in numerous ways, one of which involves extending the duration of plants' daily exposure to light, combined with early seed harvest, to cycle quickly from seed to seed, thereby reducing the generation times for some long-day or day-neutral crops. A new method for rapid generation advance, called 'speed breeding', has considerable advantages over DH technology for spring wheat because it provides increased recombination during line development and enables selection in early generations for some traits.

1. **A Rapid Method:** Speed breeding allows researchers to rabidly mobilise the genetic variation found in wild relatives of crops and introduce it into elite varieties that can be grown by farmers. The EU ruling that heavily regulates gene editing means we are more reliant on speed breeding to grow sturdier, more resilient crops. Speed breeding technology allows six generations of wheat to be grown per year, compared to two generations using traditional breeding methods. By shortening breeding cycles, the method allows scientists and plant breeders to fast-track genetic improvements such as yield gain, disease resistance and climate resilience in a range of crops such as wheat, barley, oilseed rape and pea.
2. **Rapid Generation Advancement:** 'Speed breeding' technology shortens the breeding cycle and accelerates crop research through rapid generation advancement. Speed breeding techniques can help plant breeders grow six generations of spring wheat, chickpea and barley and four generations of canola plants in specially modified glasshouses. In comparison, they can grow only one or two generations in the field and two or three in normal glasshouses. This technology helps shorten the breeding cycle of new varieties significantly. The speed breeding system is used normally for accelerating the development of plants that have better genetics and then they go to the fields. In fields, they need to be tested for yield, disease resistance and quality. Speed breeding can be used to achieve up to 6 generations per year for spring wheat (*Triticum aestivum*), durum wheat (*T. durum*), barley (*Hordeum vulgare*), chickpea (*Cicer arietinum*) and pea (*Pisum sativum*), and 4 generations for canola (*Brassica napus*), instead of 2-3 under normal glasshouse conditions. The technique has also been successfully adapted to oat, various Brassica species, grass pea, quinoa, *Medicag otruncatula* and *Brachypodium distachyon*.
3. **Early Decision:** Generation time in most plant species represents a bottleneck in applied research programmes and breeding. Tackling this bottleneck means scientists can respond quicker to emerging diseases, changing climate and increased demand for certain traits.

4. **Adoption:** Speed breeding technology will become the norm in research institutes: "We know that more and more institutes across the world will be adopting this technology and by sharing these protocols we are providing a pathway for accelerating crop research."
5. **Drought Resistance:** In Australia, speed breeding technology is being used to rapidly cycle genetic improvements to make crops more drought resistant.
6. **Refinement:** This technology needs refinement for use as a research tool. Changes to soil/ media composition, lighting, temperature, spacing of plants and premature seed harvest have led to the team cutting down the seed-to-seed generation time in wheat to just eight weeks.
7. **Rapid Gene Transfer:** Development of techniques such as rapid gene discovery and cloning that, alongside speed breeding, would allow crop improvements via a non-GM route.
8. **More Adoption:** In years ahead, crop research and breeding will become more dependent on speed breeding in looking to its various advantages. The ability to work at these scales gives scientists greater opportunities than ever before to breed disease resistant, climate resilient and nutritious crops to feed a growing global population.
9. Speed breeding accelerates the rate at which we can develop hardier, healthier, and more versatile plants in the face of climate change. As climates change, so too does a plant's productivity in a given region. The key to our well-fed future may be a variety of resilient crops that can grow in diverse environmental conditions.
10. Speed breeding will be able to more quickly breed and engineer plants which are more nutritious, resist disease, and which are better adapted to tomorrow's climate.

THE NEED FOR SPEED BREEDING

The growing human population and a changing environment have raised significant concern for global food security. The current improvement rate of several important crops is inadequate to meet future demand. This slow improvement rate is attributed partly to the long generation times of crop plants. Speed breeding can help breeders to grow up to six generations every year in crops like wheat, barley, triticale, etc. Under the speed breeding protocol, plants like wheat can go from seed-to-seed in just eight weeks, meaning breeders can grow up to six generations every year.

CHALLENGES AHEAD

Thus far, speed breeding has shown the biggest potential in long day species that flower in response to longer days, which makes confident by Hickey and his colleagues from University of Queensland that it will work with plants like sunflower, pepper, and radish. It will be trickier to apply speed breeding to 'short day' species like rice, maize, and sorghum also by his statement. Anyhow long cycle of breeding evaluation has to be shortening to develop superior varieties. So speed breeding is the better choice for future breeding programme.

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GENETICS OF ROOT ARCHITECTURE AND ITS APPLICATIONS IN PLANT BREEDING

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Abstract

Roots are crucial for nutrient and water acquisition and can be targeted to enhance plant productivity under a broad range of growing conditions. A current challenge for plant breeding is limited ability to phenotype and select for desirable root characteristics, due to its underground location. Genotypes evaluation for root architecture can harbor as valuable genetic resources for drought and salt tolerance and could be used in breeding to improve abiotic stress tolerance in crop plants. High-throughput phenotyping of root systems can be specialized technique and can better understanding through plant growth, root imaging and software tools. Currently, the genetic improvement of abiotic stress resistance can be understand through cloning and characterization of various abiotic responsive genes which regulates the root architecture.

Keywords: Root architecture – phenotyping – analysis

Introduction

Roots provide essential functions including the uptake of water and nutrients for plant growth, serve a role as storage organs, anchor the plants to the soil and are the site of interactions with pathogenic and beneficial organisms in the rhizosphere (Kano, M. *et al*., 2011). Different root characteristics enable plants to respond, adapt and thrive in different environments. An increasing global population requires agricultural production systems and cultivars that can continue to be productive in erratic weather patterns and are capable of more efficient resource capture from the soil. Breeding programs have traditionally focused on the aboveground plant parts (forage, seed or grain production) for the generation of food, feed and fiber. Breeders aim to develop improved cultivars that can tolerate a variety of abiotic stress conditions such as drought or flooding. These approaches include selection of individuals with improved plant growth characteristics such as grain or biomass yield, seed production, leaf surface area, the number of tillers and disease resistance.

Root architecture:

The term ‘root architecture’ refers to the spatial configuration of a plant’s root system. Root architecture plays the important role of providing a secure supply of nutrients and water as well as anchorage and support. The main hormones and respective pathways responsible for root architecture development which include auxin, cytokinins, gibberellins, and ethylene.

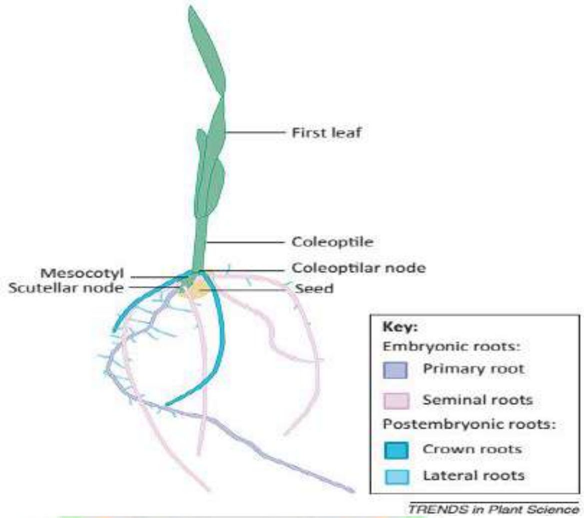
Each root apex is proposed to harbor brain-like units of the nervous system of plants. The number of root apices in the plant body is high, and all ‘‘brain units’’ are interconnected via vascular strands (plant neurons) with their polarly-transported auxin (plant neurotransmitter), to form a serial (parallel) neuronal system of plants

Development of Roots:

The root system of cereals is composed of different types of roots that are exemplified here by the schematic representation of a maize seedling (Figure I). The primary root (termed ‘radicle’ in rice) emerges from the seed quickly after germination. In the next few days, seminal roots emerge from the scutellar node in maize, whereas five embryonic crown roots emerge from the coleoptilar node in rice. These roots constitute the embryonic root system, which is essential during plant establishment and sometimes remains functional over the whole life cycle. The largest part of the root system is made up of shoot-borne post-embryonic roots that are produced sequentially from the successive shoot nodes, starting at the coleoptilar node. These adventitious roots, which are part of the normal development plan of cereals are designated crown roots or nodal roots (Beata Orman Ligeza et al., 2013).

Importance of Root Genetic Improvement :

1. Increasing productivity: Among essential nutrient elements required for rice growth, inorganic carbon is absorbed mainly by leaves in the form of carbon dioxide, the other essential mineral elements are all absorbed mainly through root surface from the soil. Root is the foundation of rice development. The high grain yield was mainly due to a larger sink size as a result of a larger panicle in rice (Gangling Li *et al*. 2021). The yield of elite varieties can be further increased by an increase in filled grains through enhancing root activity during grain filling in rice (Yang 2011).



2. Enhancing tolerance to abiotic stresses: Drought resistance is a boon for rainfed agriculture. "More crop per drop". Salinity resistance 20% of the world's cultivated land and near half of all irrigated lands are affected by salinity.

3. Improving efficiency of nutrients supplied: The use of fertilizer changed dramatically in the twentieth century, but excess nutrients have involved in many environmental problems. Unused fertilizer is washing off fields into rivers, poisoning coastal waters and causing acid rain (Nicola Nosengo, 2003). Nitrogen use efficiency (NUE) for cereal production is approximately 33% worldwide. The remaining N from fertilizer is lost to the atmosphere or leached into the groundwater and other freshwater bodies

Methods for root phenotyping :

Phenotyping root traits in the field is difficult, limiting the evaluation of RSA features and their use or selection during breeding. Field-based techniques are also laborious and require plot destruction for sample collection. The heterogeneity in the soil structure and composition that can impact the RSA of field-grown plants at different sites within a field is another factor confounding the effect due to the genetic and the environment interactions. Alternative methods to root phenotyping in the field involve measuring roots in plants grown under a range of controlled conditions.

Several software packages have been developed for imaging roots and extracting quantitative data from captured root images. A few examples of these software tools include

RootScan, RootNav, DART, GiARoots, IJ Rhizo, RootSystemAnalyzer, RootReader, RootReader3D and RooTrak. The growing number of image analysis tools dedicated to roots led to the recent development of Root System Markup Language (RSML) format to facilitate sharing of root architectural data between the different software packages and provide a standard format upon which to base centralized repositories of root trait data.

Measurement of Roots

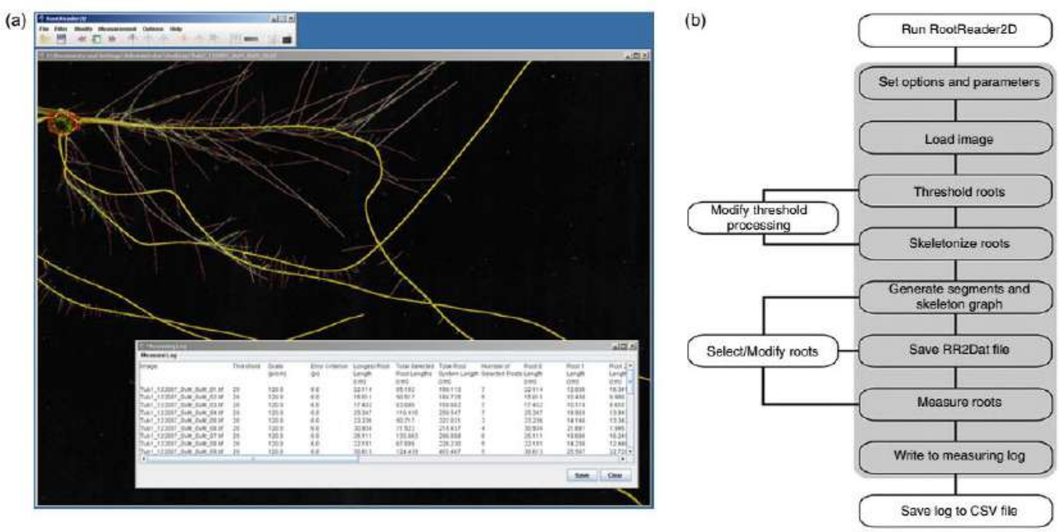
Differences in the maximum root depth between 'IR64' and Dro1-NIL in a paddy field after the imposition of drought stress. They examined the root systems of 'IR64' and Dro1-NIL plants by excavating a trench that allowed direct observation. White dashed lines indicate the approximate extent of root elongation by each accession. The maximum root depth of the Dro1-NIL plants was more than twice that of the 'IR64' plants. Scale bars, 10 cm.

DRO1-kp allele enables rice to produce more grains under drought induced stress. Under non-drought conditions, these plants show no yield penalty because DRO1 alters only root growth angle and does not decrease root biomass. This characteristic of DRO1 is of benefit for farmers, who seek the highest possible grain yields under both drought and non-drought conditions. New breeding strategies using genes influencing root system architecture to develop crop cultivars with high adaptability to drought. (Yusaku uga *et al*., 2013)

Measurements were made on seedlings after cultivation in control for 4 days. The seedlings were assigned to the two water regimes using a RBD, and two replicate experiments were performed. The complete root system was isolated from each plant and placed on a tray with no overlapping of any roots. The WinRhizo Pro 2007a (Regent Instrument Inc., Quebec, Canada) root analysis system was used to investigate root morphology based on images (400 DPI) captured using the EPSON professional scanner (Magalhaes *et al*.,2011).

RootReader2D processing and analysis

A novel phenotyping platform to grow, capture, process and measure root systems using digital imaging. This platform facilitates the high-throughput phenotyping of root systems while also allowing the nondestructive measurement of unique and challenging root phenotypes. The whole platform or parts of the imaging and analysis platform have been adapted and are generally applicable to a wide range of plant species, growth systems and root traits. The integration of both batch processing functionality and user-guided features into the RootReader2D software enhances utility when measuring root system characteristics while also ensuring flexibility for further trait extraction and development.



(a) RootReader2D software screenshot with measuring log and image of analysed maize root system where primary, seminal and total root lengths have been measured.

(b) Diagram of processing steps for root analysis with the RootReader2D software. The steps shaded in grey are performed automatically during batch processing routines.

Four days after transplanting, the root systems of 188 maize seedlings were imaged and the primary roots were carefully measured by hand with a ruler. The WinRHIZO software used is part of the WinRHIZO root analysis system, which consists of both image acquisition hardware and root analysis software. During WinRHIZO analysis, the root images were imported into WinRHIZO and analysed using a fixed threshold parameter of 40. The root images and threshold level corresponded to the same images and threshold level used during the RootReader2D processing and analysis of the maize root systems.

Conclusion

The root system being less accessible and more complex than other agronomical traits, achieving the ambitious goal of breeding the roots of the future requires a coordinated effort and joint resources. Utilization of a combination of root phenotyping strategies proposed to incorporate "root breeding" strategies aimed at enhancing plant performance through more efficient utilization of water and nutrients that will contribute to the sustainability of agricultural systems worldwide.

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CROP DOMESTICATION AS A LONG TERM EXPERIMENT

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Introduction

The present-day cultivated plants have been derived from wild weedy species. The first step in the development of cultivated plants was domestication, bringing wild species under human management, which began over 11,500 years ago where humans began agriculture. Domestication is a continuing process. While in the strictest sense of the definition, domestication could refer only to the first stages of selection that coincided with the initiation of agriculture, selection by humans continues to this day.

Selection under Domestication

When different genotypes present in a population reproduce at different rates, it is called selection. Domestication of wild species is likely to continue for a long time in the future since human needs are likely to change with time, and the wild species of little importance today may assume great significant tomorrow. This is particularly true for forest trees producing timber and other commercial products, medicinal plants, and plants fulfilling specific needs A notable case of recent and continuing domestication relates to several plant species for production of biofuels (eg) Jatropha, a member of Euphorbiaceae family, cultivation is being popularised since oil extraction from its seeds is used to produce biofuel, It also has medicinal value, is used as species and its leaves enrich soil carbon. kala jeera a perennial spice, was domesticated during 1990s in Himachal Pradesh, and is being cultivated as an orchard crop.

Important changes occurs under domestication

1) Elimination of or reduction in shattering of pods spikes, etc has taken place in most of the cultivated species. Examples include pea, *Brassica* spp, Wheat, barley etc.
2) Decrease in toxins or other undesirable substances has occurred in many crops. The bitter principle of cucurbitaceous plants and almond provide examples of this type.
3) Plant type has been extensively modified. The cultivated plants show altered tillering, branching, leaf characters etc
4) In several crop species, there has been a decrease in plant height, (eg) cereals, millets, etc. This is often associated with a change from indeterminate to determinate habit.
5) In some species, on the other hand, there has been an increase in plant height under domestication (eg) Jute (*Corchorus sp*), sugarcane, forage grass etc.
6) Life cycle has become shorter in case of some crop species, particularly in crops like cotton, pigeon pea, etc
7) Mort of the crop plants show an increase in size of their grains or fruits
8) Increase in economic yield is the noticeable as well as desirable change under domestication in every crop Species
9) In many crop species, asexual reproduction has been promoted, under domestication, (eg) banana, sugarcane, potato
10) There has been a preference for polyploidy under domestication. Many of the domesticated plant species are polyploids, (e.g.) potato, wheat while diploid counterparts are present in nature.
11) In many species, there has been a shift in the sex form of the species. In Many diocious fruit, trees, bisexual forms have developed under domestication, self-incompatibility has also been eliminated in several crop species.
12) Variability within a variety has drastically decreased under domestication. The extreme case is represented by pure line varieties, which are completely homozygous and consist of a single genotype.

Advantages

Improved Nutritional value: through selective breeding, domesticated plants have been developed with enhanced nutritional value, providing essential vitamins, minerals, and nutrients for human health.

Stages of Crop Domestication, on evolutionary process

The domestication of crop plants is not on instantaneous event but rather a gradual process that unfolds over multiple generations. It is characterized by several distinct stages

Incipient domestication

- Initial interaction between humans & wild plants, leading to the recognition of desirable traits
- Selection and progress, selective cultivation and propagation of individuals with favourable traits, leading to the development of landraces

Intensification and Genetic modification

- Increased cultivation intensity and the application of genetic modification techniques to further enhance crop traits.

Modern Breeding hybrid development

- Advanced breeding techniques, including hybridization and genetic engineering, to create modern, high-yielding crop varieties.

Conclusion

Crop domestication stands as a testament to humanity's ingenuity and resourcefulness. By understanding its nuances, we gain profound insights into the intricate relationship between humans and the plants that sustain us. From the challenges of genetic diversity loss to the promises of increased agricultural productivity, the journey crop domestication continues to shape our world.

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MUGA SILK (GOLDEN SILK) - THE FABRIC AND WEAVING GOLDEN DREAMS

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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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BLACK SOLDIER FLY LARVAE AND ITS IMPORTANCE IN AQUAFEEDS

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Abstract

Aquaculture faces challenges due to the reliance on fish meal and fish oil, leading to a need for sustainable alternatives. Black Soldier Fly (BSF) larvae, with their ability to convert organic waste into high-quality protein, offer a promising solution. This article explores the biology, nutritional composition, and culture methods of BSF, highlighting its potential as an aquafeed ingredient. Studies on various fish species demonstrate that BSF larvae meal can replace fish meal without adverse effects on growth or nutritional quality. However, challenges such as substrate variability and regulatory constraints must be addressed for widespread adoption. Despite these hurdles, integrating BSF into aquafeed formulations shows promise for enhancing the sustainability and resilience of aquaculture.

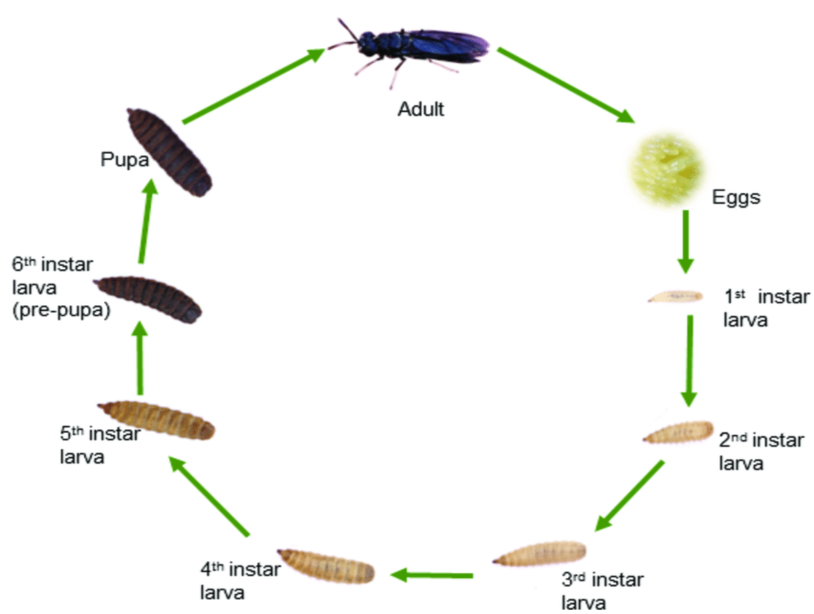
Introduction

Aquaculture, a significant sector in food production, relies heavily on fish meal and fish oil for the cultivation of aquatic species. These substances are rich in essential nutrients like proteins, amino acids, and fatty acids. Historically, fish meal and soya meal have served as primary protein sources in aquaculture due to their nutritional value. However, due to increasing demands, overfishing, scarcity of fish oil, and rising costs, there is a pressing need for alternative protein sources to substitute fish meal in the aquaculture industry. Various types of insects have been used in aquaculture to make feed ingredients. Among them, the Black Soldier Fly (BSF), scientifically known as *Hermetia illucens*, has become particularly popular among aquaculturists. This is because it can turn leftover food and manure into high-quality insect proteins. The BSF has been studied extensively for its nutritional value and amino acid content, and its larvae are considered an excellent protein source. Many studies have shown that BSF larvae (BSFL) meal can be included in the diets of aquatic animals such as salmon, tilapia, sturgeon, swamp eels, bass, catfish, sea bass, and crayfish, thereby offering a sustainable solution to the challenges faced by the aquaculture industry.

Biology

The black soldier fly (*Hermetia illucens)*, is indigenous to the Neotropics, but in recent years it has spread to every continent, almost becoming a global species. The adults of *H. illuciens* measure 16 millimetres in length, have a black body, and occasionally have a red-ended abdomen. The thorax has blue-to-green metallic reflections. The larvae can grow to be 6 mm wide and 27 mm long. Their hue is dull and colourless, and they have a little head that protrudes and teeth for biting. Larvae develop throughout the course of six instars, taking around 14 days to finish. The larvae of black soldier flies are voracious feeders while they are developing. BSFs go through four stages in their life cycle: eggs, larvae, pre-pupa, and adult. The length of the cycle is roughly 45 days. They live in the developing media for four days during the egg stage and eighteen days during the larva stage. It is only during their transition from pre-pupa (14 days) to adult (9 days) that they separate from the media and seek out a dry location to finish the process.

Figure 1: Life cycle of Black Soldier fly



Nutritional composition of BSF larvae

Black soldier fly larvae contain 42.1% crude protein, and the defatted black soldier fly larvae contain 56.9% crude protein, comparable to that of soybean meal and slightly less than fish meal. The processing and extraction of a lipid fraction from black soldier fly larvae generate protein meals with lipid content from 3.4 to 38.6% of DM. The black soldier fly larvae have a better amino acid profile than soybean meal; hence, a better substitute for fish meal. However, the oil must be extracted from the black soldier fly larval biomass before processing. They are rich in ash, calcium, and phosphorus, with a nutritional peak at the pupal stage. Maximum shelf life is achieved at 10 to 16 °C (50 to 60 F), while at room temperature, they can be kept for several weeks.

Table 1 - Nutritional composition of Black Soldier Fly Larvae

Nutritional components	%
Crude protein	42.1
Lipids	26.0
Calcium	7.56
Phosphorus	0.90
Ca: P ratio	8.4
Eicosapentaenoic acid (EPA) 20:5n-3	0.06 – 0.79
Docosahexaenoic acid (DHA), 22:6n-3	1.96-5.52

Culture method

Breeding of BSF

To enable males to conduct aerial questing prior to mating, black soldier flies are housed in 1.5×1.5×3m nylon cages with 200 mesh size in a 7×9×5m greenhouse. Throughout the breeding time, keep the temperature at 25±1°C, the relative humidity at 40±10%, and the photoperiod at 12:12. Misting water was used to keep the artificial plants and cage netting hydrated for the adults housed here. Fill a plastic bucket with 50% wheat bran, 30% alfalfa meal, and 20% maize meal to hold the Gainesville House Fly Diet. As an oviposition attractant, equal volumes of this dry medium and water were combined. Set the egg traps 2 to 5 cm above the attractant at this point. Following the breeding process, female flies lay eggs on "egg traps," which were constructed by glueing together three layers of double-faced corrugated cardboard, each measuring 2.5 by 5 cm.

Larval Rearing

Using plastic spatulas, eggs were removed from egg traps, then added to plastic boxes (19.5 × 16.5 × 9.5 cm), sprayed with water, and cover with lid .200 mg eggs can be stocked which would around 9,000 eggs per box. A fine mesh lid had been placed once approximately 50% of the larvae had hatched. BSF Larvae can be reared in a climate room at 27 ± 1°C and 65 ± 5% RH in the dark. The biodegradable substance like plant waste, poultry and pig manure can be used as substrate which act as feed. The larvae continue to feed for next 14 days, which will grow upto 2.5cm long, 200mg weight.

Use of Black soldier fly as aquafeed

Fish meal has been a main ingredient in feed preparation for the majority of farmed fishes. However, since feed accounts for about 60% of the overall expenditures associated with fish production and raw materials are becoming more difficult to get, BSF larvae may be a good option to replace fish meal in aquaculture. Numerous studies were conducted on a range of fish species at different Black soldier fly larval concentrations. Some of the researchers' findings are as follows:

1) Zebra fish

In the raising of zebra fish larvae, the substitution of BSF meal for FM was assessed. According to Vargas *et al.* (2018), the study's findings indicated that there were no negative effects on the fish larvae's growth or intestinal health. Furthermore, the fifth instar stage of the BSF larvae could be a considerable substitute for fish meal.

2) Rainbow trout

The use of BSF meal in place of FM at three different inclusion levels 0%, 50%, and 75% was reported by Stamer *et al.* (2014). They found that while the highest concentration treated group had some negative effects, such as leaner rainbow trout, the 50% inclusion level maintained normal function, similar to the control groups regarding body weight, feed conversion rate, and protein efficiency ratio.

3) Atlantic salmon

The incorporation of 50 g kg^{-1}, 100 g kg^{-1}, and 150 g kg^{-1} black soldier fly larval meal in place of fish meal did not have any detrimental effects on *Salmo salar*, according to Belghit *et al*. (2019). Furthermore, there were no changes observed in the composition of the entire body, including the components of protein, fat, and amino acids. The impact of consuming a black solider fly insect meal in place of FM entirely was assessed and documented in relation to Atlantic salmon.

4) Tilapia

Without creating any detrimental effects, *Oreochromis niloticus* grows much better when FM is substituted with BSFL (10%, 20%, 40%, 60%, 80%, and 100%). Additionally, they discovered that BSF larvae meal can completely substitute fish meal (Tippayadara *et al.*, 2021). Substituting BSFL meal for FM can be beneficial up to 50% of the time without having any negative consequences.

5) Seabass

According to Katya *et al.* (2017), replacing FM with 28.4% of BSF larvae meal was shown to be the ideal concentration for barramundi culture, with no detrimental effects on the growth, proximate composition, or amino acid levels of *Lates calcarifer*.

Challenges in using BSF larvae as aquafeed

The nutrient quality of the BSFL generated varies based on the end user's needs and the intended use of the product (pet food, aquafeed, or poultry feed, for example). The BSFL produced can maintain its nutritional quality by standardizing the substrate that is fed to them. However, the final quality of the BSFL is impacted by the substrate from different waste streams. Even though we use identical substrates, the fatty acid, lipid, and chitin content of their bodies affects the protein nutritional pattern. This serves as a barrier to the use of BSFL as feed, which has the ability to become main source of protein for animal feed. In addition, a regulatory problem and biosecurity clearance present further difficulty. Since the types of substrate used for insect farming, including BSFL, are subject to strict EU rules. As the larvae are efficient at breaking down and using the waste stream, the growing substrate should be thoroughly inspected for physical (plastic) and chemical (antibiotics/pesticide residue) pollutants. When plastics are used in aquafeed, the bioconversion or biotransformation of plastics into microplastics may also build up in the BSF body, which could have an adverse effect on quality and cause the product to fail the health certificate. Additional difficulties include determining the exact BSFL stage and how it affects growth of fishes. Therefore, pinpointing the precise stage and pattern of fish eating would be a laborious operation requiring more research in the aquafeed sector.

Conclusion

In summary, the black soldier fly (BSF) emerges as a promising solution to the challenges facing aquaculture. With its remarkable ability to convert organic waste into high-quality protein, BSF larvae offer a sustainable alternative to fish meal in aquafeed. Extensive research has underscored the nutritional value and efficacy of BSF meal across various fish species, demonstrating its potential to maintain growth performance and nutritional quality. However, hurdles such as substrate variability, regulatory constraints, and biosecurity concerns must be addressed for widespread adoption. Overcoming these challenges requires concerted efforts from researchers, industry stakeholders, and regulatory bodies to optimize BSF cultivation and processing methods while ensuring product quality and safety. Despite these obstacles, the integration of BSF into aquafeed formulations holds great promise for enhancing the sustainability and resilience of the aquaculture industry, paving the way for a more environmentally friendly and economically viable future.

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SUSTAINABLE AGRICULTURE FOR 21st CENTURY IN INDIAN CONTEXT

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Introduction

Many developing countries like India were facing many challenges over decades for providing food to feed affluent and growing populations. Green revolution has helped in the process of modernization of agriculture, which is an important contributing factor to meet this increasing food demand, has resulted in overuse of fertilizers and pesticides for reaching high productivity of land, has created modern high input agriculture.

The adverse effects of modern high input agriculture has resulted in overuse of natural resources causing depletion in ground water, loss of forests and wild habitats, loss in absorption capacity of soil, causing water logging and increasing salinity of soil, contamination of food, fodder, atmosphere, water by leaving pesticide residues, global warming, building up of resistance to pesticides in pests, erosion of genetic diversity, disturbance in crop ecosystem, new health hazards for workers in agrochemical and processing industries and in consumers.

Hence, the immediate action is to improve agricultural productivity besides conserving and enhancing natural resources. The only solution to this in changing scenario is sustainability in agricultural production. Maintaining sustainability is important for present and future generations because India is basically an agroeconomic country and majority of people directly and indirectly depends from farm related economic activities besides it not only employs 70% of workforce of country but also provides food, raw materials for industries, wood for fuel and shelter, herbs for medicines. Sustainability in agriculture sector means boosting up the rural livelihood system.

Sustainable Agriculture

Sustainable agriculture refers to successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing natural resources and avoiding environmental degradation. Sustainable development of agriculture in present scenario should be based on four pillars i.e., economic, social, environmental and cultural, it means it is ecologically sound, economically viable and socially just and culturally appropriate humane and based on holistic scientific approach.

Sustainable agriculture is achieved through low-input methods and skilled management. It means cutting off external inputs i.e., off-farm resources, such as fertilizers, pesticides to lower the production costs and also to help in increasing both short-term and long-term profitability. The ultimate goal of sustainable agriculture is to develop farming systems that are productive and profitable, conserve the natural resource, protect environment and enhance health and safety. This approach emphasizes on cultural and management practices such as crop rotations, use of animal manures and conservation tillage to control soil erosion and nutrient losses for enhancing soil productivity.

There are many ways of improving sustainability of farming system which vary from region to region. Some of them are follows,

- Soil conservation practices like, contour banding, vegetative barriers, cover cropping, reduced tillage
- Growing great variety of crops to overcome the risk from extremes of weather, market and pests
- Integrated nutrient management
- Integrated pest management
- Adopting water conservation practices such as deep ploughing, mulching, micro irrigation.

These all practices were also adopted in organic farming. Therefore, organic farming is considered as one of the main approach for achieving sustainability in agriculture.

Now-a-days field level challenges we face in the process of achieving sustainability in agriculture are as follows,

- Problem of Insufficient or overabundance availability of water resource as Indian farming is mostly based on seasonal rains

- Lack of adequate irrigation projects for providing irrigation facilities
- Lack of labour
- Inadequate market opportunities
- 5)Want of immediate results from farming for farmers so less adoption of sustainable practices
- Lack of available government policies and support
- Lack of on farm energy sources i.e., electricity
- Achieving sustainability through organic farming is a slow process
- Insufficient credit
- Cultivating single crop in large areas by farmers
- Lack of knowledge on sustainable practices of agriculture
- Problematic soils and soil erosion.

The solutions for these above problems can be as follows,

- Practice of surface and subsurface drainage in flood prone areas
- Practice of micro irrigation, constructing farm ponds, conjunctive use of water in drought prone areas
- Forming water users association among farmers for planning cooperative use of available water
- Lining of canals so that there will be no seepage losses
- Government should help farmers in providing on farm free electricity, market facilities, credit and irrigation facilities
- Farmers should be given training on sustainable practices in agriculture
- Cultivating diverse crops
- Adopting reclamation practices for problematic soils and soil conservative practices.
- Though there are many challenges while adopting the sustainable practices in agriculture, we should not strive for instant profits at the cost of our nature as it will become curse to our next generations.

"A SUSTAINABLE AGRICULTURE IS ONE WHICH BRINGS PROFITABILITY OF BOTH PEOPLE AND LAND"

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ENVIRONMENTAL DEGRADATION: CAUSE AND EFFECT ON EARTH

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Introduction

Environmental degradation is the deterioration of the environment through depletion of resources such as quality of air, water and soil; the destruction of ecosystems; habitat destruction; the extinction of wildlife; and pollution. It is defined as any change or disturbance to the environment perceived to be deleterious or undesirable. It is an increasingly persistent issue that affects us all and caused by a variety of factors, ranging from human activities to natural disasters, and its effects can be devastating.

The various causes of environmental degradation are:

The rapid population growth and economic development in country are degrading the environment through the uncontrolled growth of urbanization and industrialization, expansion and intensification of agriculture and the destruction of natural habitats. One of the significant reasons for environmental degradation in India could be ascribed to quick development of population which is antagonistically influencing the natural resources and condition.

Poverty is a major contributor to environmental degradation. People living in poverty often experience hunger and food insecurity, leading to over-exploitation of natural resources. For example, trees are frequently harvested to turn into charcoal, a product that can be sold for quick cash. This can lead to deforestation, air pollution, and other unsustainable practices that have a negative impact on the environment. These activities can have long-term negative impacts on the environment, including air and water pollution, soil erosion, and loss of biodiversity.

Deforestation

Deforestation is the permanent destruction of forests in order to make the land available for other uses. It is one of the leading causes of environmental degradation because it reduces biodiversity, disrupts the water cycle, and contributes to climate change. Trees also play an important role in the water cycle by absorbing water from the ground and releasing it into the atmosphere. Without trees, the water cycle is disrupted, leading to droughts and floods.

Climate change

Climate change is a major contributor to environmental degradation because it can cause soil erosion, which is the process of wearing away the land surface by the action of natural forces such as wind, water, and ice. Climate change can cause an increase in the intensity and frequency of storms, worsening erosion. Additionally, climate change can cause an increase in the intensity and frequency of floods. Furthermore, climate change can cause an increase in the intensity and frequency of droughts, which can lead to soil erosion due to wind and water

Soil erosion

Soil erosion can lead to increased air pollution, as the dust particles are carried away by wind and deposited in other areas. Finally, soil erosion can lead to a decrease in biodiversity, as it can reduce the amount of habitat available for plants and animals. Besides these some of the long-term environmental effects of habitat fragmentation have the potential to wipe out entire ecosystems.

Air and water pollution

Air and water pollution, miserably, are the main contributors to environmental deterioration. Contaminants brought into the ecosystem by pollution have the potential to harm or even eradicate some plant and animal species. Air pollution in India is a serious issue with the major sources being fuel wood and biomass burning, fuel adulteration, vehicle emission and traffic congestion.. India is the world's largest consumer of fuel wood, agricultural waste and biomass for energy purposes. Traditional fuel (fuel wood, crop residue and dung cake) dominates domestic energy use in rural India and accounts for about 90 per cent of the total.

In urban areas, this traditional fuel constitutes about 24 per cent of the total. Fuel wood, agri-waste and biomass cake burning releases over 165 million tons of combustion products into India's indoor and outdoor air every year. These biomass-based household stoves in India are also a leading source of greenhouse emissions contributing to climate change. Acid rain that arises from the reaction of moisture in the air with sulphur dioxide (SO_2) from coal plant emissions. Lakes and streams can get acidified and contaminated by acid rain. The effects on the soil are comparable.

The various effects of environmental degradation are

Deforestation, overgrazing, pollution, and climate change all contribute to environmental degradation and can lead to decreased crop yields and water shortages. These factors can all contribute to poverty, as people are unable to produce enough food to feed their families. It promotes erosion, which removes topsoil and reduces the fertility of the soil. It can also cause an increase in salinity, affecting the ability of plants to absorb water and nutrients. Soil compaction due to environmental degradation reduces the amount of air and water into the soil. Finally, it can lead to a decrease in soil organic matter content, which affects the ability of the soil to retain nutrients and water to support plant growth.

When people living in rural areas experience environmental degradation and increasing poverty, they help to distracted actions. Many times, children are taken out of school to work on their farm, and this disproportionately applies to girls. As a result, gender equality and education suffer. Many people resort to migration, either to more urban areas or other countries, in search of sufficient work opportunities. Environmental degradation is a significant contributor to human trafficking and violent activity.

Areas exposed to toxic air pollutants can cause respiratory problems like pneumonia and asthma. Millions of people are known to have died of due to indirect effects of air pollution. Air pollution Indian cities are among the most polluted in the world. Suspended particulate levels in Delhi are many times higher than recommended by the World Health Organization (WHO). Some of the most important air pollutants are residual suspended particulate matter (RSPM), suspended particulate matter (SPM), nitrogen dioxides (NO2), carbon monoxide (CO), lead, sulfur dioxide (SO2) etc. The main factors account to urban air quality deterioration are growing industrialization and increasing vehicular pollution, industrial emissions, automobile exhaust and the burning of fossil fuels kills thousands and lives many more to suffer mainly from respiratory damage, heart and lung diseases. In the countryside, nitrates from animal waste and chemical fertilizers pollute the soil and water, and in the cities, the air is contaminated with lead from vehicle exhaust. The indoor air pollution may pose an even greater hazard for human health. When fuels such as these are burned indoors, using inefficient stoves and poor ventilation, they can cause tuberculosis, other serious respiratory diseases, and blindness.

Biodiversity is important for maintaining balance of the ecosystem in the form of combating pollution, restoring nutrients, protecting water sources and stabilizing climate. The main cause of loss of biodiversity are deforestation, global warming, overpopulation and pollution are few of the major causes for loss of biodiversity. In fact human beings have deeply altered the environment, and have modified the territory, exploiting the species directly, for example by fishing and hunting, changing the biogeochemical cycles and transferring species from one area to another.

Ozone layer is responsible for protecting earth from harmful ultraviolet rays.. There are many other substances that lead to ozone layer depletion such as hydro chlorofluorocarbons (HCFCs) and volatile organic compounds (VOCs). Such substances are found in vehicular emissions, by-products of industrial processes, aerosols and refrigerants. All these ozone depleting substances remain stable in the lower atmospheric region, but as they reach the stratosphere, they get exposed to the ultra violet rays. This leads to their breakdown and releasing of free chlorine atoms which reacts with the ozone gas, thus leading to the depletion of the ozone layer. Global warming is another result of environmental degradation.

These human disturbances and unsustainable use of natural ecosystem which posed a lot threat to local biodiversity; leading to environmental degradation need to be addressed. Therefore there is need to embrace agroforestry a promising land use system that involves the integration of variety of trees species with herbaceous crops and / animal in some form of spacial arrangement or temporal sequence. These systems have the ability to increase the biodiversity and increase the overall productivity consumed by household. It also reduces soil loss and improves the physical, chemical properties of soil and at the same time helps in climate change mitigation for the sustainability of the environment.

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COMPUTER IMAGE MARKERS ON ASSESSING SEED QUALITY

Article ID: AG-V04-I06-49

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Abstract

Image analysis is referred as to the extraction of data from an acquired image. Image analysis is mainly used for varietal identification, but now a days this image analyser used seed quality assessment i.e. purity test. In varietal identification, image analysis was carried out using WINDIAS software. In purity analysis the software measures a number of features from eacseedsuch as the height, width, area etc and this information is stored into a database.

Introduction

Machine vision system is a computerised tool for image analysis (IA). Its functions are similar to the human observations. Human mind can be proved the best image analyst provided talented with of accuracy and vast regular memory, an image analysis system is the best aid, which can provide best skill to an investigator. Simply machine vision refers to the acquisition of data (shape, size, etc) via video camera or similar system and subsequent computer analysis of these data following suitable processing. The term “image analysis” has also been used in this context, but it more strictly refers to the extraction of numerical data from an acquired image.

Image analysis is generally recognized as having many important advantages over other manual techniques.

- It is non-invasive and in the case of seeds they are not subjected to any kind of treatment.
- Imaging software provides an increasingly interactive and user friendly environment to work.

- After the initial outlay for equipment and research unlike other systems, IA has very few additional costs.

Image analysis having some disadvantages

- The procedure described is essentially oriented at analyzing just one specimen or a small number of seeds at a time though it can do this at very high speed.
- Although spectral properties do relate to the bulk surface chemistry of the seed, nothing is gained on the detailed chemistry, especially, of the seed.
- It is not always possible to achieve the confidence level desired in the decision.
- It is not possible to distinguish a variety with 100 % accuracy level.

Application of image analyser

Image analysis is mainly used for varietal identification, but now a day this image analyser is used for seed quality assessment.

- ✓ Varietal identification
- ✓ Purity test

In the two last decades, new techniques based on machine vision systems have been developed to assist researchers and analysts in seed quality testing and sorting, in order to try to overcome some of the operational limitations of the standard methods of testing (AOSA, 2002; ISTA, 2005). Various methods use CCD-cameras and flatbed scanners to acquire seed images, high power computers, and fast image analysis software packages that allow rapid data processing and storage of data on hard disk (Chen and Sun, 1991). These outcomes suggest computerised image analysis is a promising technique as an approach to studying seed biology, with further potential in seed quality testing procedures.

Varietal identification

In varietal identification, image analysis was carried out using WINDIAS software (Nick Webb and Dick jerkins, 2000).

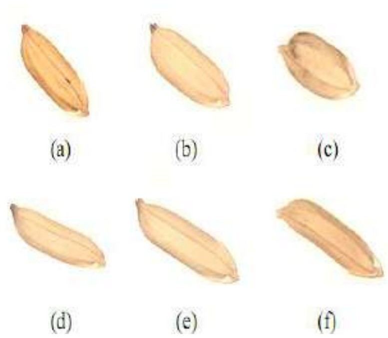
WinDIAS uses a PC computer with an image grabber board to acquire and analyse images.

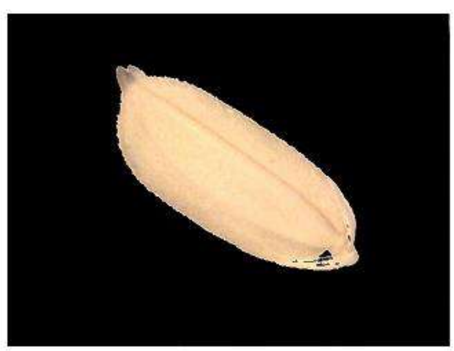
- It is particularly good at measuring the area of healthy and diseased plant leaves.
- It works with colour video camera.
- Rapid measurement of large quantities of leaves is possible with the conveyor belt option.
- Percentage diseased area can be measured.

- Further image analysis can be performed on static images i.e. without the conveyor.
- Simple shape analysis functions are provided including: length, width, perimeter, area, angles, centroid, average radial, shape factor, size distribution and object count.

S.No.	Parameters	
1	Length	Distance between two points marked on screen using mouse. Diameter of the smallest circumscribed circle that will fit around an object.
2	Width	Length is measured in horizontal X axis.
3	Elongation	Elongation is the ratio of the length and width E =w/l
4	Centroid	The centroid of an object is the most central point or centre of gravity of the object, (measured from the top left-hand corner of the screen).
5	Circularity	Circularity is the square root of the ratio of the actual area of the object to the area of a circle with the same circumscribed diameter.
6	Average radial	This is an average of all the distance measured from the centroid measured from the centroid to each perimeter point
7	Radial variance	Radial variance is the square of the standard deviation of all distances measured from the centroid to each perimeter point.
8	CMRV	This is the correlation of the average radial and radial variance.
9	Shape factor	Shape factor is the ratio of the actual perimeter to them of a circle with the same area.

Identification of rice seed varieties





Source: Zhao-yan Liu *et al.*, 2005

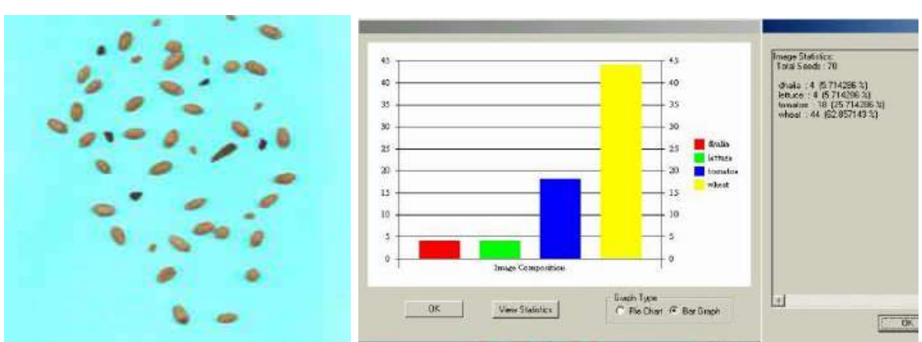
- It can count seeds and other objects.
- It can measure maps.
- It can be used with optical and electron microscopes.
- List of descriptors possible from WinDIAS SYSTEM

Area, perimeter, centroidX, centroidY, length, width, average radial, radial variance, CMRV, circularity elongation, shape factor.

Purity analysis

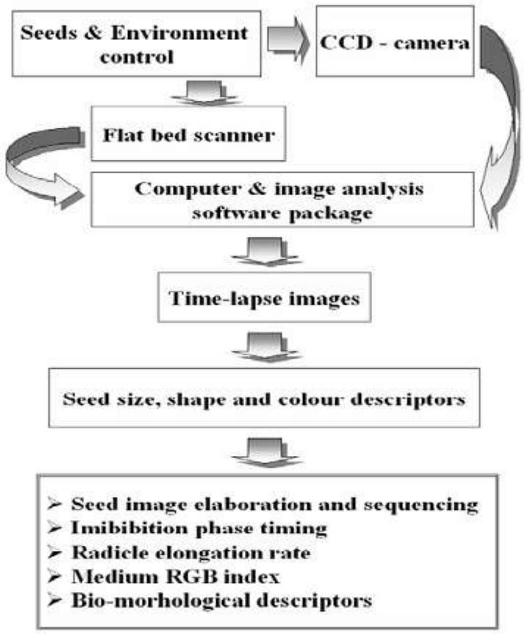
- The software measures a number of features from each seed such as the height, width, area etc.
- This information is stored into a database
- The user provides the name of the seeds, which is stored along with the statistics.
- This procedure is repeated for each seed the user would like the software to recognize.

Sample image (left); Computer is trained to remember characteristics of this seed class (right)



The software automatically analyzes and classifies the seeds in the purity image. The user can view the statistics and correct misclassifications.

Scheme of image analysis systems



Source: **Dell'Aquila Antonio , 2006**

Conclusion

Once the system that works has been designed then the whole process can be automated and the speed of analysis is much higher than any of the conventional methods.

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DOCUMENTING LONG SMUT DISEASE OF SORGHUM CAUSED BY *SPORISORIUM EHRENBERGII* IN NAMAKKAL DISTRICT

Article ID: AG-VO4-I06-50

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Abstract

Sorghum (*Sorghum bicolor* L.), known as "The King of Millets," is a vital staple crop in arid and semi-arid regions worldwide. However, the long smut disease caused by *Sporisorium ehrenbergii* threatens its cultivation, particularly in areas with low rainfall and high temperatures. This review examines the characteristics of *S. ehrenbergii* and the environmental conditions favouring its spread. Understanding its infection mechanisms and dissemination is crucial for implementing effective management strategies.

Introduction

Sorghum, scientifically known as *Sorghum bicolor* L., holds a significant position within the Poaceae family, recognized as "The King of Millets." With its abundance in carbohydrates, sorghum serves as a staple crop for millions residing in arid and semi-arid regions. Globally, it ranks fifth among major crops, following rice, wheat, maize, and barley, while in India, it claims the fourth position after rice, wheat, and maize. Notably, sorghum's main component, starch, undergoes slow digestion compared to other cereals, alongside possessing lower protein and fat digestibility. This crop plays a vital role in providing sustenance, feed, and to some extent, fuel to rural populations in arid and semi-arid regions worldwide. It stands as a dietary cornerstone for rural communities across Africa and Asia. In India, sorghum is cultivated as a rainy, post-rainy, and summer crop, reflecting its adaptability to diverse agricultural conditions.

The long smut of sorghum, caused by *Sporisorium ehrenbergii* (Formerly *Tolyposporium ehrenbergii*), stands as a significant fungal disease in Africa and Asia, particularly prevalent in regions characterized by inadequate rainfall and high temperatures, leading to low soil moisture levels.

The etymology of the genus name Sporisorium can be explained through the combination of "spora" (Greek for "seed" or "spore") with "sorium," derived from "soros" (Greek for "heap" or "pile"), referring to a cluster of spores (sori). Thus, Sporisorium means "a place for a heap or cluster of spores," highlighting the fungus's characteristic spore aggregation.

The specific epithet ehrenbergii recognizes the distinguished German naturalist and microscopist Christian Gottfried Ehrenberg (1795-1876). The suffix "-ii" is a Latin genitive case used in taxonomy to honour a person, signifying that the species is named after Ehrenberg, reflecting his significant contributions to science.

Symptoms of Long Smut of Sorghum Caused by *Sporisorium ehrenbergii*

The incidence of Sorghum long smut disease was recently documented at PGP College of Agricultural Sciences, Namakkal, marking the first report of this disease in the Namakkal district. This discovery highlights its unexpected appearance in the region and underscores the need for further study and management efforts.

In a serendipitous discovery, the disease was encountered while searching for herbarium specimens, emphasizing its unexpected appearance in the region. Sorghum long smut exhibits a distinctive pattern of infection, primarily targeting a small fraction of the florets scattered irregularly across the head. This sporadic distribution suggests potential infection by wind-borne inoculum following head emergence. The characteristic sori, or spore sacs, display cylindrical and elongated structures, often curved, with a notable thick, creamy-brown outer membrane (peridium). Upon splitting from the apex, the peridium unveils a dark mass of spores intertwined with dark brown filaments representing the vascular bundles of the infected ovary. Notably, in comparison to covered-kernel smut of sorghum, the sori of sorghum long smut are significantly longer, ranging between 2 to 4 centimeters, and wider. Infection initiates when wind-borne teliospores are carried into the boot and germinate, giving rise to sporidia that invade the spikelets during the boot stage up to anthesis. Subsequently, symptoms emerge approximately 11 to 14 days post-infection, coinciding with the heading stage of the crop's development. Upon maturity, the peridium ruptures to release teliospores, facilitating further dispersal of the pathogen within the environment.

Figure 1 Long Smut of Sorghum Caused by *Sporisorium ehrenbergii*

Figure 2 Dark filaments from split peridium representing the vascular bundles of the infected ovary

The teliospores of *Sporisorium ehrenbergii* disperse within fields and over long distances through air currents, insects, contaminated soils, and seeds. Often adhering together, these teliospores form spore balls that can persist in the soil for several years, serving as primary inocula for future infections.

Characterization of *S. ehrenbergii*

The galls were crushed, and spores were placed on a microscopic slide for observation.

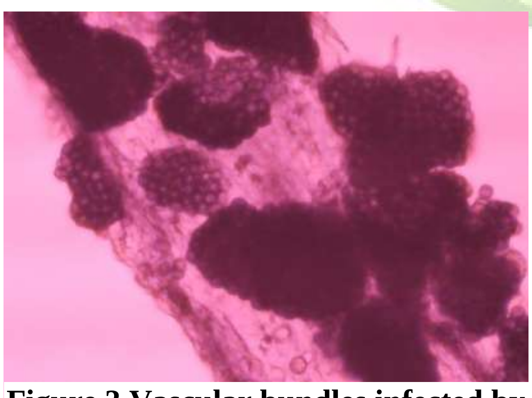

Figure 3 Vascular bundles infected by spores of *Sporisorium ehrenbergii*

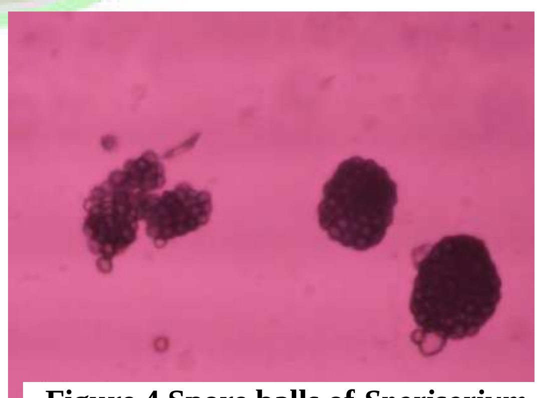

Figure 4 Spore balls of *Sporisorium ehrenbergii*

The teliospores of *Sporisorium ehrenbergii*, commonly known as 'long smut' fungus, are packed in spore balls that are dark brown and vary in size, ranging from 30 to 230 µm in diameter .

These teliospores are typically globose to subglobose in shape, with warty walls and a brownish-green coloration. They are present in loosely bounded balls. Under a microscope, the spores appear as tiny, round structures often clustered together within the smut balls characteristic of this fungal infection in corn.

Favourable conditions required for *S. ehrenbergii*

Namakkal district in the North Western Zone of Tamil Nadu experiences a predominantly semi-arid to arid climate, with high temperatures year-round. Summers are hot, often exceeding 35°C (95°F), while winters are milder at 20-25°C (68-77°F). The region receives moderate to low rainfall, mainly during the northeast monsoon (October to December), with some showers in May and June. These conditions favour the prevalence of the long smut of sorghum, caused by *Sporisorium ehrenbergii*, which thrives in areas with inadequate rainfall and high temperatures, leading to low soil moisture levels.

Conclusion

In conclusion, sorghum is a vital crop for arid and semi-arid regions, but the threat of long smut disease, caused by *Sporisorium ehrenbergii*, necessitates a thorough understanding of its characteristics and environmental requirements. Effective management strategies are crucial to safeguarding sorghum production and ensuring food security. Collaboration between researchers, farmers, and policymakers is essential to mitigate the impact of long smut disease and sustain sorghum cultivation.

Acknowledgement

The glass slide containing *Sporisorium ehrenbergii* was examined using an Almicro compound light microscope, and images were captured using a Strange View electronic eyepiece in the plant pathology laboratory of the Department of Crop Protection at PGP College of Agricultural Sciences, Namakkal.

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RECENT DEVELOPMENTS IN DNA FINGERPRINTING

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Introduction

The blood sample is an important piece of evidence for personal identification, forensic analysis, and even reconstruction of crime scenes. In past decades, novel reagents (chemicals, new recent techniques, and advanced materials have emerged in the development of blood fingerprinting. It serves as forensic science efficiently. We can also determine age by using fingerprints. DNA typing is otherwise called DNA fingerprinting. It has been developing since the mid-1980s. It is used not only in crime investigation but evolved into a versatile discipline with a wide range of applications. The gene that used for the protein synthesis for only 2-6% of coding DNA involves while remaining 95% junk or non-coding DNA present in the cell which are otherwise called as repetitive DNA. The differences in the minisatellites pattern that are detected by a probe along with stable inheritance forms basis for DNA fingerprinting. It includes

- DNA sequencing technologies
- Mixture analysis
- Body fluid identification
- Phenotyping profiling
- Forensic genealogy

- Microbiological analysis
- Exploration of novel markers
- Ethical and legal consideration

These developments make it possible to analyse difficult samples and provide comprehensive insights into the origins of biological evidence. Forensic genetics now includes a broad range of applications for instance mixture analysis, body fluid identification, phenotypic profiling, rapid DNA analysis, forensic genealogy, and forensic microbiology. Advances in DNA sequencing technology have greatly impacted diverse fields for example genomics, forensics and medicine. The field of DNA sequencing technology rapidly developed since the completion of HGP (2003). It is leading to various breakthroughs and innovations. In forensics, one of the high-throughput sequence technology such as MPS, also known as NGS, the second-generation sequence has become an invaluable tool for the analysis of DNA evidence. Traditional Sanger sequencing method enables fast, parallel sequencing of millions of DNA sequencing/ fragments simultaneously and also greater sensitivity, specificity, and ability to deal with complex DNA mixtures.

PCR in Forensic Science

The introduction of PCR into forensic science marked the beginning of a new era of DNA profiling. This era pushed PCR to its limits and allowed genetic data to be generated from trace DNA. Trace samples contain a very small amount of DNA associated with inhibitory compounds and ions. The PCR is a technique used to amplify the DNA by using a small amount of samples. There are five components required for amplification of DNA.

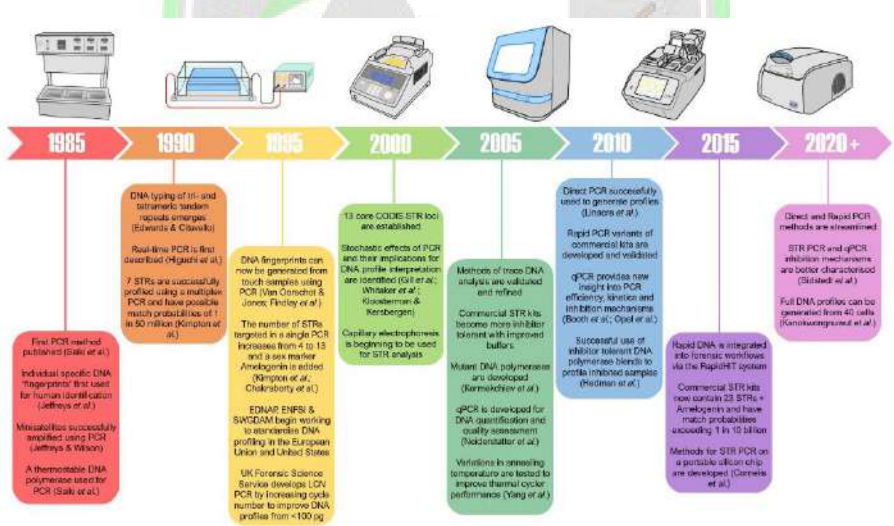
1. Deoxynucleotide triphosphate (dNTPs)
2. DNA polymerase
3. Template DNA
4. Primers
5. Buffer containing potassium and magnesium

The PCR programs involve three basic steps:

1. Denaturation
2. Annealing
3. Extension

Historical significance and advantages of PCR in forensic science:

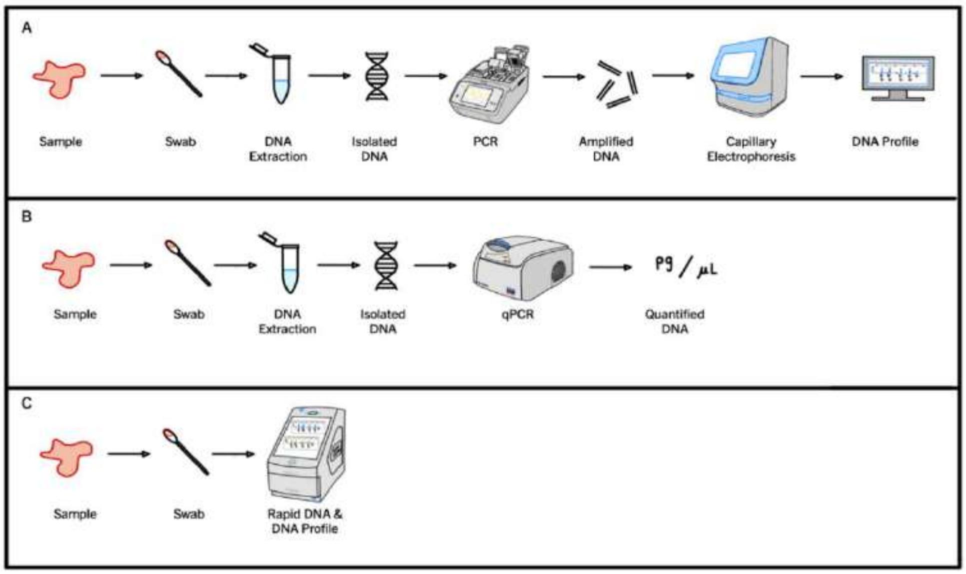
1981	The entire human mitochondrial genome was sequenced known as Cambridge Reference Sequence CRS).
1985	**Jeffrey** used radioactive probes to identify minisatellites (VNTR) to solve disputed parental affairs.
1990	Initially, forensic science was conducted by using restriction enzymes that targeted hypervariable regions within the human nuclear and mitochondrial genomes which is called RFLP (Restriction Fragment Length Polymorphism)
1991	PCR is used to amplify two regions of the mitochondrial genome which are HV1 and HV2 from skeletal remains using oligonucleotide hybridization.
1993	AFLP is used as a marker for finding out the human major histocompatibility complex (MHC), also known as HLA or DQa.
1994	STR analysis and mtDNA were used to identify the Romanor family in the Russian forest which is missing case has investigated by using forensic science.



DNA Fingerprinting in crop improvements

Plant breeding is vigorously developing by using crop DNA fingerprinting because of its advantages in forensic science, research, dispute resolution and variety protection. Before coming to proteomic and technology, the varieties were detected using morphological markers. In the 20^{th} century, protein-based markers were used for genetic diversity analysis in crops and DNA markers are mainly served for crop fingerprinting like RFLP, RAPD, SSRs, AFLPs, ISSRs, SNPs, and DAr (Diversity Array Technology). The upcoming innovations of crop fingerprinting are contingent to the creation of whole genome sequencing methods that are reasonable.

A comparison of the steps required to go from the initial crime scene sample to the final product via three different PCR methodologies: traditional PCR (**A**), quantitative PCR (qPCR) (**B**), and Rapid DNA (**C**).



DNA profiling and its role in forensic odontology

DNA fingerprinting made DNA evidence most widely accepted in court. It has transformed the features of forensic odontology. DNA fingerprinting pushed a long way from conventional fingerprinting. DNA is liable for all the cells' transfer of information both healthy and disease-related. But it is very difficult to detect DNA while mass calamities or fire explosions, carbonization and dissolutions, teeth consist a rich content of DNA. It has high physical and chemical resistance. It is served for the detection and determination of disaster victims and involves comparing related antemortem data available with their post-mortem reports. DNA profiling is the only reliable and responsible method for identifying when ante mortem data are not available.

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SEED TAPE TECHNOLOGY FOR PRECISION SOWING

Article ID: AG-VO4-I06-52

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Abstract

One type of carrier-based crop cultivation technology is seed tape sowing technology. Using this process, crop seeds are first turned into seed tape by wrapping them in a type of carrier material. In farms, the seed tape is subsequently spread using specialized machinery. The benefits of seed tape planting include precise control over hill spacing, a simpler field sowing procedure.

Key words: seed tape, precision sowing, manual seed tape, machinery seed tape, seed sowing

Introduction

Sowing is one of the important processes in crop production. There are currently two methods for planting / sowing crops, one is direct sowing and the other one is transplanting. As agricultural technology advances, sowing practices are gradually changing and agricultural production is developing towards refinement and intelligentization.

People have gradually paid attention to precision seeding since it can reduce seed wastage and improve economic efficiency (Pandey *et al*., 2002) while dealing the seeds which are very small in size, we tend to face many problems with seeding / sowing operations like spacing between the crops is not uniform, smaller smooth and round seeds are easily washed away by rain and wind, birds and insects may take up the seeds sometimes germination will not be uniform and intercultural operations are tough to overcome the above issues the seed tape technology was developed (Zhang, B *et al.*,2021).

What is seed tape

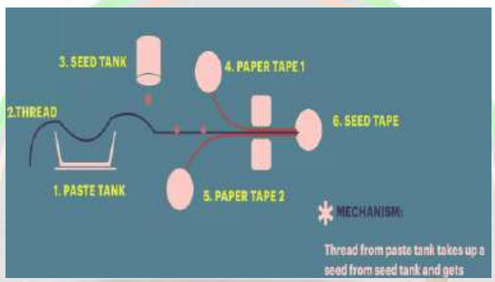
Seed tape sowing (also called seed rope), as a niche kind of precision seeding technique, can meet the requirements above because of its technological characteristics. Seed tape sowing can be independent of the seed size restrictions. It belongs to direct seeding and was first proposed by William Nelson McComb (Redenbaugh *et al*., 1991).

Seed tapes are pre- sown product of single or multiple species of seeds that are correct distance for sowing. Many small seed crop seeds, vegetable seeds, flower seeds or herb seeds can be incorporated into these products. It was discovered and patented by Schindler George Antony.

How to develop seed tape by using machines

There are two machines required for making and implementing the seed tapes in respectively

1. Seed tape making machine: it encloses the seed into two layers of paper and gives stiffness to extend it.
2. Tape seeder machine: it is used for settling the seeds in the field



Seed tape making machine

Source : https://www.slideshare.net/slideshow/seed-tape-technology/240794077- DevasenaM

These threads increase the strength for pulling the seed tape and setting it. Spacing between each seed can be variably adjusted based on the variety. The seed lots with two cotton threads are passes to through a paste tank that is made by glutinous rice and not involving any synthetic chemicals. The paper must be ventilative and permeable to water required for germination of seeds

Seed tape machine

Source : https://www.slideshare.net/slideshow/seed-tape-technology/240794077- DevasenaM

- ✓ The weight of this machine would be 5 kg so it is very handy and it is suitable even if the conditions of field is bad
- ✓ The drills make furrows of 6 cms width and 2 cm depth
- ✓ Consequently, the seed tape is pressed down and both the sides of furrows will fall down
- ✓ After germination the basal part of stem is covered sufficiently with soil.

Seed tape sowing in the field

Source : https://www.slideshare.net/slideshow/seed-tape-technology/240794077- DevasenaM

Advantages

- ✓ Maintain spacing, especially small seed vegetables
- ✓ Prevents birds from eating
- ✓ Eco friendly technology. All produce are biodegradable

Disadvantages

- ✓ Machineries used for seed tape production needs more cost
- ✓ Seed tape is costly compared seed.
- ✓ Sometimes gum used for sticking the seed is made with chemical and it will affect the quality of seeds.

Suitable seeds for seed tape technology

Anything on the smaller side that you would direct-sow in rows or squares is a prime candidate for seed tape.

The most popular seeds are:

- Lettuces
- Radish

- Onions
- Leeks
- Carrots
- Turnips

Step by step process for making seed tape by manual method


1. Material needed for making seed tape (gum, paper and seeds)


2. Cutting and folding of biodegradable paper


3. Marking the point for seed placement


4. Making glue and dab a small dot of glue onto each mark on the paper

5. Placing the seeds in each dot and allow to dry

6. labelling of tape

Source : **https://www.ruralsprout.com/diy-seed-tape/ - Tracey Besemer**. 2022.

Conclusions

Seed tape sowing technology has significant advantages, such as saving seeds, simplifying the sowing process, reducing labour costs and so on. However, seed tape technology also has advantages and certain disadvantages but this technology has wide scope in future towards greener environment.

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NUTRIENT MANAGEMENT TECHNIQUES FOR SOIL HEALTH

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Introduction

Use of fertilizers has become inevitable to increase agricultural productivity world over. There is a near linear relationship between fertilizer consumption and food production in most of the countries including India. The hope of meeting the food requirement of ever increasing population stands on this relationship. It is believed hat our population stabilizes around 1.4 billion. To feed this 1.4 billon mouths we need to produce around 340 mt of food. For this the only hope is by increasing the fertilizer consumption from the current 18.4 mt to 30 to 35 mt for NPK fertilizers apart from 10 mt supplied through organic and bio-fertilizers. In order to avoid the higher usage of chemical fertilizer and also due to high cost, we are in the position to adopt the new technologies to improve the nutrients user efficiency.

In general, the soil-water-plant system is a very heterogeneous system. Bio- production depends upon the efficiency of this system. Nutrients are generally applied to soil. It then enters water (solution phase) and plant roots and then to plant top.

The efficiency is influenced at each stage. They may be lost physically through erosion, surface run-off, leaching and adsorption and chemically through fixation and transformation into unavailable forms. The most serious step is the reaction and transformations for fertilizer nutrients when they enter soil system. Roughly the efficiency of N is estimated as 30-40 per cent, P 15-20 per cent, K 50-70 per cent, S 8-10 per cent, and micronutrients <10 per cent.

LOSSES OF NUTRIENTS

NITROGEN

The low efficiency of nitrogen fertilizers is thought to be largely due to N losses from soil-water-plant-atmosphere system. Ammonia volatilization, de-nitrification, surface run-off and leaching are the major routes of N losses from the system. The N use efficiency in rice soils ranges from 25-30 percent and it seldom exceeds 50 per cent with the heavy losses of N though leaching, denitrification, run off and ammonia volatilization.

Harper et al., 1987, and francis et al., 1993 documented that plants release N from plant tissue, (predominantly as NH_3) following anthesis. In temperate environment loss of N through surface run-off range between 1per cent (Blevins et al., 1996) and 13 per cent (Chichester and richerdson, 1992) of the total N applied. But in tropics high intensify rains and over flow of water from rice fields cause much larger amount of losses. The Gaseous N losses due to de-nitrification from applied fertilizer N may go up to 22 per cent in corn (Hilton et al., 1994), 10 per cent in low land rice (De Datta et al., 1991) and 9.5 per cent in wheat (Aulakh et al., 1982). Addition of decomposable plant material may substantially increase de-nitrification (Aulakh et al., 1984).the Losses of N through leaching can be significant when fertilizer N is applied at rates in excess of that needed for maximum yield.

Under temperate environment nitrate losses through the drainage may be as high as 26 kg N ha^{-1} when 115 kg N ha^{-1} was applied (Drury et al., 1996). Losses of N through ammonia volatilization are a major loss mechanism that affects the efficiency of urea and other N fertilizers in irrigated low lands. The magnitude of losses depends on wind speed. Temperature, rainfall, NH_4-N concentration, pH and CEC. Depending upon mode of application and time of application the loss may range from 7 to 54 per cent (De Datta et al., 1991).

PHOSPHORUS

The efficiency of phosphorus is generally lower than nitrogen. The low efficiency of P is thought to be largely due to fixation by the soil, and chemical transformation to insoluble forms ranged from 5-95 per cent, depending upon soil type. And some extent due to erosion and surface run-off.

POTASSIUM

Among the major nutrients efficiency of potassium is much higher. It is generally above 50 per cent.

The Loss of K from soil may occur through the surface run-off and through leaching in highly sandy irrigated soil.

SECONDARY AND MICRONUTRIENTS

Among secondary nutrients the efficiency of Sulphur follow similar pattern of phosphorous or slightly less than that. Generally micronutrients, which are applied in very small quantity undergoes transformation is soil and becomes unavailable with time. Specific work to evaluate the efficiency of applied micronutrients is very scanty. But the efficiency of soil applied micronutrients is generally less than 10 per cent.

Improving the Nutrient Use Efficiency in soil

The improvement of nutrient use efficiency of soil in most important because an unit increase in fertilizer use efficiency will have its direct impact on national economy and this will reduce the adverse effects of fertilizers on environment. It also improves the nutritive value of food produced.

There are several ways to improve the nutrients use efficiency like source of nutrients, method of application of nutrients, time of application, modified material, arresting chemical transformation, efficient crop rotations, nutrient use efficient varieties or hybrids, conservation tillage, foliar application, water management and precision agriculture. Which are discussed here,

1. Modified Materials:

Straight fertilizers that are added to soil come in direct contact with soil colloids and undergo transformations. To increase efficiency of such fertilizer either the contact is reduced or contact period is reduced or such additives are added which suppress the rate of chemical reaction. Since urea is the chief source of N world over, most of the efforts have gone in for reducing loss of N by modifying urea as (i) urea super granule (USG) to reduce contact area , contact period and to have advantage of facilitating deep placement in rice fields which enhances N utilization, (ii) Coated urea to reduce contact period and to suppress urease activity. Coating are done with numerous materials like coal, tar, lac etc., to reduce physical contact period or coated with sulphur, urease inhibitors or neem cake etc., to reduce rate of transformations.

Coating of phosphatic fertilizers is also gaining momentum. Coating of P fertilizers could limit the contact of applied P with soil possibly by reducing its precipitation and or adsorption on soil colloids and increasing their availability to plant roots. Experiments have demonstrated that polymer coating of mono ammonium phosphate has increased the estimated fertilizer P use efficiency from 16 to 32.6 per cent depending upon thickness of coating and has generally improved the response level (Malthi et al., 2002).

2. Efficient Crop rotations:

A crop plant can be more nutrient efficient by absorbing more nutrients form the limited soil source or from applied source and /or by utilizing the absorbed nutrient more efficiently for seed or grain production (Ganeshamurthy,1998). The Efficiency with which a crop produces a harvestable or economic product per unit of available plant nutrient varies with crop species. Rice, wheat, soybean, food legumes fall within the medium category with respect to their nutrient use efficiency. Hence, while formulating an efficient rotation one must select such crops which feeds on both applied nutrients and the residues of nutrients applied to previous crops in rotation.

3. Nutrient Use Efficient cultivars/Hybrids:

With the advancement of bio-technological tools, the interest in development of nutrient use efficience cultivars and Hybrids has increased. Considerable progress has been made in improving plants to grow and produce effectively on nutrient deficient soils. Ramani and kannan (1986) used nitrate reductase activity as a screening trait to screen sorghum germplasm for N efficiency.

4. Conservation tillage:

Conservation tillage is becoming popular as they control erosion, prevent environmental pollution and lowers the operational cost. But recent reports suggest that conventional tillage causes organic carbon loss whereas conservation tillage conserves organic carbon. This in turn helps in improving nutrient use efficiency. In the no-tillage production system, grain yield was improved 32 per cent when 60 kg N ha was banded 8-10 cm below the seed row and 15 per cent when banded between rows compared to surface broadcast urea. Adoption of sub-surface placement of N fertilizer for no-till winter wheat significantly improve N availability to plants and thereby improver NUE and reduced environmental and economic risks.

5. Split and Foliar application:

Split application of nitrogen fertilizer has been recommended for most of the field crops but P and K are generally applied as basal applications. Split application of N has been found to improve N use efficiency and reduces losses. It has also been found to increases protein content.

More the number of splits are better in the results. But economics of application comes in the way of increasing the number of splits. Since most crops receive one to two sprays of pesticides, it is always feasible to have sprays of nutrients along with fertilizer as they are compatible. Though legumes fixes atmospheric nitrogen and receives only a starter doze of nitrogen, it has been recently demonstrated that one spray of DAP at peak flowering has increased the yield levels of pulse crops. In case of micronutrients foliar applications have always been found superior to soil application. This is mainly because of the quantity of nutrient required to be pumped into plants.

6. Water management:

Moisture condition of the soil has a profound influence on nutrient availability to plants and losses through erosion and leaching. This is the basis on which fertigation has developed. Fertigation has a built-in mechanism of split application of nutrients. Hence efficiency of nutrient use is relatively higher in fertigation. The split application of nutrients matching with soil moisture condition will help in increasing nutrient use efficiency.

7. Precision Agriculture:

Current nutrient recommendations are based on soil testing. If a soil low in available nutrients then nutrients are added 25 per cent above recommended level and if it is high then 25 per cent less is added. In any case it is a blanket recommendation for a large area. Natural and acquired variability in production capacity or potential within a field cause the average rate to be inadequate in some parts and excess in other areas. In precision agriculture, timely and precise applications are done to meet plant needs as they vary across the landscape. In order to capitalize on any potential fertilizer saving and increase nutrient utilization efficiency management decisions need to be made at the appropriate field element size (FES). FES is defined as that area or resolutions which provide the most precise measure of the available nutrient where the level of the nutrient changes with distance.

Random field variability in soil test and plant biomass has been documented at resolution less than or equal to one square meter. When nutrient management decisions are made on areas of one square meter, variability present at that resolution can be detected using sensors, treated accordingly with foliar nutrient application thus increasing the nutrient use efficiency. It is however, important to note that soil testing irrespective of within field is a first approximation to refine nutrient rates. A combination of soil testing, fertilizer experience of the farmer and projected nutrient requirement are the best management tools available for farmers to determine fertilizer requirements.

Conclusions

The best hope for reducing nutrient loss and increase nutrient use efficiencies lies in finding efficient ways to fertilize crops and by developing better fertilizer materials. The nutrient use efficiency should be viewed differently for different nutrients depending upon the chemistry of the element in question and their residual effects. Soil test based fertilizer recommendations help in increasing fertilizer use efficiency. Balanced nutrition improves nutrient use efficiency as deficiency of one or more elements can reduce the use efficiency of others. The Effort must be made to develop ways and means to reduce canopy loss of nutrients.

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REVOLUTIONIZING AGRICULTURE: THE IMPACT OF NANO UREA ON POTATO FARMING

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Abstract

The agricultural technology breakthrough known as nano urea holds the potential to completely transform potato cultivation practices. By downsizing urea particles to the nanoscale, nano urea minimises nitrogen leaching that happens during the application of conventional urea and offers regulated release characteristics for nutrients. Increased yields of potatoes will result from this revolutionary technique, with minimal adverse effects on the environment and soil health. Plants receive accurate nutrient supply through the controlled release system, which promotes improved plant growth throughout the growing season. Using nano urea helps farmers become more financially stable and promotes ecologically friendly farming practices. But as a prerequisite to this technology to be widely used, issues with cost, scalability, and obtaining government approvals must be addressed. Stakeholders must cooperate to advance research and development in nano urea formulations especially intended for potato farming. With more research and development, nano urea has the potential to revolutionise the potato business and offer a workable way to attain food security and sustainable intensification in the face of global concerns.

Introduction

Innovation in agriculture is crucial to achieving sustainable food production to meet the needs of a growing global population. One notable technological development in recent years is the development of nano urea, a novel method for controlling the waste of fertilisers in agricultural activities. Nano urea has the ability to totally change the potato producing sector because it can raise crop yields while having a minimal negative environmental impact. One of the primary issues confronting the agriculture sector is how to maximise the amount of food produced while minimising its negative effects on the environment and ecology. Despite being essential for increasing agricultural yields, the application of conventional fertilisers frequently has undesirable impacts, such as nutrient runoff that can contaminate waterways and increase greenhouse gas emissions. This is the field in which nano fertilisers show great promise. A ground breaking advancement in the world of agriculture that makes use of nanotechnology is the use of nano fertilisers. In nanotechnology, materials are engineered at the nanoscale, or one billionth of a metre. When applied to fertilisers, nutrients are coated or encapsulated within nanoparticles, creating a unique delivery mechanism that could significantly improve nutrient use efficiency. Because of this, crops are able to absorb a larger proportion of the nutrients that are applied, which lowers waste and contamination to the environment.

Table 1: Effect of nano fertilizers on different crops

Crop	**Effect of Nano Fertilizers**
Potato	Controlled release for optimal nutrient uptake
	Minimized nitrogen runoff and leaching
	Increased tuber formation and yield
	Improved resistance to diseases and stress
	Cost savings and environmental sustainability
Soybean	Enhanced nitrogen fixation
	Reduced reliance on chemical fertilizers
	Enhanced soil health and fertility
	Improved pod setting and seed development
	Higher protein content in seeds
Tomato	Enhanced nutrient absorption by plants
	Reduced fertilizer application rates
	Improved fruit set and quality

	Enhanced shelf life and marketability
	Increased tolerance to abiotic stresses
Maize	Reduced greenhouse gas emissions
	Enhanced root development
	Reduced fertilizer input and associated costs
	Promoted flowering and pollination
	Higher biomass accumulation
Wheat	Reduced environmental impact (e.g., leaching, runoff)
	Controlled release for sustained plant nutrition
	Enhanced nutrient uptake
	Improved yield and quality
Rice	Enhanced water and nutrient use efficiency
	Minimized nitrogen loss and environmental pollution
	Increased resistance to pests and diseases
	Improved grain quality and yield

Understanding Nano Urea

Conventional urea has long been a mainstay in agriculture as a nitrogen fertiliser. Its use does have certain drawbacks, though, such as decreased fertiliser efficiency and environmental contamination via leaching, volatilization, and nitrogen runoff. Nano urea, however, provides an effective remedy to these issues. One kind of fertiliser made possible by nanotechnology is nano urea. It's a liquid nitrogen fertiliser with nanoparticles of urea. Because the nanoparticles are so much smaller than the particles in conventional urea, plants may be able to absorb them more readily.

Particles of urea that have been miniaturised to the nanoscale typically one to one hundred nanometers make up nano urea. There are several advantages when comparing this lower particle size to conventional urea. Above all, because of its regulated and controlled nutrient release properties, nano urea offers plants a more steady and gradual supply of nitrogen. This reduces the chance of nitrogen loss from leaching and volatilization, improving the efficiency of nitrogen fertilisers. Compared to ordinary urea, nano urea requires lower application rates in order to further minimise its environmental impact.

The Impact on Potato Farming

One of the most important food crops in the world, potatoes are harvested annually for use in feeding people and livestock in millions of tonnes. But conventional urea's harmful impacts are often felt by potato cultivation because it often requires massive fertiliser applications to get maximum yields.

Worldwide potato producers have a lot of opportunities owing to the recent discovery of nano urea. In addition to significantly raising potato yields, nano urea provides a more sustainable and ecologically friendly alternative to nitrogen, minimising the negative environmental effects of intensive agriculture practices. Moreover, potato plants receive nitrogen at precisely the right time due to the controlled release of nano urea, which promotes better growth and development all through the growing season. (Manikanta *et al*., 2023a)

Benefits for Farmers and the Environment:

For potato farmers, the adoption of nano urea translates into tangible benefits beyond just increased yields. With lower application rates and reduced nutrient loss, farmers can save on fertilizer costs while achieving comparable or even higher productivity levels. Furthermore, the environmental benefits of nano urea cannot be overstated. By minimizing nitrogen runoff and leaching, nano urea helps preserve water quality and mitigate the ecological impacts associated with conventional fertilizers. This not only safeguards the surrounding ecosystem but also contributes to the long-term sustainability of agricultural practices. (Manikanta *et al*., 2023b)

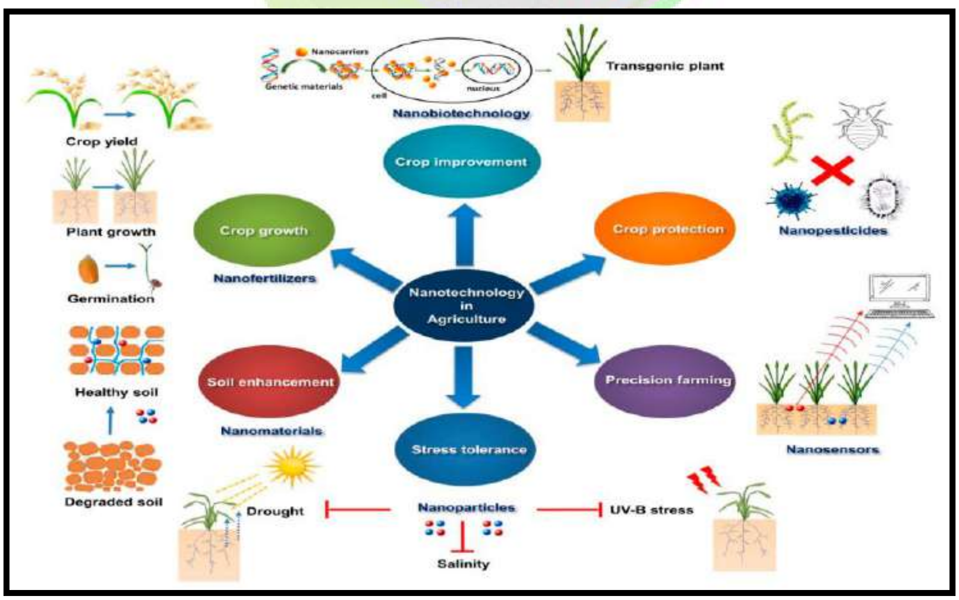

Fig: 1 Applications of Nanotechnology in agriculture (Source: Shang *et al*., 2019)

Challenges and Future Prospects

Despite its potential, the widespread adoption of nano urea in potato farming is not without challenges. The challenges about production scalability, cost for small and marginal farmers, and regulatory permits need to be addressed in order to guarantee equitable access and appropriate use of this technology. Future development and study will be required to further refine nano urea compositions and various application techniques created with potato cultivation in mind. To promote innovation and facilitate the widespread use of nano urea, governments, agribusiness associations, and private sector entities will need to collaborate.

Despite the challenges, nano urea offers exciting opportunities for the future of agriculture. Increased nitrogen uptake by plants can lead to more efficient nutrient utilisation, which can significantly lower environmental contamination and fertiliser waste. According to research, applying nano urea may improve yield, which would improve food security. By lowering the quantity of fertiliser needed and its environmental impact, nano urea has the potential to play a significant role in sustainable agriculture.

Furthermore, the customised nitrogen delivery mechanism of nano urea may be highly useful for precision agriculture, potentially maximising crop development. With further research resolving the problems and ensuring responsible development, nano urea has the potential to completely transform productive and sustainable farming operations.

Conclusion

In conclusion, the development of nano urea marks a monumental leap forward in agricultural technology, holding immense potential not just for potato farming, but for revolutionizing crop production across the board. By fundamentally transforming nutrient management practices, nano urea paves the way for a paradigm shift towards sustainable intensification. This innovative fertilizer empowers farmers to address the ever-growing demand for food security, while simultaneously safeguarding the environmental well-being of our planet for generations to come. As we delve deeper into unlocking the full potential of nano urea, a future beckon where agriculture is not only resilient but thrives in harmony with the environment. This future promises not just prosperity for farmers but a world where nourishment is available for all.

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BIOLUMINESCENCE IN INSECTS

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Introduction

Bioluminescence means when a living organism produces and discharges light as an effect of a chemical reaction - bio means 'living' in Greek while `lumen means 'light' in Latin. Through the process, chemical energy is converted into light energy. Bio luminescence is a creation of a chemical reaction in a creature; it involves a group of chemicals called luciferins which means light provider. This luciferin oxidizes in the existence of a catalytic enzyme luciferase and to create light and an ineffective compound (oxyluciferin). This light producing effect in any organism serves various purposes, including sexual attraction, courtship, predation and defence. Bioluminescence has possibly progressed from early ultra-weak chemiluminescent oxidase-catalysed reactions to become very effective purposeful light emitting processes. A primitive role in O_2 detoxification, joined with evolutionary benefits existing by specific light communication, may have permissible these types to flourish.

Origin of Bioluminescence:

Aristotle (384-322 BC) described 180 marine species and was the first to identify "cold light." The Greeks and Romans were the first to report the characteristics of luminous organisms. The Greeks also completed reference to sea phosphorescence (about 500 BC). The leading book devoted to bioluminescence was published in 1555 by Conrad Gesner. Later in 19th century Raphael Dubois achieved a significant research where he extracted the two key constituents of a bioluminescent reaction which was able to produce light. He coined the terms **luciferin** and the heat labile **luciferase.** The first luciferin was isolated in 1956 (Green and McElroy, 1956).

Light Production in insects

The light is formed as an effect of interaction among a substance called luciferin and the enzyme, luciferase. Several luciferins have been isolated in more or less pure forms from a wide diversity of organisms. The luciferin of firefly is 2-(4-carboxythazol)-6-hydroxybenzothyzol which is acted upon by ATP under the catalytic effect of luciferase. Still other luminescent scheme exists in Cypridina (a small marine crustacean) in which the luciferin is a polypeptide related to a yellow chromophore. Fireflies in which luciferin is secreted by specialized cells called photocytes. This material is liquidated to the outside along with luciferase where photogenic response takes place in the existence of oxygen.



When a suitable nerve impulse reaches the photogenic structure the nerve endings produce acetylcholine which is quickly hydrolyzed to form acetic acid and choline. ATP and co-enzyme-A present in photocytes now react with acetic acid developing pyrophosphate, adenylic acid and acetyl co-enzyme A. The luciferin now combines with adenylic acid to form a substance called adenylluciferin which in the presence of luciferase is oxidized to form excited or high-energy-adenyloxyluciferin which immediately deteriorations to a low-energy adenyloxyluciferin with the creation of light. The nervous system of insects is closely connected with the working of light organs and if the insect is executed or a nerve supply to the organ is cut, the flashes immediately cease. Insects under the effect of a nerve poison stop producing light and bioluminescence effect is not in insects.

Bioluminescence in various groups of insects

Light producing effect in terrestrial arthropods is found in Myriapoda and more broadly in insects and luminescence was also quantified in Amazonian species of Blattodea (Zompro and Fritzsche, 1999). Fireflies use light to fascinate mates. Two systems are involved conferring to species; in one, females emit light from their abdomens to attract males; in the other, flying males emit signals to which the sometimes inactive females respond. Click beetles emit an orange light from the abdomen when hovering and a green light from the thorax when they are troubled or moving about on the ground. The former is may be a sexual attractant but the latter is for defensive. Larvae of the click beetle *Pyrophorus nyctophanus* live in the superficial layers of termite mounds in Brazil. They light up the mounds by emitting a bright greenish glow which attracts the flying insects on which they nourish.

Importance of Bioluminescence in Insects

Bioluminescence in insects shows a major part in various important activities in insects. In simple systems of life, bioluminescence is believed to have useful importance in many arthropods, the light from bioluminescence is used to attract the opposite sex for mating, or it may be used to attract prey, or for escape from enemies.

Predation

The greatest single example of light acting as an attraction for prey is found in the New Zealand glowworm fly, *Arachnocampa luminosa*. The female fly deposits eggs on the ceiling of dark caves. Upon hatching, the larvae hang down by a sticky thread and produce light. During night, the whole cave may glimmer with this light, attracting other insect species. These attracted insects get knotted in the sticky threads and are preyed upon by the larvae. The caves inhabited by flies are popularly known as luminous caves' and are tourist attraction spots in New Zealand.

Defence mechanism

In railway larvae the nonstop glow of the head region when the larvae are walking, suggests a possible illumination function, whereas the circumstances under which the lateral light organs are switched on suggest a defence function. Sudden flashes can repel potential predators. The railroad worm larvae live at high densities, confined to small areas, and may use simultaneous emission to frighten potential enemies, or they may also use the light to intimate the mated females about to lay eggs about overcrowding and competition for food sources.

Mating signal

Bioluminescence produce light in insects is known to act as a mating signal in fireflies. In certain species the bioluminescence attracts individuals of the same species to aggregate, thus indirectly improving the chances of mating. In some species of Lampyridae, the females are wingless and sedentary; light production is therefore important for them to attract the winged males. b. Flash patterns in bioluminescent insects vary between species and between sexes. On a relatively cool night, some species wait 5.5 seconds then emit a single short flash. Other species may wait one second and then hold the flash for a full second. Some tropical species congregate in large numbers and flash in unison. c. Male and female fireflies of Photurispyralis emerge at dusk emitting a single short flash at regular intervals. d. The flashes are usually from male fireflies seeking mates. Males outnumber the females fifty to one. Females climb a blade of grass, flashing when males flash within 10-12 feet of the females. Exchange of signals is repeated 5 to 10 times until they start mating.

Conclusion

Bioluminescence plays an integral role in the natural environment and the unique feature of light production in certain organisms may have certain implications for use in the modern world. This biological phenomenon has been exploited in entomological research mainly in insect pest management. It can be used as a tool for mapping insect distributional patterns. During the year 2001, the researchers from USA attempted the fluorescence technique in key pest of cotton. The improved or GFP transgenic pink bollworm strain fluoresces powerfully green when observed in its larval stage which aims to be employ in the field performance studies and to map the distribution of the pest. In addition to this, they also are guiding temperature-sensitive lethal gene along with the GFP gene for the effective pest management.

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PESTS OF PIGEON PEA

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Introduction

Pigeon pea (*Cajanus cajan* L.,) is an important legume crop belonging to the fabaceae family. In India, it is mostly cultivated during rainy (Kharif) season as sole/intercrop for green vegetable and dry seed purpose. Major pigeon pea growing states of our country are Maharashtra, Uttar Pradesh, Madhya Pradesh, Karnataka, Gujarat, Andhra Pradesh, Tamil Nadu and Bihar. Among the various constraints limiting pigeon pea production, insect pests are the major ones. Some of the insect pests that occurred in redgram are,

1. Pod borer, *Helicoverpa armigera* (Nocutidae: Lepidoptera)

Adult moth has a V-shaped speck on the light brownish forewings and a dark border on the hind wings. Larvae is greenish with dark grey lines laterally on the body.

2. Spotted pod borer, *Maruca vitrata* (Pyralidae: Lepidoptera)

Larva is whitish to pale green in colour with dark spots on the dorsal surfaces of the body. The young larvae usually attack buds and flowers and older ones bore into maturing pods.

The flowers and pods are webbed together by frass produced by the larva. A larva may consume 4-6 flowers before larval development is completed. Seeds in the damaged pods are totally/partially eaten out by the larvae. Adult female moth lays light yellow, translucent eggs in groups on flower buds and flowers, developing pods, leaf axils, shoots etc. The adult moth has light brown forewings with white patches and white hind wings with an irregular brown border.

3. Pod fly, *Melanagromyza obtuse* (Agromyzidae: Diptera)

This is another important pod borer which is common in North and Central India. Adult female fly lay eggs individually in the developing pods and white maggots bore inside the pod and feed on the developing grains. Pupation takes place within pod itself without leaving external symptom of damage. Adult fly emerged through the pod by making a pin sized hole

4. Blue butterfly, *Lampoides boeticus* (Lycaenidae: Lepidoptera)

Larva is green colored, slug-like and oval shaped, feeds on the tender leaves, floral buds, flowers and pods. Adults are a bluish grey coloured butterfly which lays blue colour eggs singly on the buds.

5. Pod bug, *Clavigrella* spp. (Coreidae:Hemiptera)

Both adults and nymphs suck the plant sap from the flower buds and developing seeds by piercing through the pod wall. The attacked pods show dark patches outside and grains inside become shrivelled and small in size resulting in considerable yield losses. The affected grains are often, do not germinate and unfit for human consumption. Adult is a brown coloured hemipteran bug, lays eggs in clusters of 2-60, mainly on pods and leaves. It has five nymphal instars and the whole life cycle completes in an avg of 60-70 days.

6. Blister beetles, *Mylabris* spp. (Meloidae: Coleoptera)

They are also known as flower feeders as they feed the flowers and reduce the number of pod setting thereby affecting the crop yield. Adults are black beetles with bright red colouration on the forewings, are commonly seen individually or in groups @the terminal portion of the plant during crop flowering stage.

7. **Leaf webber: *Grapholita critica* (Lepidoptera: Tortricidae)**

Inconspicuous brown moth, eggs are laid in clusters of about ten on buds and young leaves, cream- yellow larvae pupates in the webs, the life cycle takes 3-4 weeks. Leaflets, flowers and pods are held together to form a web, larvae feed from inside these webs, growth of the terminal shoot is impaired if infested, infestations may begin as early as seedling stage and continue during flowering and podding, late infestation may also result as pod borer.

8. **Pulse beetle: *Callasobruchus chinensis, C. macultus* (Coleoptera: Bruchidae)**
9. **Grey weevil: *Myllocerus undecimpustutalus* (Coleoptera: curculionidae)**

Pod weevil: *Ceuthorrhynchus asperulus* (Coleoptera: curculionidae)

Adults are 5mm long with 11 black spots on its ash- grey body. Leaflets are chewed at the margins by adult beetles.

10. **Cow bug: *Otinotus oneratus*, *Oxyrachis tarandus* (Hemiptera: Membracidae)**

7mm long grey- brown bugs have thorn-like projections on the thorax. Eggs are laid on the stem. The nymphs exude a honey dew liquid which is used by ants. Damaged by sucking the green stems, formation of corky calluses, wilting and reduced plant vigor

11. **Jassids**

2.5 mm long and small green insects, nymphs and adults are of same shape but nymphs do not have wings. Nymphs run sideways when disturbed. Eggs are laid along veins on the under side of the leaflets. One generation requires 2 weeks. Damaged leaflets are cup shaped with yellow edges and tips, seedlings are stunted with red- brown leaflets followed by defoliation.

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RNAi TECHNOLOGY: BASICS AND ITS POTENTIAL APPLICATIONS IN AUGMENTING AQUACULTURE PRODUCTION

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Introduction

RNA interference (RNAi) is a biological process where the expression of a specific gene is silenced post-transcriptionally by messenger RNA (mRNA) degradation or translational inhibition after the introduction of gene-specific double-stranded RNA (dsRNA) into a cell or organism. RNAi was discovered by **Andrew Fire and Craig Mello** (1998) in nematode worms Caenorhabditis elegans, which is being used as a model to study aging and other biological processes. All living cells or biological systems have strategies to regulate gene expression at different levels. Among these, the regulation of gene expression at the post-transcriptional or translation level has a greater impact on the expression of phenotypes from an organism's genome. RNAi is one such mechanism that regulates gene expression by degrading targeted mRNAs and may result in the complete knockout of protein-coding elements. Apart from its role in controlling protein synthesis, RNAi has been found to have the ability to target viral RNAs and cleavage, ultimately inhibiting their progression. This antiviral activity of RNAi may be carried out by cleavage of important mRNAs, which have been identified with specific dsRNAs. Hence, RNAi has been used as an efficient nucleic acid-based antiviral strategy to overcome viral infections in aquatic organisms.

Summary of nucleic-acid-based antiviral strategies

Antiviral nucleic acids can be **exogenous** (e.g., siRNA or antisense oligonucleotides) or expressed **intracellularly** (shRNA, ribozymes, or RNA decoys). Viral transcripts complementary to the siRNA/shRNA are cleaved upon assembly of the RISC machinery. Modified antisense oligonucleotides have a high affinity for their target sequence and inhibit gene expression by steric hindrance of the ribosome. The binding of ribozymes to the target sequence also triggers cleavage of the viral RNA.

Importance of RNA interference

RNAi plays an important role in regulating development and genome maintenance by controlling unnecessary expression of genes. It has been reported that almost 30% of the human genome is regulated by RANi. The RNA interference pathway is effective enough to defend against viral infection and other infections caused by transposons and insertional elements. RNAi has been identified as an important component of innate immune response in some invertebrates like crustaceans (shrimps, crabs, etc..).

Important components of RNA interference pathway

We can identify three major components in an active RAN interference pathway: i. RANs include siRNA (short interfering RNA) and microRNA, ii. RNA-induced silencing complex, a multiprotein complex, induces cleavage, and iii. Enzymes, drosha, and dicer.

siRNAs

Short-interfering RNAs are small double-stranded RNA molecules of 21-22 nucleotide length that bind to target mRNA and initiate degradation. Among the two strands, the antisense strand (3'-5' orientation) acts as the guide strand for the RISC complex following the unwinding and release of the sense strand or passenger strand. The siRNA requires 100% sequence complementarity between the target and antisense strand. Structurally, siRNAs will have a 3'-overhang, usually containing two additional uridine residues.

Micro RNAs

Micro RNAs are more or less suppressive and are encoded by a non-protein-coding portion of the genome. Structurally, miRNAs originate as capped and polyadenylated precursor molecules (pri-miRNA), which will get modified into the hairpin precursor of 70 nucleotides and finally into a mature micro-RNA molecule of 22 nucleotides by the action of proteins drosha and dicer, respectively (Fig). An important feature of miRNAs is that they do not require complete sequence complementarity to target mRNAs.

Dicer

Dicer is an RNase III-like dsRNA-specific ribonuclease enzyme involved in initiating the siRNA-mediated RNAi pathway, where it cleaves dsRNA into uniformly sized small RNAs (siRNA). Dicer family proteins are ATP-dependent nucleases, and they act as dimers.

Loss of dicer activity results in loss of silencing processing.

RISC – RNA induced silencing complex

RISC is a large (~500-kDa) RNA-multiprotein complex that incorporates one strand of a small interfering RNA (siRNA) or micro-RNA (miRNA) to reach the target sequence for silencing. The ATP-dependent helicase domain helps in the unwinding of the guide and passenger strand of siRNA. The active components of an RISC are endonucleases called **argonaute proteins**, which cleave the target mRNA strand.

Argonaut protein

It has six characteristic domains: N-terminal (N), Linker-1 (L1), PAZ, Linker-2 (L2), Mid, and a C-terminal PIWI domain. PAZ (Piwi/Argonaut/Zwille) binds nucleic acids and recognizes the 3´ends of ssRNA. PIWI (P-element Induced Wimpy Testis) cleaves the phosphodiester backbone.

Mechanism of RNA interference pathway

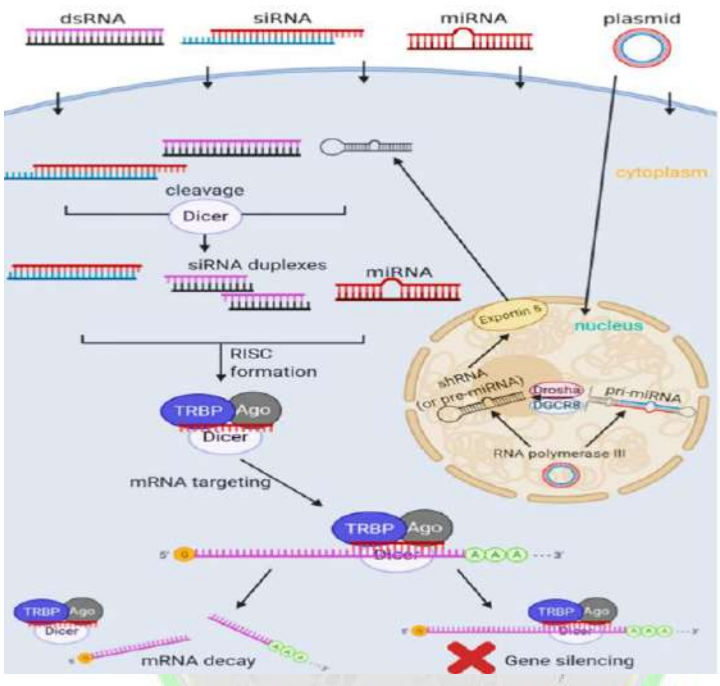
The mechanism of RNA interference may be involved in two steps:

i. initiation in the cytoplasm, followed by

ii. Effector step

During the initiation step, the mRNA-specific double-stranded RNA (dsRNA) molecule gets cleaved into small fragments of approximately 21 nucleotides by the RNase-III-like enzyme Dicer. In the case of the siRNA-mediated RNAi pathway, the dsRNA can be introduced in the form of simple blunt-ended dsRNA molecules of a certain length or directly as short interfering RNAs into cells (Fig.). After the initiation, the mature siRNAs were loaded into the RISC complex in the effector step, where double-stranded siRNAs were unwinded to release sense strands from the complex. Then, the remained antisense strand guides the RISC complex to select/target complementary mRNA sequences to degrade or silence. The degradation process carried out by argonaut protein consists of an endo-nucleolytic cleavage in the middle of the 21−23 base pair of the complementary mRNA within the region homologous to the siRNA. Finally, this process results in the inactivation of mRNA and, therefore, decreased levels of the encoded protein.

In the case of the micro-RNA mediated RNAi pathway, the miRNAs may be synthesized endogenously from the nuclear genome or may be introduced as a plasmid, containing a sequence to produce single-stranded hairpin RNA molecules (miRNAs). The only difference here is that the precursor molecules have to undergo multiple modifications to produce mature miRNAs, which can target specific RNA molecules. This modification may be carried out by a special protein called drosha/DGCR8, which brings end modification to the precursor to produce pre-miRNA. Finally, the dicer protein yields mature miRNA that can be loaded into the RISC complex and proceeds to silence mRNAs, as mentioned above.



RNAi pathway *HG Abo-Al-Ela, 2021

Potential applications of RNAi tool

Application Of RNAi In Immune-related Issues and Disease Control in Aquatic Animals

- The use of RNAi (long dsRNA) for controlling viral disease in shrimp was introduced in 2005 (Tirasophon et al., 2005), where it has been shown that dsRNA targets different regions of the yellow-head virus genome with dsRNA with more than 100 base pairs and this results in reduced viral loads.
- In fish species such as ayu, large yellow croaker *(Pseudosciaena crocea)*, and rainbow trout, the RNAi tool was successfully used to silence the *mRNA* of *Pseudomonas plecoglossicida* that was immunosuppressive.

- Through RNAi, it is possible to silence or degrade the genes that code for RNAi-resistant proteins.
- It is possible to design viral-specific dsRNAs to degrade the viral genome, thereby avoiding viral infections in crustaceans like *Penaeus monodon* (Thammasorn *et al.*, 2013).
- In a previous work carried out at ICAR-CIFE to combat WSSV infections, it has been reported that the use of RNAi-mediated long hairpin RNA molecules inhibits the replication of WSSV virus in *Penaeus monodon* to a certain extent where shrimp's immune system could deal with it.

Application of RNAi to Improve Commercial Traits in aquatic animals

- The ease of working with RNAi makes it a versatile tool to improve some of the commercial traits like growth and reproduction, etc.
- For instance, RNAi was successfully employed to produce all male stocks in *Macrobrachium rosenbergii*, where males will grow faster and enhance the return on investment.
- It has been found that the application of RNAi improves reproductive performance in crustaceans where the dsRNA-mediated RNAi pathway silences the gonad-inhibiting genes.
- RNAi was also used to knock out the myostatin gene in several fishes, and it has been applied to enhance weight gain.

Limitations of RNAi

- This system can take months to provide a complete response or results. Since RNAi molecules are introduced as dsRNA, they may recognized as viral infections, thereby activating the interferon system. It may affect its efficacy.
- The failure to distinguish between the guide strand (antisense strand) and the passenger strand (sense strand) by the RISC complex can promote off-target mRNA cleavage.
- In addition, off-target effects that resulted from triggering the innate antiviral response have raised concerns about using RNAi and also Concerns about delivery methods and how to reach target tissues with minimum side effects.
- The application of RNAi in aquaculture is facing issues due to a lack of an effective and inexpensive method that generates large amounts of RNAi molecules for large-scale use.

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CONVERSION OF VEGETABLES WASTE INTO BIOFUEL

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Abstract

The conversion of vegetable waste into biofuel represents a sustainable and eco-friendly solution to both waste management and energy production challenges. This process involves the utilization of organic waste materials, which are abundant and often discarded, to produce biofuels such as biogas, bioethanol, and biodiesel through various biochemical and thermochemical methods. Techniques like anaerobic digestion, fermentation, and transesterification are employed to convert the complex organic compounds in vegetable waste into simpler, energy-rich fuels. The benefits of this approach include reducing landfill waste, lowering greenhouse gas emissions, and providing a renewable energy source that can alleviate dependence on fossil fuels. This papert explores the methodologies, benefits, and potential applications of converting vegetable waste into biofuel, highlighting its role in promoting environmental sustainability and energy security.

Introduction

Vegetable waste poses a significant challenge across various stages of production, transportation, processing, and markets, contributing to global food waste, with about one-third of produced food being discarded. Inefficient disposal practices result in substantial losses, particularly evident in countries like India, where approximately 30% of vegetable production ends up as waste, totaling about 50 million metric tons annually (Sagar et al. 2018). This waste presents environmental risks and health concerns due to pollution, odors, and pest attraction. Nonetheless, there are management methods available, such as controlled fermentation or composting, which can convert vegetable waste into biofuels. Research increasingly explores this avenue, recognizing the potential of vegetable waste as a renewable energy source abundant in carbohydrates. Biofuel, derived from organic materials and waste, offers a promising and sustainable alternative to dwindling fossil fuels, addressing environmental, economic, and technological challenges. It includes various liquid and gaseous forms such as biogas, bioethanol, biodiesel, biobutanol, and biohydrogen, with the conversion process depending on feedstock quality and quantity. Vegetable waste undergoes physical, chemical, and biological classification to determine its suitability for energy generation, with chemical analysis assessing parameters like cellulose, sugars, and BOD/COD levels.

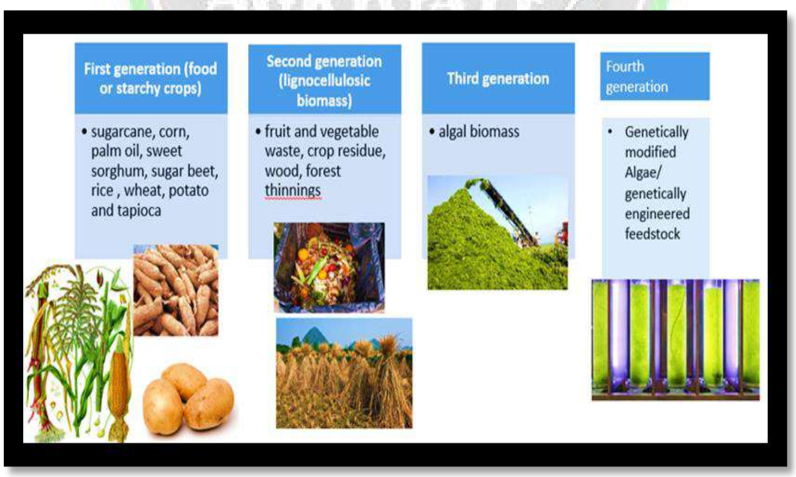

Fig: Four classification of biofuels

Biological characterization identifies pathogens and pollution indicators, guiding treatment processes for fuel recovery. Microbial or enzymatic digestion is a common method for waste utilization, converting vegetable biomass into desired fuels (Singh et al. 2012). Further, Biofuels are generally classified as first, second, third and fourth generations:

Conversion methods: Two primary pathways for biofuel conversion are thermochemical and biochemical methods. Furthermore, transesterification is recognized as a simple and cost-effective approach for large-scale biodiesel production (Lee et al. 2019).

1. Thermochemical conversion: Thermochemical conversion breaks down organic matter into solid biochar, synthesis gas, and bio-oil through high-temperature chemical reactions. Gasification, pyrolysis, and liquefaction are common methods, chosen based on biomass type and energy needs. Recent research shows increased interest due to available infrastructure, shorter processing times, and plastic waste conversion. This method is less dependent on environmental conditions, making it crucial for future energy plans. Understanding these processes is vital for evaluating their potential applications.
2. Biochemical conversion: Biochemical conversion of biomass utilizes bacteria, microorganisms, and enzymes to break down biomass into gaseous or liquid fuels, like biogas or bioethanol. Anaerobic digestion and fermentation are common biochemical technologies, with anaerobic digestion involving organic material breakdown by microorganisms in an oxygen-deprived environment. Biomass wastes can also be converted into liquid fuels such as cellulosic ethanol, providing a sustainable alternative to petroleum-based fuels.
3. Transesterification: Producing biofuels from potential biomass sources like cellulosic biomass poses challenges, as the extracted oil must match the properties of hydrocarbon-based fuels. Converting oils and fats from these biomasses into effective biofuels is a key challenge due to issues like high viscosity, low energy content, and polyunsaturated traits. Various pre-treatment methods, with transesterification as the most promising, can address these challenges. Transesterification converts fats and oils into esters and glycerol using catalysts, resulting in fatty acid methyl ester (FAME) with physical characteristics akin to petroleum fuels, while the by-product glycerol holds commercial value.

Vegetables waste to biofuels

1. Biomethane: Biomethane, a cost-effective renewable energy source, is produced through anaerobic digestion by microbial communities, involving hydrolysis, acidogenesis, and methanogenesis, with the composition influenced by bacterial populations.

2. Biodiesel: Biodiesel, derived from vegetable oils, animal fats, and oilseed plants, is a renewable, eco-friendly, and renewable fuel source, using both edible and non-edible oils.
3. Bioethanol and Biobutanol: Vegetable waste, rich in polysaccharides, can be fermented to produce bioethanol and biobutanol, with potential industrial applications in solvents and fuel additives due to its abundant availability and high cellulose content.
4. Biohydrogen: Biohydrogen, an eco-friendly biofuel, offers a viable alternative to oil reserves. Its high conversion efficiency and low CO2 emissions make it ideal for hydrogen energy production using fermentative processes.

Advantages of using biofuels:

1. Efficient Fuel: Biofuels, derived from renewable sources, offer cost-effective, eco-friendly alternatives to fossil diesel, reducing flammability, enhancing lubrication, and emitting fewer harmful emissions.
2. Cost-Benefit: The initiative aims to decrease costs associated with drop-in biofuels, enabling the production of valuable products from biomass or waste sources, and reducing biopower generation expenses.
3. Engine longevity in vehicles: Biofuels enhance engine durability by providing higher cetane ratings and better lubrication than traditional fuels, making them adaptable to existing engine designs and performing well under various conditions.
4. Simple to obtain: Gasoline originates from crude oil, a non-renewable resource expected to diminish over time. Conversely, biofuels are derived from diverse sources such as manure, crop residues, agricultural by-products, algae, and energy crops, offering a renewable alternative.
5. Renewable: Fossil fuels release emissions, while renewable sources like manure, corn, and crop waste offer sustainability and increased efficiency, making biofuels a sustainable option.
6. Decrease Greenhouse Gases: Biofuels can significantly reduce greenhouse gas emissions by up to 65%, contrasting fossil fuels that trap solar radiation and increase temperatures, further exacerbating global warming.
7. Economic Security: Biofuel production boosts agricultural sector, provides cost-effective alternatives, and creates job opportunities, strengthening economy stability.

8. Decrease reliance on imported oil: Experts suggest locally sourced crops reduce dependence on fossil fuels, but rising crude oil prices prompt urgent call for alternative energy solutions.
9. Reduce pollution levels: The use of these fuels results in lower levels of carbon dioxide and other pollutants when ignited, leading to a significant reduction in particulate matter emissions.

Disadvantages of Biofuels are:

1. Elevated production expenses: Biofuel production is currently expensive, with minimal interest and investment, but potential to meet demand. Scaling up would be costly in the long term, hindering widespread adoption.
2. Usage of Fertilizers: Biofuels, derived from agricultural crops, require fertilizers, which can lead to water pollution due to nitrogen and phosphorus washed away by runoff.
3. Water Use: Irrigation of biofuel crops requires significant water usage, potentially straining local water supplies and potentially exceeding sustainable levels for corn-based ethanol production.
4. Subsequent increase in cost: Biofuel production technology is underutilized, prompting scientists to enhance extraction methods. However, research and implementation costs may increase biofuel costs.
5. Weather problem: Biofuel is less suitable for cold temperatures than fossil diesel, as it tends to absorb more moisture, posing potential challenges in colder climates.

Conclusions

- It has the potential to be a hopeful solution for addressing global climate change.
- Large-scale production of biomethane and bioethanol from diverse food and vegetable waste sources seems economically viable.
- The growing demand for waste management is driving the development of bio-based products.
- A remedy for alleviating socio-economic challenges in developing nations.
- The likely prerequisites for achieving widespread bioenergy generation on a large scale include dedicated leadership, effective planning, technical and managerial assistance, public education, and increased investment in infrastructure.

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DROUGHT MANAGEMENT FOR SUSTAINABLE AGRICULTURE PRODUCTION IN ARID AND SEMI-ARID REGION

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Introduction

Low rainfall or failure of monsoon rains is recurring feature in India. This has been responsible for droughts and famines. The word drought generally denotes scarcity of water in a region .Thought, aridity and drought are due to insufficient water, and aridity is a permanent climatic feature and is the culmination of a number of long term processes. However, drought is a temporary condition that occurs for a short term period due to deficient precipitation for vegetation, river flow, water supply and human consumption. Drought is due to anomaly in a atmospheric circulation.

About 15 million ha dryland lies in the arid region which receives <500mm rainfall; another 15 millions ha is in 500-750mm rainfall zone,42 million has is in 750-1150mm rainfall zone, with the remaining 25 million ha receiving > 1150 rainfall per annum. Ever since the humans appeared on the earth, they have been harnessing the natural resources to meet their basic requirements. In the post independent era, India faced the daunting task of feeding the increasing populations and burdened by the recurring import of food grains. Attaining self sufficiency in food grains production was a challenge and a goal before the agricultural scientists.

- At present growth rate of nearly 2per cent annum, we will be around 1.4 bullions by 2025 and 1.6 billions by 2060.Hence, there is need to produce more from shrinking resource base.

- Major gains in productivity and production in the past three decades have been from areas, which had no serious limitations to production.

Sustainable agriculture

It is a balanced management system of renewable resources including soil, wild life, forests, crops, fish, livestock, plant genetic resources and ecosystem without degradation and to provide food, livelihood for current and future generations maintaining or improving productivity and ecosystem services of these resources

Arid means area receiving rainfall <500mm. and these are Rajasthan, Rann of kutch. Gujrat.And semi-arid where rainfall is 500-1000mm.these are Punjab, Hariyana, Maharashtra, Karnataka, Tamilnadu, Andra-Pradesh.

Distribution of arid states in India

States	**Area(10^6 ha)**
Rajasthan	19.61
Gujrat	6.22
Punjab and Haryana	2.73
Aandra-pradesh	2.15
Karnataka	0.86
Maharashtra	0.13
Total	31.70

Distribution of semi-arid states in India

States	**Area(10^6 ha)**
Maharashtra	20.12
Tamil- nadu	18.43
Karnataka	17.60
Aandra-pradesh	17.45
Punjab and Haryana	10.23
Total	83.83

Objectives-

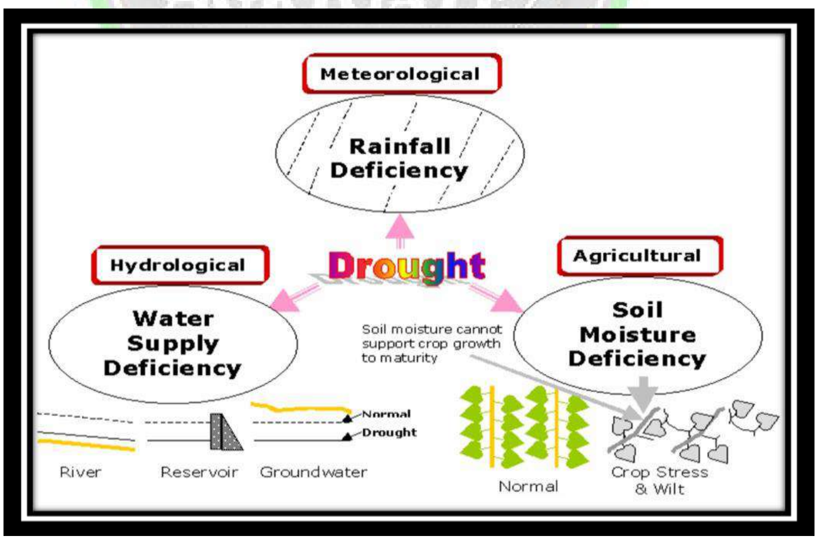
- To increase the agricultural production through drought mitigation practices.
- To conserve and sustain critical resources of arid and semi-arid region.

Causes of drought-

- Late onset of the mansoon-
- Long dry spell of the mansoon-
- Early withdrawal of mansoon –
- Erratic distribution of the mansoon-
- Inadequate precipitation-

Classification of drought

The National Commission on Agriculture in India classified three types of drought: meteorological, agricultural and hydrological. Meteorological drought is defined as a situation when there is significant decrease from normal precipitation over an area (i.e. more than 10 %). Hydrological drought results from prolonged meteorological drought resulting in depletion of surface and sub-surface water resources. Agricultural drought is a situation when soil moisture and rainfall are inadequate to support healthy crop growth. Drought is also classified on the basis of time of onset as early season, mid season and late season.



Meteorological drought

It is a situation when actual rainfall is significantly lower than the climatologically normal over a wide area or annual precipitation is less than the normal over an area for prolonged period (month, season, year).

Hydrological drought

Meteorological drought, when prolonged, results in hydrological drought with depletion with of surface water and consequent drying of reservoirs tanks etc. This is based on water balance and how it affects irrigation as a whole for bringing crop to maturity. Hydrological drought is associated with the effects of periods of precipitation (including snowfall) shortfalls on surface or subsurface water supply (i.e., stream flow, reservoir and lake levels, ground water).

Agricultural drought

It is the result of soil moisture stress due to imbanlance between available Agricultural Drought. Agriculture is the first sector to be affected by drought. Within the agricultural sector, marginal and small farmers are more vulnerable to drought because of their dependence on rain fed agriculture and related activities.

Sustainable Agriculture production-

Increases,

- High-yield polyculture
- Organic fertilizers
- Biological pest control
- Integrated pest
- management
- Irrigation efficiency
- Perennial crops
- Crop rotation
- Use of more water-
- efficient crops
- Soil conservation
- Subsidies for more sustainable farming and
- Fishing.

Decreases

- Soil erosion , Soil salinization
- Aquifer depletion, Overgrazing
- Overfishing
- Loss of biodiversity
- Loss of prime cropland
- Food waste
- Subsidies for unsustainable
- farming and fishing

- Population growth
- Poverty

Adaptations to moisture stress(drought)-

- Escaping drought.(eg.pulses like cowpea,greengram)
- Drought resistance.(sorghum,bajara)
- Drought avoidance.(millets,bajara)
- Drought tolerance.

Drought Escaping

Evading the period of drought is the the simplest means of adaptations of plants to dry conditions. Many deserts plants the so called emphemerals, germinate at the beginning of the rainy season and have an extremely short perid(5 to 6 weeks).These plants have no mechanism for overcoming moisture stress and are therefore , not drought resistant.

Drought resistance

Plants can adopt to drought either by avoiding stress or by tolerating stress due to different mechanisms.These mechanisms provide drought resistance but they mayor may not reduce productivity.

Drought avoidance

Drought avoidance is the ability to maintain a favourable water balance and turgidity even when exposed to drought conditions.A favourable water balance under drought conditions can be achived either by-

1. Conserving water.
2. Accelerating water uptake.

Drought tolerance

Drought tolerance can be defined as tolerance of the plants to a level of stress at which 50% of the cell.In drought tolerance, water potential of the plants is reduced and its adverse effects are felts.

Mechanism or drought resistance and their influence on sustainable productivity-

Drought escape

- Rapid phenomical development
- Developmental plasticity

Drought avoidance

(a) Conserving water- Increase in stomatal and cuticular resistance Reduction in radiation absorbed Reduction in leaf area

(b) Improving water uptake- Efficient root system increased liquid phase conduction

Drought monitering system in India –

i. Monitoring
ii. Declaration
iii. Preparedness
iv. Response a) preventions b) mitigation

Mitigation strategies for drought

Mitigation means actions that we can take before, or at the beginning of, drought to help reduce the impacts of drought.

Mitigating drought involves a wide range of agricultural practices including finding additional water supplies and conserving water that is already available.

However, it is not enough to make drought plans based only on agricultural practices. There are many other strategies at government level that are just as important.

The crop based strategies that will help to mitigate drought are :

- Land planning system
- Soil management techniques
- Crop management techniques
- Integrated watershed management
- Other water management technique
- Other practices

Land planning systems

Some lands can only sustain limited cultivation because they are prone to drought. These are best used for alternate uses rather than normal food grain crops.

Land-use systems give stability to dry land production systems and also make good use of the land and rainfall during the off-season.

Soil management techniques

- Tillage during the off-season or in pre-rainy season, helps with rain water intake by breaking the hard soil and making the soil surface more permeable.

- This allows water to seep to the deeper soil layers and keeps the soil wet for longer time.
- The result is the soil will have more moisture during sowing the crop.
- Tillage also controls weeds which depletes the soil moisture.
- Off-season tillage also destroys the eggs, cocoons and larvae of some pests by exposing them to the sun which otherwise affect the already stressed crop plants.

Crop management techniques

Selection of crops

- ❖ Avoid growing of drought prone crops like maize, cotton etc.
- ❖ Growing drought resistant grain crops like sorghum, pearl millet, finger millet, fox tail millet etc.
- ❖ Growing drought resistant legume crops like pigeonpea, green gram, horse gram etc.
- ❖ Growing of oil seed crops like castor, sunflower, niger, sesame, safflower etc

Oil seed crops like niger, sesame, safflower also can be grown under drought conditions. Crop management techniques Oil seed crops like niger, sesame, safflower also can be grown under drought conditions.

Interterrace land tretments for differents rainfall zones and expected yield advantage

Rainfall(mm)	**Soil type**	**Recommended land treatment**	**Yield advantage**
Arid(<500)	Arid soil Shallow red soil	Inter plot water harvesting of 1:1 croped to uncroped land Dead furrow at 3.6m interval	50% in pearlmillet 10% in groundnut
Semiarid (500-1000)	Shallow red soil Shallow black soil	Sowing across the slop Compartmental bunding for cosverd moisture	10% in sorghum 35% in rabbi sorghum

Traditional and improved crops and cropping system for arid of India

Location	CROPS		Suitable cropping system	
	Traditonal	Improved	Intercrop	Sequential
Jodhapur	Pearlmillet Mothbean Clusterbean Sesame	Hybrid pearlmillet	Mungbean Or cluster – bean	Pearlmillet -mustard
Hissar	Pearlmillet Clusterbean Mungbean	Hybrid pearlmillet Clusterbean	Pearlmillet Mungbean	Mungbean -mustard
Rajkot	Pearlmillet Cotton Sorghum Groundnut	Cotton Caster Sorghum Groundnut	Cotton/ Mungbean	-

Traditional and Improved crops and cropping system for semi-arid of India

Location	CROPS		Suitable cropping system	
	Traditional	Improved	Intercrop	Sequential
Hyderabad	Sorghum, maize, safflower	Sorghum, Safflower, chickpea	sorghum/ pigeonpea	Sorghum-safflower
Banglore	Fingermillet Maize, Groundnut	Fingermillet Maize, Groundnut	Fingermillet/soybean	Cowpea-Fingermillet
Solapur	Pearlmillet Sorghum Safflower Chickpea	Pearlmillet Sorghum Safflower Groundnut	Pearlmillet/ Pigeonpea	Pearlmillet-chickpea

Crop management techniques

Plant Density

- It is important to keep optimum plant population and row spacing. Generally wider plant spacing is preferred in drought prone areas.

- You must careful not to space the plants too widely. This will not use the available soil moisture to the capacity.
- Remember that more plants do not necessarily means more yield. In dry lands more healthy plants needed for better yield.

Crop management techniques

Weed management

- Weeds compete with crops for soil moisture and nutrients.
- Weeds also hosts some pests and diseases and these will migrate and affect the crops which are already under stress under drought conditions. So, good weed control from the early stages of crops is essential in drought areas

Surface mulching

Surface mulching either by timely intercultivation or by covering the soil surface with plant residues benefits the crops

Reduce water evaporation from soil.

- Reduces water runoffs from the cropped fields.
- Help control weeds.
- Adds organic matter to the soil and improves soil quality.

Crop residue management (CRM):

Use of the non -commercial portion of the plant or crop for protection or improvement of the soil. CRM, a cultural practice that involves fewer and/or less intensive tillage operations and preserves more residue from the previous crop, is designed to help protect soil and water resources and provide additional plant nutrients and environmental benefits.

Integrated Nutrient management (INM)-

INM takes care of physical, chemical and biological needs of the soil. It meets the nutrient needs of the soil from the use of organic and inorganic fertilizers.

Benefits of INM:

- Increases water holding capacity of the soil.
- Increases the amount of nutrients in the soil.
- The soil will be free from disease causing organisms.

Integrated watershed management (IWM)

IWM is the an efficient way to continually manage land and water resources in the drought prone areas. The focus of IWM is conservation and efficient way of using rain water. IWM combines several approaches to minimize the risk of drought.

These approaches are:

- Soil and water conservation
- Rain water harvesting
- Efficient land and crop management

Other water management techniques

Every drop of water will make a difference during drought and so efficient conservation of rain water is key to mitigate drought. The different methods of conserving water are:

- Building masonry storage tanks and broken embankments in community ponds and reservoirs.
- Building earth percolation ponds to store rain water.
- Desilting all water storage structures.
- Building check dams

Rooftop rain water harvesting

Farm pond- are small tank or reservoir like constructions are constructed for the purpose of storing the surface runoff.

Types of farm pond-

1. Embankment type.
2. Exacavated or dug type.

Check dam -a dam may be defined as an obstruction or a barrier ,constructed across the river, strem or vally to retain water for making big water body , behind.

Modern technologies used in mitigation of drought-

Use of Geographical Information System (GIS)-maps, photographs, topography, field observations, climatic data etc.

Use of Remote sensing system-

For soil and water conservation, crop identification, disease and stress detection etc.

i. Cropping System Analysis
ii. Agro-Ecological Zone based Land Use Planning
iii. Soil Erosion Inventory
iv. Soil Carbon Dynamics and land Productivity Assessment
v. Integrated Agricultural Drought Mitigation

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ARTIFICIAL INTELLIGENCE IN AGRICULTURE

Article ID: AG-VO4-I06-60

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Abstract

Artificial intelligence (AI) is revolutionizing agriculture by addressing critical challenges and enhancing productivity, sustainability, and efficiency. This article explores the importance of AI in agriculture, highlighting its various applications such as precision farming, automated machinery, and crop monitoring etc. AI technologies like machine learning, robotics, and IoT improve resource use efficiency, reduce carbon footprints, and preserve soil health. Government initiatives like Kisan e-Mitra and the National Pest Surveillance System support AI adoption, despite challenges such as high initial costs and technological limitations. By overcoming these barriers, AI has the potential to significantly boost agricultural production, ensuring food security and sustainable farming practices.

Key words: Artificial Intelligence (AI), Machine Learning (ML), Agriculture

Introduction

Artificial intelligence (AI) is a field dedicated to developing computer systems capable of performing complex tasks typically done by humans, such as reasoning, decision-making, and problem-solving. AI is becoming increasingly popular, encompassing a wide range of technologies that power everyday services and products, from booking metro tickets via chatbots to digital wristwatches that monitor physical and health activities in a real time. Agriculture, being the backbone of countries like India, provides employment to millions and significantly contributes to the national income. Therefore, prioritizing the agricultural sector is a smart and logical approach. As the global population continues to rise, the demand for food is increasing at an alarming rate. Traditional farming methods are insufficient to meet these growing demands, necessitating the adoption of new automated techniques. AI has revolutionized agriculture with advanced technologies such as machine learning, deep learning, automation and robotics, natural language processing (NLP), and machine vision. AI plays a crucial role in mitigating the impacts of climate events like drought, heat, frost, and heavy rainfall on crop yield, growth, employment, and food security. Furthermore, AI technologies enhance resource use efficiency, promote good soil health, and reduce carbon footprints. This article explores the importance of AI in agriculture, its various applications, and how these innovations can significantly boost production, productivity, and farmers' incomes while enhancing the efficient use of resources. Systematic use of AI in agriculture can mitigate the negative effects of climate change, paving the way for sustainable farming practices.

1. Principles of Artificial Intelligence (AI)

The AI implementation process encompasses defining tasks, choosing suitable models, pre-processing data, conducting exploratory data analysis, and evaluating model performance. Ensuring high-performance characteristics and stringent quality controls is crucial throughout the development of AI systems. AI plays a pivotal role in analyzing vast amounts of data (Big Data) in real-time, delivering forecasts that aid agricultural decision-making. Machine learning (ML) leverages this analyzed data to make informed decisions. Delving deeper, deep learning—a specialized branch of ML—utilizes layered artificial neural networks to interpret and derive insights from complex information (4). The basic principles of AI are illustrated in the **Figure 1.**

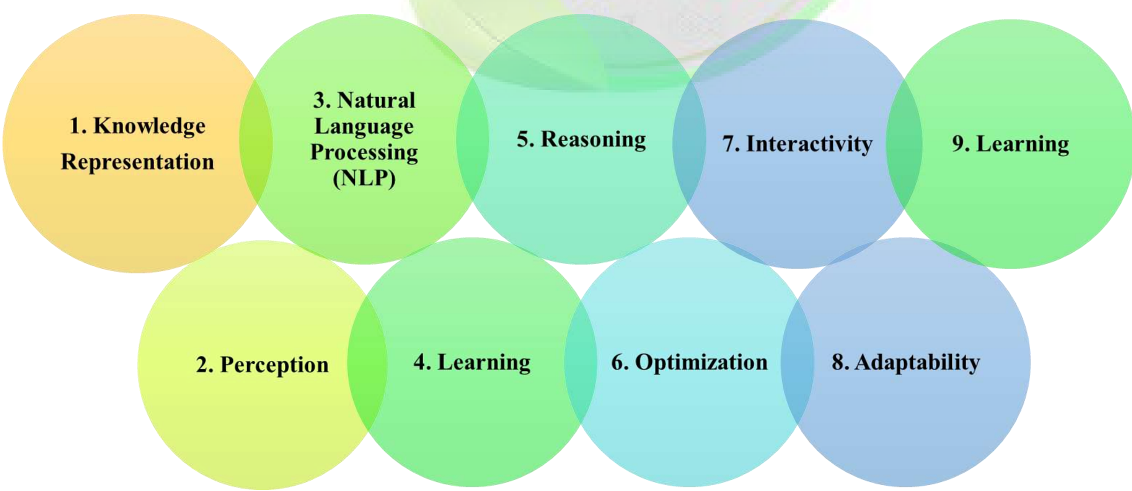

Figure 1. Basic Principles of artificial intelligence (AI)

A data model is a visual or mathematical depiction of data entities, their attributes, relationships, and constraints. It serves as a framework for organizing and comprehending data within a system or application. Data models can be divided into three categories: conceptual, logical, and physical. A conceptual data model outlines high-level concepts and relationships between data entities without delving into implementation specifics. A logical data model, on the other hand, represents data within a particular data management system, detailing tables, columns, keys, and relationships. Lastly, a physical data model describes how data is actually stored in a database, covering file structures, indexing, and storage optimization techniques.

2. Modern agricultural challenges and the Imperative for sustainable practices

- Soil degradation; Due to the uncontrolled use of fertilizers and chemicals, intensive farming practices such as monocropping, the soil is losing its natural fertility over time.
- The degraded soils are more prone to erosion, thus making them less resilient to extreme weather events like floods and droughts.
- The increasing use of chemicals and fertilizers to boost crop yield led to their negative effects on environment and human health.
- Resistance breakdown as a result of large scale cultivation of single resistant variety that leads to increase in selection pressure and hence evolution of virulent pathotype.

3. Benefits of AI to the environment and farmers

AI has various benefits to the environment and farmers owing to its integration with machine learning, deep learning, robotics, IOTs etc. (**Figure 2**). The benefits AI brings are

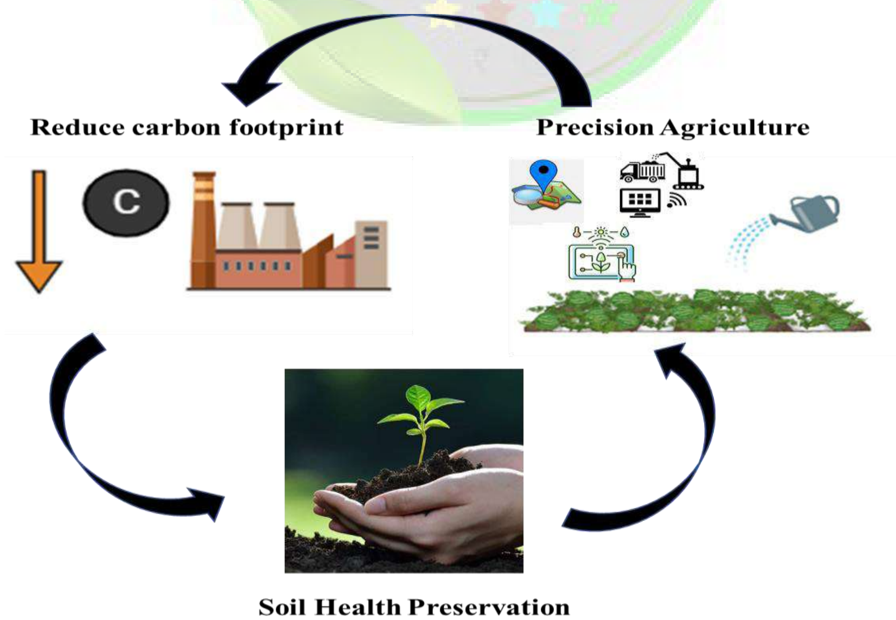

Figure 2. Benefits of AI to the environment and farmers

- **Increase resource use efficiency:** One of the biggest uses of AI in agriculture is in the field of precision farming. By using drones, advanced sensors, and other technologies to collect data of soil moistures, crop growth etc.
- **Reduced carbon footprint:** Climate change is a global crisis, and sustainable farming is essential for reducing our carbon footprint. AI-driven technology makes land use more efficient, cutting greenhouse gas emissions per farmed area.
- **Soil health preservation:** Monocropping and un-sustainable agricultural practices such as slash and burn agriculture, deep tillage practices, improper farm management and human activities as well as soil erosion due to intensive rainfall and cloudbursts led to degradation of millions of tons of soil every year.

4. Applications of AI in agriculture (Figure 3)

Surveillance:

- AI can provide 24/7 monitoring of farms, a difficult task for farmers to manage continuously.
- It offers protection against intrusions from animals like foxes and monkeys, as well as from the farmer's own livestock.
- Advanced AI systems can detect security breaches and are sophisticated enough to differentiate between employees and unauthorized visitors.

Enhanced Crop Monitoring and Management:

- AI-powered drones and sensors provide real-time data on crop health, soil conditions, temperature, and moisture levels.
- AI enables precise application of irrigation water, fertilizers, herbicides and pesticides, improving efficiency and yield.

Yield mapping and Predictive Analytics:

- AI models can predict weather phenomenon, pest infestations, and crop diseases, allowing farmers to take proactive measures.
- Helps in 3-D phenotyping of genotypes in phenomics.
- Machine learning-based yield mapping can assist in analyzing extensive data sets. This aids farmers in understanding the patterns and characteristics of their crops, enabling more effective planning.

- Integration of 3D mapping with data from sensors and drones, farmers can forecast soil yields for specific crops. Multiple drone flights collect data, allowing for progressively precise analysis through the use of algorithms.
- Helps in planning, planting, and harvesting times for optimal production.
- Detection of notorious weeds and invasive plant species.
- When integrated with machine learning, computer vision can analyze the size, shape, and color of leaves to differentiate between weeds and crops.
- This technology can be utilized to program robots for performing robotic process automation (RPA) tasks, such as automated weeding.

Automated Machinery:

- AI-driven tractors and harvesters reduce the need for manual labor, increasing productivity and efficiency.
- Autonomous machinery can work around the clock, leading to faster and more consistent farming operations.
- AI can help farmers in grading and sorting of produce based on its size, color, and shape.
- Thus, farmers can sell different categories of produce based on customer's need at different prices.

Precision Agriculture:

- AI technology allows effective use of resources and minimizes waste, thereby facilitating the implementation of precision farming.
- Ensures that each plant receives the exact amount of nutrients and care it needs.

Supply Chain Optimization:

- AI can streamline the agricultural supply chain by predicting market demand and optimizing logistics.
- Reduces food waste and ensures that produce reaches markets in the best condition.

Labor Shortage Solutions:

- AI and robotics help address labor shortages in agriculture by performing tasks that are difficult or undesirable for human workers, such as spraying harmful chemicals.
- Increases operational efficiency and reduces dependency on seasonal labor.

Sustainability and Environmental Impact:

- AI helps in implementing sustainable farming practices, reducing the environmental footprint of agriculture.
- Promotes the use of renewable resources such as solar, wind, and conserves water and soil health.

Data-Driven Decision Making:

- AI transforms vast data sets into actionable insights, empowering farmers to make informed decisions with precision.
- It elevates farm management and strategic planning to new heights, ensuring efficiency and productivity.

Cost Reduction:

- Automation and precision agriculture lower operational costs by reducing the need for inputs like water, fertilizers, herbicides, and pesticides.
- Increases profitability and economic sustainability of agricultural farms.

Improved Quality and Yield:

- AI techniques enhance the quality and quantity of produce by optimizing growing conditions and detecting issues early.
- Leads to higher market value and better food security.

Table 1 AI technologies in Agriculture

Technology	Crop management	Water management	Soil management	Fertigation	Disease and pest	Crop prediction	Crop classification
Robotics and automation	12, 14, 15	12					
Drones and unmanned aerial vehicles	2, 12	12					
Machine learning	2, 11		11			3, 13	
Artificial Neural Networks	14	8					
Deep Learning:			5		6, 9, 17		1, 16

Convolutional neural network							
Genetic algorithm				7			
Computer Vision	14						16
Digital Twins	10						
Internet of Things	11		11	7			
Cloud computing	2						
Data analytics and Big data	15						

5. Government initiatives by implementing "AI" in agriculture

A) Kisan e-Mitra: An AI-powered chatbot is available to assist farmers with queries about the PM Kisan Samman Nidhi scheme. This multilingual solution, which supports Hindi, Tamil, Odia, Bangla, and English, is continuously evolving to help with other government programs as well.

B) National Pest Surveillance System: This innovative system addresses crop loss caused by climate change by utilizing AI and Machine Learning to detect issues early. This allows for timely interventions, ensuring healthier and more resilient crops.

C) AI based analytics: It leverages field photographs for enhanced crop health assessments and uses satellite imagery, weather data, and soil moisture datasets to monitor the health of rice and wheat crops.

D) Namo Drone Didis: This Central Sector Scheme provides drones to 15,000 Women Self Help Groups (SHGs), offering rental services for agricultural activities such as applying fertilizers and pesticides. Additionally, the scheme imparts knowledge and technical skills in drone operation, opening new career opportunities in the agriculture sector.

Challenges of AI in agriculture:

There are following challenges in adoption of AI in agriculture

A) High Initial Costs: While AI holds significant potential for the medium to long term, the initial investment can be quite expensive. However, as technology advances, the cost of implementing AI on farms is expected to decrease.

B) Reluctance to New Technologies: Farmers, especially in countries like India, often hesitate to adopt new technologies, preferring traditional methods. To encourage AI adoption, both private and public sectors need to provide motivation, guidance, resources, and training to farmers.

Figure 3: Artificial Intelligence in Agriculture (AI)

C) Lengthy Adoption Process: Beyond the lack of knowledge and reluctance to embrace AI, the agricultural sector lacks the necessary infrastructure for its implementation. Even early adopters face challenges in advancing further. A stepwise approach is recommended, starting with simpler technologies and gradually incorporating more advanced features.

D) Technological Limitations: AI is still in its early stages and has its limitations. Accurate simulation modeling requires high-quality and reliable data, which is often scarce in agriculture. Overcoming these challenges requires continuous research and data analysis.

E) Privacy and Security Concerns: The use of AI in agriculture raises various legal and security issues due to the lack of regulations across industries. Cyber-attacks and data breaches pose significant risks to farmers, highlighting the need for robust security measures.

Conclusion

In conclusion, the integration of AI in agriculture presents transformative opportunities to enhance productivity, sustainability, and efficiency. By addressing modern agricultural challenges such as soil degradation and labor shortages, AI-driven technologies offer significant benefits to both the environment and farmers. Government initiatives and advancements in AI applications can further propel this sector towards a more sustainable and profitable future. Despite challenges like high upfront costs and technological limitations, the potential of AI to revolutionize agriculture is immense and promising.

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MICRO COMPOSTING

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Introduction

Micro composting in agriculture refers to the practice of using small-scale composting methods to recycle organic waste materials into nutrient-rich compost for use in soil fertility management. It involves the decomposition of organic matter by microorganisms into humus-like material, which can improve soil structure, increase water retention, and provide essential nutrients for plant growth. Micro composting can be done on a small scale, making it suitable for individual households, community gardens, or small farms. It's an environmentally friendly practice that reduces waste and promotes sustainable agriculture.

Micro- composting Centre

A micro composting center is a small-scale facility designed to process organic waste into compost. These centers are often community-based and aim to reduce waste sent to landfills while producing nutrient-rich compost for gardening and agriculture. Micro Composting Centre (MCC) was established under Swatch Bharat Mission (Gramin) to. Micro composting is one of the crucial component of sustainable waste management efforts. By decentralizing the composting process and conducting it at a smaller scale within local communities, the financial burden of transporting waste to dumpsites can be reduced significantly.

Moreover, micro composting not only helps in waste reduction but also generates valuable compost that can be used to enrich soil fertility and support local agriculture. This approach not only promotes environmental sustainability but also empowers local communities by providing them with an opportunity to benefit from the waste they produce.

Micro- Composting Process:

The composting process involves several steps:

1. Shredding the wet waste into smaller pieces to facilitate decomposition and aeration.
2. Preparing compost tubs or bins to receive the shredded waste, ensuring proper drainage and aeration.
3. Processing the wet waste by layering it in the compost tubs along with other organic materials such as dry leaves, grass clippings, and kitchen scraps.
4. Allowing the waste to decompose over time, periodically turning and aerating the compost pile to promote microbial activity and decomposition.
5. Once the composting process is complete and the organic materials have broken down into nutrient-rich compost, it is ready for use in gardens or agricultural fields.
6. Packaging the compost into bags or containers for distribution and marketing purposes, ensuring proper labeling and compliance with local regulations.
7. Marketing the compost to local gardeners, farmers, or other potential customers, highlighting its benefits for soil health and plant growth.

Waste Management from Local Bodies

The responsibilities of the Local Body regarding waste management include:

1. Collection and transportation of waste to the Material Recovery Facility (MRF) or Material Collection Centre (MCC) for further processing.
2. Provision of infrastructural facilities such as waste collection bins, transfer stations, and composting facilities to facilitate waste management processes.
3. Ensuring that the MCC meets the requirements for effective waste processing, including adequate space, equipment, and trained personnel.
4. Ensuring the personal health and safety of workers involved in waste collection and processing by providing them with Personal Protective Equipment (PPE) such as gloves, masks, and uniforms.
5. Facilitating the packaging and marketing of compost produced from organic waste through proper channels to ensure its utilization and generate revenue or benefits for the local community.

Limitations

The disadvantages associated with composting techniques include:

1. Time and effort: Composting can be a time-consuming process, as it typically takes weeks to months for organic matter to fully decompose into compost. Regular turning and monitoring of the compost pile are necessary to promote decomposition and prevent issues such as odour or pests.
2. Physical work: Turning the compost pile and maintaining proper conditions (such as moisture and aeration) may require physical labor, especially for larger compost piles. However, many people find the process to be rewarding and beneficial for soil health and plant growth.
3. Pest attraction: Certain food scraps, such as meat, dairy, and oily foods, can attract pests such as rodents or flies to the compost pile. To minimize pest issues, it's essential to avoid adding these materials and stick to plant-based materials instead.
4. Environmental factors: Environmental conditions, such as temperature, moisture levels, and airflow, can affect the composting process. Inconsistent or extreme conditions may slow down decomposition or lead to unpleasant odours.

Despite these challenges, composting offers numerous benefits, including the production of nutrient-rich soil amendments, reduction of organic waste sent to landfills, and improvement of soil health and fertility. With proper management and attention, composting can be a sustainable and rewarding practice for gardeners and environmental enthusiasts alike.

Conclusion

Micro composting is a valuable practice of reducing organic waste, improving soil health, and promoting sustainable gardening practices. The initiative taken by the government to install micro composting centres in areas with high organic waste generation is commendable. By establishing these centres, the government not only addresses the issue of organic waste management but also promotes sustainable practices at the community level.

Micro composting centres provide a convenient and accessible solution for residents to responsibly dispose of their organic waste while contributing to environmental conservation efforts. Moreover, these centres play a crucial role in raising awareness about the importance of composting and fostering a culture of waste reduction and resource conservation. Overall, the government's investment in micro composting centres reflects its commitment to promoting environmental sustainability and creating healthier, more resilient communities.

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ROLE OF KRISHI VIGYAN KENDRAS IN INDIA AGRICULTURE

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Introduction

The first KVK was established in 1974 at Puducherry. The number of KVKs has risen to 731. The KVK scheme is 100% financed by Govt. of India and the KVKs are sanctioned to Agricultural Universities, ICAR institutes, related Government Departments and Non-Government Organizations (NGOs) working in Agriculture. KVK, is an integral part of the National Agricultural Research System (NARS), aims at assessment of location specific technology modules in agriculture and allied enterprises, through technology assessment, refinement and demonstrations. KVKs have been functioning as Knowledge and Resource Centre of agricultural technology supporting initiatives of public, private and voluntary sector for improving the agricultural economy of the district and are linking the NARS with extension system and farmers.

Aim

The aim of the portal is to transfer the technologies developed by the agricultural scientists to the farmers in a fast and effective manner using web and mobile technology as well as to monitor the activities of Krishi Vigyan Kendras (KVKs).

Objectives

- To create a platform to monitor the various activities as well as resource utilization by various KVKs;

- To create a database of the various programmes organized by the KVKs along with their detailed information and learning resources;
- To help the farmers in resolving their queries using web and mobile technologies;
- To provide information about various facilities and activities performed by the KVKs and to provide linkage to other important information such as weather and market information.

KVK System: Mandate and Activities

The mandate of KVK is **Technology Assessment and Demonstration** for its **Application** and **Capacity Development**.

To implement the mandate effectively, the following activities are envisaged for each KVK

1. On-farm testing to assess the location specificity of agricultural technologies under various farmingsystems.
2. Frontline demonstrations to establish production potential of technologies on the farmers' fields.
3. Capacity development of farmers and extension personnel to update their knowledge and skills on modern agricultural technologies.
4. To work as Knowledge and Resource Centre of agricultural technologies for supporting initiatives of public, private and voluntary sector in improving the agricultural economy of the district.
5. Provide farm advisories using ICT and other media means on varied subjects of interest to farmers

In addition, KVKs produce quality technological products (seed, planting material, bio-agents, livestock) and make it available to farmers, organize frontline extension activities, identify and document selected farm innovations and converge with ongoing schemes and programs within the mandate of KVK.

History of Kvks

The Education Commission (1964-66) recommended that a vigorous effort be made to establish specialized institutions to provide vocational education in agriculture and allied fields at the pre and post matriculate levels to cater the training needs of a large number of boys and girls coming from rural areas. The Commission, further, suggested that such institutions be named as 'Agricultural Polytechnics'. The recommendation of the Commission was thoroughly discussed:

during 1966-72 by the Ministry of Education, Ministry of Agriculture, Planning Commission, Indian Council of Agricultural Research (ICAR) and other allied institutions. Finally, the ICAR mooted the idea of establishing Krishi Vigyan Kendras (Agricultural Science Centres) as innovative institutions for imparting vocational training to the practicing farmers, school dropouts and field level extension functionaries. The ICAR Standing Committee on Agricultural Education, in its meeting held in August, 1973, observed that since the establishment of Krishi Vigyan Kendras (KVKs) was of national importance which would help in accelerating the agricultural production as also in improving the socio-economic conditions of the farming community, the assistance of all related institutions should be taken in implementing this scheme. The ICAR, therefore, constituted a committee in 1973 headed by Dr. Mohan Singh Mehta of Seva Mandir, Udaipur (Rajasthan), for working out a detailed plan for implementing this scheme. The Committee submitted its report in 1974.

DIFFERENT ZONES OF KVK THEIR LOCATIONS AND NUMBER OF KVKS

ATARI Name	ATARI Address	No. of KVKs under Atari
ICAR-ATARI Zone-I Ludhiana	PAU Campus Ludhiana, Punjab	72
ICAR-ATARI Zone-V Kolkata	Bhumi Vihar Complex Block- GB Sector-III, Salt Lake Kolkata, West Bengal	59
ICAR-ATARI Zone-VII Barapani	ICAR Research Complex for NEH Region Barapani, Meghalaya	43
ICAR-ATARI Zone-III Kanpur	Rawatpur Near Vikas Bhawan Kanpur, Uttar Pradesh	89
ICAR-ATARI Zone-X Hyderabad	CRIDA Campus, Santhosh Nagar Hyderabad, Telangana	71
ICAR-ATARI Zone-II Jodhpur	CAZRI Campus, Diesel Shed Road PO Krishi Upaj Mandi, Basni Jodhpur, Rajasthan	66
ICAR-ATARI Zone-IX Jabalpur	PO Adhartal, JNKVV Campus, Jabalpur, Madhya Pradesh	82
ICAR-ATARI Zone-XI Bangalore	M.R.S, H.A.Farm (P.O), Hebbal, Bengaluru, Karnataka	48
ICAR-ATARI Zone-IV Patna	ICAR-Agricultural Technology Application Research Institute, Zone-IV, Patna.	68
ICAR-ATARI Zone-VI Guwahati	ICAR Agricultural Technology Application Research Institute, ICAR CPCRI Campus Kahikuchi ,Guwahati, Assam	47
ICAR-ATARI Zone-VIII Pune	ICAR-Agricultural Technology Application Research Institute (ATARI), College of Agriculture Campus, Shivajinagar, Pune,M.H	82

DIFFERENT ONGOING SCHEMES AT KRISHI VIGYAN KENDRAS

CLUSTER FRONTLINE DEMONSTRATION (CFLDs)

Cluster frontline demonstration is a unique approach by the Indian Council of Agricultural Research on Oilseed and Pulse crops to provide a direct interface between scientists and farmers where farmers are guided by the KVK scientists during demonstrations in implementation of improved technologies like seed treatment, IPM, INM, land preparation etc . Demonstrated fields are regularly monitored by the scientists. Cluster Frontline Demonstration project started since 2015-16 under NFSM and NMOOP

Tribal Sub Plan (TSP)

The Tribal Sub-Plan (TSP) strategy of tribal development is a concept intended to address the issues of backwardness in tribal areas and tribal population in an integrated way. The aim is to minimize the gap between the livelihood of tribal people and general communities.

SCHEDULED CASTE SUB PLAN (SCSP)

The basic objective of the SCSP has been to channel the flow of outlays and benefits from the general sectors in the Plan of States for the development of Scheduled Castes, at least in proportion to their population, both in physical and financial terms.

OUT SCALING OF NATURAL FARMING THROUGH KVKS

The project "Out scaling of Natural Farming" aims at bringing sustainability in production system and restoring soil fertility. Natural Farming offers a solution to various problems, such as food insecurity, farmers' distress, and health problems arising due to pesticide and fertilizer residue in food and water, global warming, climate change and natural calamities. It also has the potential to generate employment, thereby stemming the migration of rural youth. Ministry of Agriculture and Farmers Welfare has taken an initiative for promotion of Natural Farming as BharatiyaPrakritik Krishi Paddhati Programme (BPKP) under centrally sponsored scheme- Paramparagat Krishi Vikas Yojana (PKVY). It is largely based on on-farm biomass recycling with major stress on biomass mulching, use of on-farm cow dung-urine formulations; periodic soil aeration and exclusion of all synthetic chemical inputs.

SPECIAL PROJECT ON COTTON

Ministry of Agriculture & Farmers Welfare, Govt. of India has approved a special project on cotton entitled 'Targeting technologies to agro-ecological zones- large scale demonstrations of best practices to enhance cotton productivity' under National Food Security Mission (NFSM) for implementation during 2023-24. The project is being implemented through ICAR-Central Institute of Cotton Research (CICR), Nagpur on PPP mode in the identified clusters through value chain approach by collaboration with Ministry of Textiles, CITI & SIMA; Seed Industry Associations (NSAI and FSII); Extension partners (Cotton Development and Research Associations of CITI and SIMA); Agricultural Technology Application Research Institutes (ICAR-ATARIs) & their Krishi Vigyan Kendras (KVKs); State Departments of Agriculture-ATMA, Textile partners and Cotton Corporation of India (CCI) to increase productivity of cotton and production of Extra Long Staple (ELS) cotton.

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NANOTECHNOLOGY IN SPICES: ENHANCING FUNCTIONALITY, QUALITY, AND SHELF LIFE

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Abstract

Spices are renowned for their unique flavors, aromas, and potential health benefits. However, the bioactive compounds present in spices, such as essential oils, oleoresins, and polyphenolic antioxidants, can be susceptible to degradation, volatilization, and low bioavailability, limiting their effectiveness. Nanotechnology offers innovative solutions to address these challenges by enhancing the functionality, stability, and controlled release of spice-derived compounds. This chapter explores the applications of nanotechnology in the spice industry, including nanoencapsulation, nano emulsions, nanofillers, nano sensors, and nanocomposites. These technologies can improve the bioavailability, controlled delivery, and targeted release of spice compounds, leading to enhanced sensory properties, antioxidant activity, and shelf-life extension. Additionally, nanotechnology can contribute to sustainable spice production by reducing chemical inputs, minimizing environmental impact, and enabling precise resource utilization.

Introduction

Spices have been an integral part of culinary traditions across the world, not only for their unique flavors and aromas but also for their potential health benefits. These natural seasonings are rich sources of bioactive compounds, such as essential oils, oleoresins, and polyphenolic antioxidants. However, these compounds can be susceptible to degradation, volatilization, and low bioavailability, limiting their effectiveness in food systems. Nanotechnology has emerged as a promising approach to address these challenges, offering innovative solutions for enhancing the functionality, stability, and controlled release of spice-derived compounds.

Nanoencapsulation of Spice Compounds

Nanoencapsulation involves the entrapment or encapsulation of bioactive compounds within nanoscale delivery systems, such as nanoparticles, nano capsules, or nanoliposomes. These nanocarriers can protect the encapsulated compounds from degradation, improve their solubility and bioavailability, and enable controlled release in food systems. Various nanoencapsulation techniques have been explored for spice compounds, including emulsion-based methods (e.g., nano emulsions, solid lipid nanoparticles), polymer-based approaches (e.g., polymeric nano particles, nano capsules), and supramolecular self-assembly (e.g., nanoliposomes, cyclodextrin complexes). For instance, essential oils from spices like cumin, black pepper, and cinnamon have been successfully encapsulated in nanocarriers, enhancing their stability, bioavailability, and controlled release in food matrices.

Nano emulsions and Nano composites

Nano emulsions are colloidal dispersions of two immiscible liquids, stabilized by nanoparticles or surfactants. In the context of spices, nano emulsions can be used to encapsulate essential oils or extracts, improving their solubility, bioavailability, and controlled release in food systems. Nanocomposites, which are materials reinforced with nanoparticles or nanofillers, can also find applications in spice-related products. For instance, nanocomposites can be used in packaging materials for spices, enhancing their barrier properties, mechanical strength, and antimicrobial activity, thereby prolonging the shelf life and maintaining the quality of the spices.

Nano filters and Nano sensors

Nano filters, composed of materials with nanoporous structures, can be employed in the purification and separation processes of spice extracts or essential oils. These filters can selectively remove unwanted compounds or contaminants, resulting in higher-quality and purer spice products. Nano sensors can be integrated into packaging materials or food processing equipment to monitor the quality, freshness, and safety of spices during storage and transportation. These sensors can detect the presence of pathogens, contaminants, or changes in the chemical composition of spices, ensuring their quality and safety.

Crops	Nanoparticle Application	Specification	Impact	Uses	References
			Major Spices		
Black pepper	Nanoencapsulation of piperine in chitosan nanoparticles	Nanoparticle size range: 100-300 nm, encapsulation efficiency: 75-85%	Improved bioavailability and controlled release of piperine, enhanced antioxidant activity	Food & pharmaceutical industries	Gonçalves *et al.*, (2018)
Cardamom	Nanoemulsions of essential oil	Droplet size: 30-80 nm, stability over 4 months	Improved solubility, bioavailability of aroma compounds	Food flavoring	Moghimi *et al.*, (2016)
Ginger	Nanocomposite packaging films with ginger extract	Film thickness: 50-100 nm, antimicrobial activity	Enhanced shelf life and quality retention	Food packaging	Qin *et al.*, (2015)
Turmeric	Nanoencapsulation of curcumin in liposomes or solid lipid nanoparticles	Encapsulation efficiency: 80-90%, particle size: 50-200 nm	Increased solubility, stability, bioavailability and controlled release of curcumin	Food, nutraceutical & pharmaceutical industries	Tapal & Tiku (2012), Gera *et al.*, (2017)
			Minor Spices		
Coriander	Nanoencapsulation of linalool in liposomes	Liposome size: 100-200 nm, encapsulation efficiency: 70-85%	Improved stability, controlled release of aroma compounds	Food flavoring	Bakry *et al.*, (2016)

Cumin	Nanoencapsulation of essential oil in cyclodextrin complexes	Complexation efficiency: 70-85%, particle size: 100-500 nm	Improved stability and controlled release of aroma compounds	Food flavoring, preservation	Ayazi Yazdi *et al., (*2021)
Fenugreek	Nanoencapsulation of extract in solid lipid nanoparticles	Nanoparticle size: 50-150 nm, encapsulation efficiency: 65-80%	Improved bioavailability, controlled release of bioactives	Nutraceutical, pharmaceutical	Rajeswari *et al.*, (2012)
Tree Spices					
Cinnamon	Nanoemulsions of cinnamon essential oil	Droplet size: 20-50 nm, stability over 6 months	Improved solubility, bioavailability of volatile compounds, enhanced antimicrobial activity	Food preservation, flavoring	Salim *et al.*, (2016)
Clove	Nanoencapsulation of eugenol in chitosan nanoparticles	Nanoparticle size: 150-250 nm, encapsulation efficiency: 60-80%	Improved antimicrobial activity, controlled release of eugenol	Food preservation, pharmaceutical	Keawchaoon & Yoksan (2011)
Saffron	Nanoencapsulation of crocin in cyclodextrin complexes	Complexation efficiency: 75-90%, particle size: 200-500 nm	Improved stability, controlled release of crocin, antioxidant activity	Food coloring, nutraceutical	Visentin *et al.*, (2012)

Challenges and Future Perspectives

While nanotechnology offers exciting opportunities for enhancing the functionality and applications of spices, several challenges need to be addressed. These include the potential toxicity and environmental impact of nanomaterials, regulatory concerns, and the scalability and cost-effectiveness of nanotech-based processes for commercial applications. Future research should focus on developing eco-friendly and sustainable nanotech approaches for spice applications, ensuring the safety and biocompatibility of nanomaterials, and addressing regulatory challenges. Additionally, interdisciplinary collaborations between food scientists, nanotechnologists, and industry stakeholders will be crucial for translating these innovations into practical applications and bringing nanotechnology-enhanced spice products to the market.

Impact of Nanotechnology on Spices

1. **Improved Bioavailability and Controlled Release** – Nano encapsulation techniques can enhance the bioavailability and controlled release of bioactive compounds present in spices, such as essential oils, oleoresins, and polyphenols. By encapsulating these compounds within nanocarriers, their stability, solubility, and targeted delivery can be improved, leading to improved sensory properties, antioxidant activity, and potential health benefits.
2. **Extended Shelf-Life** – Nano composites and nano emulsions can be used in packaging materials for spices, improving their barrier properties and mechanical strength. This can lead to extended shelf life and better-quality retention of spices during storage and transportation.
3. **Enhanced Sensory Properties –** Nano technology can be used to encapsulate and protect volatile aroma compounds in spices, ensuring their controlled release and enhancing the overall sensory experience.
4. **Targeted Delivery and Controlled Release** – Nano carriers can be designed to release spice compounds in a targeted and controlled manner, enabling precision in flavor delivery, antioxidant activity, and potential health benefits.
5. **Improved Extraction and Purification** - Nano filters can be employed in the extraction and purification processes of spice compounds, resulting in higher-quality and purer products with reduced contamination.
6. **Quality Monitoring and Safety -** Nano sensors can be integrated into packaging materials or processing equipment to monitor the quality, freshness, and safety of spices, ensuring consistent product quality and safety for consumers.
7. **Sustainable Production** – Nano technology can contribute to sustainable spice production by reducing chemical inputs, minimizing environmental impact, and enabling precise resource utilization through controlled delivery systems and precision agriculture techniques.

Conclusion

Nano technology presents a promising avenue for enhancing the functionality, quality, and shelf life of spices. By leveraging nanoencapsulation, nano emulsions, nanocomposites, nano filters, and nano sensors, researchers and industry professionals can unlock the full potential of spices, creating value-added products with improved sensory properties, bioavailability, and shelf life. However, addressing challenges related to safety, regulation, and scalability will be essential for the successful integration of nanotechnology into the spice industry. Interdisciplinary collaborations and continued research will be crucial in driving the responsible and sustainable application of nanotechnology in the spice sector.

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SHIFTING SANDS: THE CONNECTION BETWEEN CLIMATE CHANGE AND EARTH'S ROTATION

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Introduction

The Earth's rotation, a fundamental aspect of our planet's dynamic system, is not immune to the far-reaching impacts of climate change. As temperatures rise, ice caps melt, and oceans warm, scientists are uncovering a profound connection between these environmental shifts and alterations in the Earth's rotation.

At its core, Earth's rotation dictates our daily rhythms, influencing everything from the length of our days to the direction of our winds. However, as climate change accelerates, this delicate balance is being disrupted in unprecedented ways. The melting of polar ice caps, for instance, redistributes vast amounts of mass across the planet, subtly altering its rotational speed and axis.

Moreover, changes in ocean currents and atmospheric pressure further contribute to this intricate dance, amplifying the effects of climate change on Earth's rotation. As these phenomena unfold, they have profound implications for our planet's climate patterns, weather systems, and ultimately, the stability of ecosystems and societies worldwide.

Earth’s rotation

Rotation refers to the circular movement of an object around a center of rotation. When three-dimensional objects such as the Earth, Moon, and planets consistently revolve around an imaginary line, it is termed a rotation axis. If this axis intersects the body's center of mass, the body is described as rotating around itself or spinning.

Earth rotates on its axis from west to east, and the Sun and the Moon appear to move from east to west across the sky. The spinning of the Earth around its axis is called 'rotation'. Earth also moves around the sun. This movement is called a revolution, which is different from rotation. Objects rotate around an axis, but revolve around other objects. So Earth rotates around its axis as it revolves around the sun. It takes Earth 365 days to complete a revolution. Positioned at an angle of 23 1/2º, the axis of the Earth is perpendicular to the plane of its orbit. Consequently, the Earth is tilted on its axis, causing the northern and southern hemispheres to lean away from the Sun. The Earth's axis runs vertically, extending from the North Pole to the South Pole. It requires 24 hours for the Earth to complete one full rotation around this unseen line.

The rotation of the Earth divides it into a lit-up half and a dark half, which gives rise to day and night. The direction of the Earth's rotation depends on the direction of viewing. When observed from the North Pole, the Earth rotates counterclockwise, whereas when viewed from the South Pole, it appears to rotate clockwise. Without the Earth's rotation, one hemisphere would perpetually experience warmth and light, while the other would remain cold and dark. The rotation of the Earth generates the daily cycle of light and darkness, as well as fluctuations in temperature and humidity. Additionally, Earth's rotation induces tides in the oceans and seas.

Climate Change

Climate change encompasses prolonged alterations in temperatures and weather patterns. These shifts can stem from natural factors like fluctuations in solar activity or significant volcanic eruptions. However, since the 1800s, human activities have become the predominant catalyst for climate change, primarily through the combustion of fossil fuels such as coal, oil, and gas. The burning of these fuels releases greenhouse gas emissions, enveloping the Earth like a blanket, trapping heat from the sun and elevating temperatures.

The primary greenhouse gases contributing to climate change are carbon dioxide and methane. These emissions result from activities such as driving cars using gasoline, heating buildings with coal, and land clearing, including deforestation. Additionally, methane emissions arise significantly from agricultural practices and oil and gas operations. Various sectors, including energy, industry, transportation, construction, agriculture, and land use, contribute to greenhouse gas emissions. These human-induced emissions are warming the planet at an accelerated rate unprecedented in the last two millennia.

Presently, the Earth's surface temperature is approximately 1.2°C higher than in the late 1800s, before the industrial revolution, surpassing temperatures seen over the past 100,000 years. The most recent decade (2011-2020) holds the record as the warmest in history, with each of the last four decades surpassing the warmth of any preceding decade since 1850. The repercussions of climate change encompass a wide array of impacts, including intensified droughts, water scarcity, severe wildfires, rising sea levels, increased flooding, melting polar ice, catastrophic storms, and declining biodiversity.

Melting polar ice caps

Ice serves as a protective layer over the Earth and its oceans, reflecting excessive heat back into space and maintaining cooler temperatures. The Arctic, in particular, remains colder than the equator due to the high reflectivity of ice, which deflects more sunlight back into space. Approximately 10% of the Earth's land area is covered by glacial ice, with Antarctica holding nearly 90% of this ice mass, while the remaining 10% is found in the Greenland ice cap.

Since the early 1900s, numerous glaciers worldwide have undergone rapid melting. The industrial revolution has exacerbated this trend, with carbon dioxide and other greenhouse gas emissions elevating temperatures, particularly in polar regions, accelerating glacier melt, leading to calving into the sea and retreat on land.The melting glaciers contribute to rising sea levels, intensifying coastal erosion, and heightening storm surges. Warming air and ocean temperatures also foster more frequent and severe coastal storms like hurricanes and typhoons.

The Arctic experiences warming at a rate twice that of other regions on Earth, with sea ice diminishing by over 10% every decade. Consequently, as ice melts, darker patches of ocean emerge, diminishing the previously cooling effect of ice and leading to warmer air temperatures. This disrupts normal ocean circulation patterns. Moreover, glacial melt in Antarctica and Greenland alters Atlantic Ocean circulation, potentially contributing to more destructive storms and hurricanes globally.

Connection to earth's rotation

Our daily timeframes are regulated by the Earth's rotation, determining the duration of hours and minutes. A more precise era of timekeeping commenced in 1967 with the global adoption of atomic clocks, utilizing the frequency of atoms as their timekeeping mechanism. Nevertheless, sailors historically navigated using celestial bodies like stars and the sun, resulting in a discrepancy between these traditional methods and atomic time due to the Earth's inconsistent rotation, which has lagged slightly behind atomic time for an extended period. This necessity spurred the development of Coordinated Universal Time (UTC) to synchronize timekeeping worldwide.

Due to the Earth's variable rotation rate, influenced by factors such as changes in its surface and molten core, occasional adjustments are necessary to synchronize Coordinated Universal Time (UTC) with the planet's rotation. These adjustments, like the addition or subtraction of a leap second, ensure temporal alignment. When the disparity between the two time measurements approached 0.9 seconds, a 'leap second' was introduced into UTC, constituting a positive leap second. Since 1972, 27 leap seconds have been incorporated into UTC, with the most recent one occurring in 2016. Scientists have determined that without the influence of climate change, a negative leap second might have been necessary for UTC as early as 2026.

However, a new concern has emerged in recent years: the Earth's rotation is accelerating, surpassing atomic time. Satellite gravity measurements have revealed that the melting of polar ice caps in Greenland and Antarctica since 1990 is contributing to this phenomenon by slowing down the Earth's rotation. As the polar ice melts, it disperses, forming a mass of water around the equator, while previously ice-bound land at the poles springs back up. This redistribution of mass affects the Earth's rotation rate as the liquid responds to the planet's spin. Additionally, in recent decades, the Earth's core has experienced a slowdown. This deceleration is the result of intricate interactions between the liquid core and the solid mantle and crust, along with the gravitational influence of the moon.

Consequently, the Earth's crust is spinning at an accelerated pace. The unpredicted change in the core's rotation, coupled with the subsequent decrease in the overall rotation rate, causes the Earth's surface to rotate faster, potentially leading to shorter days. This scenario implies that by 2029, Coordinated Universal Time (UTC) may require a negative leap second to synchronize atomic and astronomical time. Nonetheless, the impact of melting polar ice caps might postpone this adjustment from 2026 to 2029.

Consequences

The introduction of a negative leap second (a minute containing only 59 seconds) into standard time could potentially pose unforeseen challenges for computer systems and software architectures. While our computer infrastructure is capable of accommodating positive leap seconds, virtually none of our networks or web services is prepared for negative leap seconds. The main focus lies in the impacts of our actions on substantial changes in the Earth's movements.

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SOIL FERTILITY MAPPING IN HORTICULTURAL CROPS

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Introduction

The modern-day space-age technologies can be adopted for speedy dissemination of the research results on optimum doses of nutrients for maximum farm profitability (Singh *et al*., 2005) to scientists, industry personnel, extension workers and farmers. One of them is the use of soil fertility maps for fertilizer recommendation with a support to calculate fertilizer doses based on soil test values interactively. Inventory of the available macro and micronutrient status of the capsicum soils help in demarcating areas where, the application of particular nutrient is needed for profitable crop production

In agriculture, global positioning system (GPS) and geographic information system (GIS) technologies have been adopted for better management of land and other resources for sustainable crop production. Fertilizer is one of the costliest inputs in agriculture and the use of right amount of fertilizer is fundamental for farm profitability and environmental protection.

Soil

Soil**,** the biologically active, porous medium that has developed in the uppermost layer of Earth’s crust. Soil is one of the principal substrata of life on Earth, serving as a reservoir of water and nutrients, as a medium for the filtration and breakdown of injurious wastes, and as a participant in the cycling of carbon and other elements through the global ecosystem. It has evolved through weathering processes driven by biological, climatic, geologic, and topographic influences.

Soil is life supporting system and one of the most vital and precious natural resource of country and socio-economic development of people depends on soil that sustains life on earth.

Soil Fertility

What is Soil fertility?

It is defined as the inherent capacity of a soil to supply available nutrients to plants in an adequate amount and in suitable proportions to maintain growth and development. It is measure of nutrient status of soil which decides growth and yield of corp.

Importance of Soil fertility

- Soil fertility is a key factor for successful crop production and it is a measure of capacity of soil to supply plant nutrients. Soil fertility and fertilizers are very much closely related terms. Soil fertility acts as a 'SINK' where in plants can draw nutrients for maximum yield, where as fertilizer, acts as a 'SOURCE' wherein we can draw continuously different nutrients and also add to the sink.
- The importance of soil fertility and fertilizer management is being increasingly recognized in all countries recently to meet the demand for food and other agricultural raw materials.
- Intensive use of fertilizer, intensive cropping with high yielding varieties have no doubt increased the food production and reduced the food shortage but it has also brought in numerous problems of soil fertility, soil and water pollution. On the other hand, fast depletion of nutrients due to over exploitation, a wide spread deficiency of N, P, K and S coupled with micro nutrients deficiencies especially Zn and boron has been noticed in many soils.
- Further deforestation, shifting cultivation, burning of trees, bushes, grasses and cow dung, soil erosion, soil degradation, nutrient losses, excessive fertilizer application, leaching losses etc., have aggravated the depletion of soil fertility status. It is being realized that the future of Indian agriculture is closely related to scientific management of soil fertility along with judicious and efficient use of fertilizers.

So with all these conditions soils become deficient and very "hungry" for the need of nutrients day by day. It is therefore, imperative that sound soil and crop management practices, Judicious use of fertilizers and Integrated nutrient management practices must be adapted to improve and maintain good soil fertility and better soil physical condition for the purpose of sustained crop production.

Soil Fertility Mapping

Soil fertility map is one which is a geographical representation showing diversity of soil properties (soil pH, EC, Organic Carbon, Available nutrients, etc.) in the area of interest.

Purpose of soil fertility mapping

To make awareness among the farmers, researchers, planners and administrators regarding use of balanced fertilization according to soil test-based recommendation and integrated nutrient management for higher and sustainable crop production.

Soil fertility maps are integral components of all major land evaluation and land use planning endeavours

- Soil and land resource inventory reports
- Soil survey reports
    - Natural Fertility
    - Soil depth
    - Tendency to soluble salts
    - Soil structure
    - Soil engineering properties
    - Climate
    - Natural vegetation
    - Adapted crops and their expected productivity
- Watershed reports
- Fertility assessment studies etc
- Exclusive soil information systems for consultancy services
- Enviornmental reports (Climate and Rain fall)
- Industrial purposes (feasibility Assessments)

Preparation of soil fertility maps

Steps involved in preparation of soil fertility maps

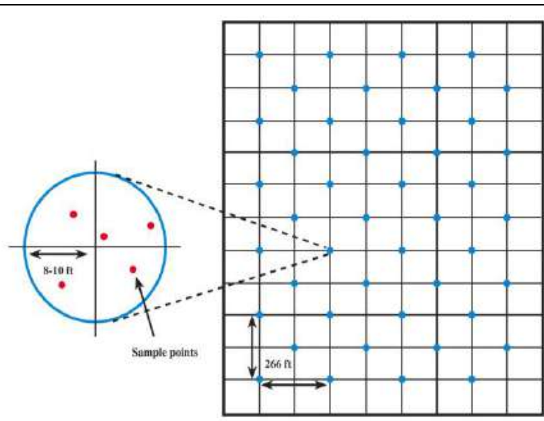
- Soil sample collection
- Soil analysis
- Fertility maps

Soil sampling method followed

GRID SOIL SAMPLING:

SITE-SPECIFI C nutrient management for crop production begins with an inventory of soil test nutrient levels in a field. Fertilizer recommendations are based on expected response to fertilizer application as a function of soil test levels. Therefore, site-specific fertilizer applications can be no better than the accuracy of the soil test map from which the fertilizer recommendations are based. Precision usually increases as fields are divided and sampled as smaller areas.

The common approach to achieve systematic soil sampling is to overlay a square or rectangular grid on a map or photograph of the field, identify and drive to the middle of each grid cell, and collect a soil sample at that point (Figure 1). The soil sample consists of several soil cores collected within a small radius of the cell center. The soil cores are composited and bagged as one soil sample for analysis at a soil testing laboratory. The purpose of compositing several cores is to average or "bulk" out variability in soil test properties that occurs over small distances.



- A grid of equally spaced lines is established.
- 8 soil cores randomly collected within a 10 ft. radius of the grid center.
- Cores composited as one soil sample.

Grid cell sampling can be efficiently conducted by counting crop rows and using distance measuring devices to locate sampling points. While easy to implement in the field, this practice can lead to bias. Tillage, fertilizer application, drainage, old field boundaries and cropping patterns tend to occur in regular patterns across fields. If the grid sampling pattern is a multiple or fraction of other patterns, the soil samples may not correctly represent the soil test variability within the field.

The potential for bias can be minimized by shifting the sampling locations to the right or left of the cell center in alternating rows perpendicular to the management pattern (e.g. row direction). The resulting sampling grid takes on the appearance of a diamond pattern (Figure 2). This sampling pattern can also be implemented by counting rows and measuring distances.

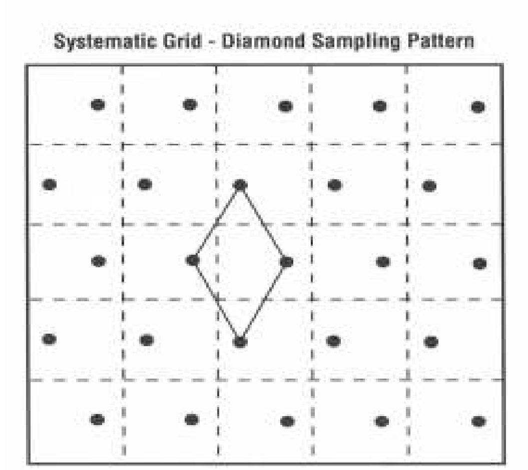


Fig 2: Modification of a square grid where altering rows of sample points are shifted one half the distance from the cell centre and edge

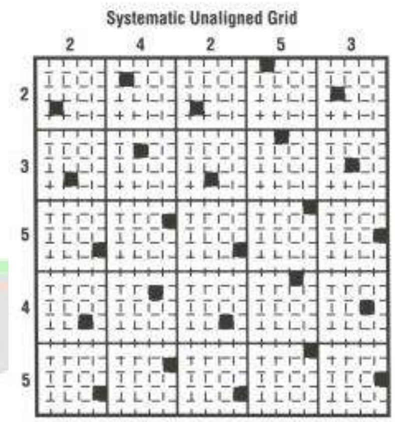


Fig 3: Schematic showing the layout of a systemativ unaligned grid. The x,y coordinates were determined from a random number table

With the development of the Global Positioning System (GPS), we can now navigate to locations in a field without counting rows or physically measuring distance. As farm level GPS hardware and software become available, we recommend adopting a systematic unaligned sampling protocol. This method combines the best of systematic sampling and random sampling.

Systematic unaligned sampling locations as illustrated in Figure 3 can be determined for a field by the following procedure

- →Divide the field into cells by means of a coarse grid. Square cells are the norm but not mandatory.
- →Superimpose a finer grid (reference grid) in each coarse cell. For example, if there are 5 rows and 5 columns in the coarse grid, you might choose to divide each coarse cell into 25 smaller cells.

→Choose a corner of the coarse grid, say top left, and randomly select a reference cell-in this example, one of the 25 reference cells.

→Move horizontally to the next coarse cell in the top row and keep the X coordinate the same but randomly select a new Y coordinate.

→Repeat the process for all the coarse cells in the top row.

→Return to the upper left corner and repeat the process down the first column of cells, this time keeping the Y coordinate the same, but changing the X coordinate in each successively lower coarse cell.

→The remaining positions are determined by the X coordinate of the point in the left-hand square of its row and the Y coordinate of the point in the uppermost square of its column.

Soil sample collection

Materials required

1. Spade or auger (screw or tube or post hole type)
2. Khurpi
3. Core sampler
4. Sampling bags
5. Plastic tray or bucket

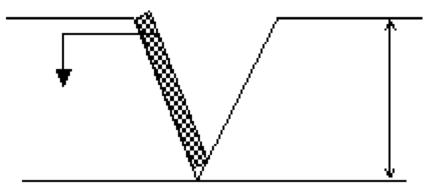
Points to be considered while collecting the samples

- Collect the soil sample during fallow period.
- In the standing crop, collect samples between rows.
- Sampling at several locations in a *zig-zag* pattern ensures homogeneity.
- Fields, which are similar in appearance, production and past-management practices, can be grouped into a single sampling unit.
- Collect separate samples from fields that differ in colour, slope, drainage, past management practices like liming, gypsum application, fertilization, cropping system *etc*.
- Avoid sampling in dead furrows, wet spots, areas near main bund, trees, manure heaps and irrigation channels.
- For shallow rooted crops, collect samples up to 15 cm depth.

- For deep rooted crops, collect samples up to 30 cm depth. For tree crops, collect profile samples.
- Always collect the soil sample in presence of the farm owner who knows the farm better

Procedure for soil sample collection

1. Divide the field into different homogenous units based on the visual observation and farmer's experience.
2. Remove the surface litter at the sampling spot.
3. Drive the auger to a plough depth of 15 cm and draw the soil sample.
4. Collect at least 10 to 15 samples from each sampling unit and place in a bucket
5. If auger is not available, make a 'V' shaped cut to a depth of 15 cm in the sampling spot using spade.
6. Remove thick slices of soil from top to bottom of exposed face of the 'V' shaped cut and place in a clean container.



1 inch / 2.5 cm 6 inches (15 cm)

1. Mix the samples thoroughly and remove foreign materials like roots, stones, pebbles and gravels.
2. Reduce the bulk to about half to one kilogram by quartering or compartmentalization.
3. Quartering is done by dividing the thoroughly mixed sample into four equal parts. The two opposite quarters are discarded and the remaining two quarters are remixed and the process repeated until the desired sample size is obtained.
4. Compartmentalization is done by uniformly spreading the soil over a clean hard surface and dividing into smaller compartments by drawing lines along and across the length and breadth. From each compartment a pinch of soil is collected. This process is repeated till the desired quantity of sample is obtained.
5. Collect the sample in a clean cloth or polythene bag.

6. Label the bag with information like name of the farmer, location of the farm, survey number, previous crop grown, present crop, crop to be grown in the next season, date of collection, name of the sampler *etc*.

Collection of soil samples from a profile

1. After the profile has been exposed, clean one face of the pit carefully with a spade and note the succession and depth of each horizon.
2. Prick the surface with a knife or edge of the spade to show up structure, colour and compactness.
3. Collect samples starting from the bottom most horizon first by holding a large basin at the bottom limit of the horizon while the soil above is loosened by a khurpi.
4. Mix the sample and transfer to a polythene or cloth bag and label it.

Processing and storage

1. Assign the sample number and enter it in the laboratory soil sample register.
2. Dry the sample collected from the field in shade by spreading on a clean sheet of paper after breaking the large lumps, if present.
3. Spread the soil on a paper or polythene sheet on a hard surface and powder the sample by breaking the clods to its ultimate soil particle using a wooden mallet.
4. Sieve the soil material through 2 mm sieve.
5. Repeat powdering and sieving until only materials of >2 mm (no soil or clod) are left on the sieve.
6. Collect the material passing through the sieve and store in a clean glass or plastic container or polythene bag with proper labelling for laboratory analysis.
7. For the determination of organic matter it is desirable to grind a representative sub sample and sieve it through 0.2 mm sieve.
8. If the samples are meant for the analysis of micronutrients at-most care is needed in handling the sample to avoid contamination of iron, zinc and copper. Brass sieves should be avoided and it is better to use stainless steel or polythene materials for collection, processing and storage of samples.
9. Air-drying of soils must be avoided if the samples are to be analysed for NO_3-N and NH_4-N as well as for bacterial count.

10. Field moisture content must be estimated in un-dried sample or to be preserved in a sealed polythene bag immediately after collection.
11. Estimate the moisture content of sample before every analysis to express the results on dry weight basis.

Guidelines for sampling depth

S.No	Crop	Soil sampling depth (cm)
1	Grasses and grasslands	5
2	Rice, finger millet, groundnut, pearl millet, small millets *etc*.(shallow rooted crops)	15
3	Cotton, sugarcane, banana, tapioca, vegetables *etc*. (deep rooted crops)	22
4	Perennial crops, plantations and orchard crops	Three soil samples at 30,60 and 90cm

Frequency of sampling

S. No	Cropping System	Frequency
1	Lawn and ornamental area	Every two three years
2	Vegetable gardens	Every one to two years
3	Plantations	Three to five years

Sampling strategies for fertility assessment and mapping

S.No	Study area	Strategy	GPS	GIS	RS
1	Districts, states (wide geographic areas covered)	Random Sampling	Yes	Yes	Yes
2	Village/ Panchayat/ Water sheds	Grid/ Zig zag	Yes	Yes	Yes
3	Fertility assessment of problematic soils	Intensive mapping	Yes	Yes	Not necessary
4	Indls/ groups	Localised	Yes/No	Yes/No	Not necessary

Soil analysis

1. A soil test is a chemical method for estimating the nutrient supplying power of a soil. It is much more rapid and has the added advantage over other methods of soil fertility evaluation. One can determine the needs of the soil before the crop is planted. A soil test measures a part of the total nutrient supply in the soil.
2. Soil testing plays a key role in today's modern and intensive agriculture production system as it involves continuous use and misuse of soil without proper care and management. Soil analysis is helpful for better understanding of the soils to increase the crop production and obtaining sustainable yield. Soil testing is an indispensable tool in soil fertility management for sustained soil productivity.

Objectives of soil testing

1. To evaluate fertility status of soil by measuring available nutrient status
2. To prescribe or recommend soil amendments like lime and gypsum and fertilizers for each crop
3. To assess nutrient deficiencies, imbalances or toxicities in soil and crop
4. To test the suitability of soil for cultivation or gardening or orchard making
5. To know acidity, alkalinity and salinity problems
6. To know morphology, genesis and classification of soil
7. To find out the effect of irrigation on soil properties.
8. To prepare a soil fertility map of an area (village, taluk, district, state)
9. In the soil testing programme, "soil sampling" is most important step to be followed for getting accurate results. Soil sampling is a process by which a true representative sample of an area or orcahrd can be obtained. The soil sampling must be done scientifically by adopting appropriate time and depth of sampling given for each crop for accurate analysis of soils.

ESTIMATION OF SOIL NUTRIENT INDEX (SNI)

Parker's (1951) method of calculating Nutrient Index (NI) values to indicate fertility status of soils for the purpose of mapping. The

following equation is used to calculate Nutrient Index Value:-

$$\text{Nutrient Index} = \frac{(Nl \times 1) + (Nm \times 2) + (Nh \times 3)}{Nt}$$

Nh = Number of samples falling in high category of nutrient Status.

Nt = Total number of samples analyzed for a nutrient in any given area.

Nl = Number of samples falling in low category of nutrient status.

Nm = Number of samples falling in medium category of nutrient status.

Separate indices are calculated for different nutrients like nitrogen, phosphorus and potassium.

soil nutrient index standards

Parker's nutrient index standard	Description
<1.5	Low nutrient status
1.5-2.5	Optimum nutrients
>2.5	High nutrient status

Preparation Fertility maps:

Major functions are….

1. Spatial indicators of limitations and potentials of soils
2. Indispensable instruments for formulating, establishing and maintaining site specific soil fertility Programmes
3. A tool in farmer education and awareness campaigns
4. Easy devices for predicting the behavioral pattern of soils

Technologies involved in preparation of fertility maps:

Remote Sensing

Remote Sensing means acquiring information by using satellites and spacecraft about a phenomenon object or surface at a remote vantage point without making physical contact with the object or subject.

Remote sensing is a non-destructive method of retrieving the information. It refers to the science of identification of earth surface features using electromagnetic radiation as a medium of interaction. It is defined as the science and technology by which the characteristics of the objects of interest can be identified, measured or analysed without direct contact. RS is a technology to identify and understand the object or the environmental condition through the uniqueness of the reflection or emission. It produces measurable physical data which will be qualitative and quantitative. The RS data is reproducible at any time. Since human ability of observation is subjective and individual, remote sensing instruments offer the possibility of selection, so as to view objects in a more detail and contrast manner, under different angle of incidence and from various distances.

This science differs from astronomy by way of looking at the object on earth from the space. This technique has a unique capability of recording data in visible as well as invisible (UV, reflected Infrared, thermal Infrared and microwave) part of electromagnetic spectrum. Therefore certain phenomenon which cannot be seen by human eyes, can be observed through remote sensing techniques *i.e.* the trees which are affected by diseases or insect attack can be detected by this much before human eyes can see them.

Remote sensing technology has seen many changes in the past five years. The major changes are that from the altitude of the satellite,

- We are able to image or see with more detail, a smaller piece of land.
- Define more precisely the specific colours or light reflecting off the field.
- Obtain data on a regular interval of every other day or every 5-7 days.

These make real advances to vegetable farming as we can able to view those small problematic fields and by interpreting through the remotely sensed data, we can determine the existing problem and could receive remotely sensed data /information on a regular interval.

Types of remote sensing with respect to wavelength regions

There are three types of remotes sensing with respect to wavelength regions. They are,

→ Visible and reflective infrared remote sensing

→ Thermal infra red remote sensing

→ Microwave remote sensing

- **VISIBLE AND REFLECTIVE INFRARED REMOTE SENSING**

Energy source used is the sun. The remote sensing data obtained depends on the reflectance of objects on ground surface. Therefore, the information about objects can be obtained from 'Spectral reflectance'.

- **THERMAL INFRARED REMOTE SENSING**

Source of energy is the object itself because any object with a normal temperature will emit Electro-Magnetic Radiation (EMR) with a peak at about 10mm. Therefore; in the wavelength region shorter than 3.0mm spectral reflectance is observed and in regions longer than 3.0mm, thermal radiation is observed.

- **MICROWAVE REMOTE SENSING**

There are two types and they are,

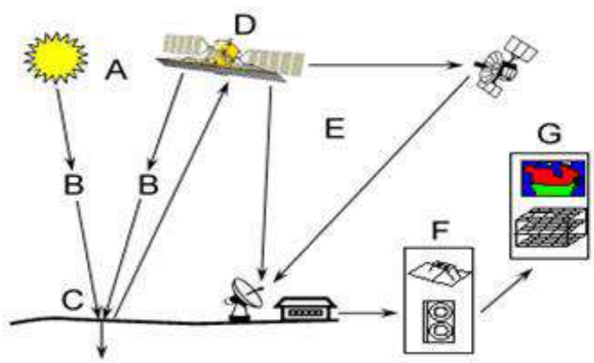
- **Passive microwave remote sensing:**Microwave radiation emitted from an object is detected
- **Active microwave remote sensing:**Back scattering coefficient is detected.

Remote Sensing Processes

- Remote Sensing is a multi disciplinary activity which deals with the inventory, monitoring and assessment of natural resources through the analysis of data obtained by observations from a remote platform.
- This is exemplified by the use of imaging systems where the following seven elements are involved. Further remote sensing also involves the sensing of emitted energy and the use of non-imaging sensors.

A) Energy source or illumination- The first requirement for remote sensing is to have an energy source which illuminates or provides electromagnetic energy to the target of interest.

B) Radiation and the atmosphere- As the EMR travels from its source to the target, it will come in contact with and interact with the atmosphere it passes through. This interaction may take place a second time as the energy travels from the target to the sensor.



12 Fig. 1.2. Remote Sensing process.

(Source: gisceu.net/tutorial/chap1/c1p1_i2e.html**; August: 10)**

C) Interaction with the target- once the energy makes its way to the target through the atmosphere, it interacts with the target depending on the properties of both the target and the radiation.

D) Recording of energy by the sensor- after the energy has been scattered by, or emitted from the target, a sensor is required (remote- not in contact with the target) to collect and record the electromagnetic radiation.

E) Transmission, reception and processing- the energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data are processed into an image (hardcopy and/or digital).

F) Interpretation and analysis- the processed image is interpreted, visually and/or digitally or electronically, to extract information about the target which was illuminated.

G) Application – the final element of the remote sensing process is application i.e. after extracting the information from the image to solve a particular problem.

Source of Energy

Depending on the predominant source of electromagnetic energy in the remote sensing system, the remote sensing can be passive or active.

- **Passive Remote Sensing** depends on a natural source to provide energy. The sun is the most commonly used source of energy for passive remote sensing. The satellite sensor in this case records primarily the radiation that is reflected from the target. Remote sensing in the visible part of the electromagnetic spectrum is an example of passive (reflected) remote sensing.
- **Active Remote Sensing** uses an artificial source for energy. For example, the satellite itself can send a pulse of energy which can interact with the target. In active remote sensing, humans can control the nature (wavelength, power, duration) of the source energy. Remote sensing in the microwave region of the electromagnetic spectrum (radar remote sensing) is an example of active remote sensing. Active remote sensing can be carried out during day and night and in all weather conditions.

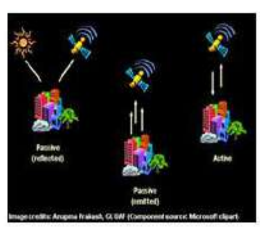


Fig. 2.1. Active and passive satellite sensors

Advantages of remote sensing technology:

- Large area coverage: Remote sensing allows coverage of very large areas which enables regional surveys on a variety of themes and identification of extremely large features.

- Remote sensing allows repetitive coverage which comes in handy when collecting data on dynamic themes such as water, agricultural fields and so on.
- Remote sensing allows for easy collection of data over a variety of scales and resolutions.
- A single image captured through remote sensing can be analysed and interpreted for use in various applications and purposes. There is no limitation on the extent of information that can be gathered from a single remotely sensed image.
- Remotely sensed data can easily be processed and analysed fast using a computer and the data utilized for various purposes.

Disadvantages of remote sensing:

- Remote sensing is a fairly expensive method of analysis especially when measuring or analyzing smaller areas.
- Remote sensing requires a special kind of training to analyze the images. It is therefore expensive in the long run to use remote sensing technology since extra training must be accorded to the users of the technology.
- It is expensive to analyze repetitive photographs if there is need to analyze different aspects of the photography features.
- It is humans who select what sensor needs to be used to collect the data, specify the resolution of the data and calibration of the sensor, select the platform that will carry the sensor and determine when the data will be collected. Because of this, it is easier to introduce human error in this kind of analysis.
- Powerful active remote sensing systems such as radars that emit their own electromagnetic radiation can be intrusive and affect the phenomenon being investigated.

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ABIOTIC AND BIOTIC FACTORS IN PLANT GROWTH AND DEVELOPMENT

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Introduction

Plant growth and development are dynamic processes influenced by a wide range of environmental factors, which can be broadly classified into abiotic (non-living) and biotic (living) components. These factors play crucial roles in determining the health, productivity, and resilience of plants. Plant growth and development are influenced by a myriad of factors, which can be broadly classified into abiotic and biotic factors. Understanding these influences is crucial for enhancing agricultural productivity and ecosystem management.

Abiotic factors include temperature, water, light, soil, and climate. These non-living elements provide the essential conditions for plant physiological and metabolic activities.

A. Abiotic Factors

Abiotic factors refer to the non-living components of an environment that affect plant growth. These include:

Temperature: Optimal temperature ranges are necessary for enzymatic activities and physiological processes in plants. Extreme temperatures can hinder growth and cause stress.

1. Merits: Most plants have an optimal temperature range for growth, typically between 15-30°C. Beyond this range, enzymatic activities slow down or speed up excessively, affecting metabolic processes.

2. Demerits: Extreme temperatures can cause stress, inhibit growth, and even lead to plant death. Impact of Extremes: Low temperatures can lead to frost damage, affecting cell structure, while high temperatures can cause heat stress, leading to protein denaturation and increased water loss through transpiration.

Water: Water is vital for photosynthesis, nutrient transport, and cellular activities. Drought or excessive water can lead to adverse effects on plant health.

Merits: Adequate water availability is vital for photosynthesis, nutrient transport, and maintaining cell turgor pressure.

Demerits: Both drought and waterlogging can severely impact plant health, leading to wilting or root diseases.

Deficit and Excess: Drought conditions can lead to wilting, reduced photosynthetic activity, and eventual plant death. Conversely, water logging can cause root hypoxia and promote root rot.

Light: Light intensity, quality, and duration influence photosynthesis and photoperiodic responses in plants.

Photosynthesis: Light intensity directly affects the rate of photosynthesis. Light quality (wavelength) and duration (photoperiod) also influence growth phases like flowering and seed germination.

Photomorphogenesis: Light regulates various developmental processes, including seedling elongation, leaf expansion, and chloroplast development.

Merits: Sufficient light is necessary for photosynthesis and influences developmental processes such as flowering.

Demerits: Excessive light can cause photooxidative damage, while insufficient light limits photosynthesis and growth.

Soil: Soil composition, pH, and nutrient availability are critical for root development and nutrient uptake.

Nutrient Availability: Soil provides essential nutrients like nitrogen, phosphorus, and potassium. Soil pH affects nutrient solubility and uptake.

Structure and Texture: Soil structure influences root penetration and water retention. Sandy soils drain quickly, while clay soils retain water but may impede root growth.

Merits: Nutrient-rich soil with appropriate pH levels supports robust root development and nutrient uptake.

Demerits: Poor soil quality, imbalanced pH, or contamination can restrict plant growth and reduce productivity.

Climate: Overall climate conditions, including humidity, wind, and seasonal variations, impact plant physiology and productivity.

Humidity: High humidity reduces transpiration rates, while low humidity increases water loss from leaves.

Wind: Wind can enhance transpiration and cool plants but can also cause physical damage or desiccation.

Merits: Stable climatic conditions facilitate predictable growth cycles and optimal development.

Demerits: Extreme or unpredictable weather patterns, such as droughts, floods, or storms, can disrupt plant growth and damage crops.

B. Biotic Factors

Biotic factors involve the living components that affect plant growth, such as:

Microorganisms: Beneficial microorganisms, such as mycorrhizal fungi and nitrogen-fixing bacteria, enhance nutrient availability and uptake.

Merits: Beneficial microbes, like mycorrhizal fungi and nitrogen-fixing bacteria, enhance nutrient availability and uptake.

Demerits: Pathogenic microbes can cause diseases that weaken plants and reduce yields.

Pests and Diseases: Pathogens, insects, and weeds can cause significant damage to plants, reducing yield and quality.

Insects: Herbivorous insects can defoliate plants, damage stems, and reduce photosynthetic capacity. Examples include aphids, caterpillars, and beetles.

Pathogens: Fungi, bacteria, and viruses cause diseases like powdery mildew, root rot, and mosaic viruses, affecting plant health and productivity.

Merits: Natural predators of pests can control harmful insect populations.

Demerits: Pests and pathogens can cause significant damage to plants, leading to loss of foliage, stunted growth, and reduced productivity.

Competition: Plants compete with each other and other organisms for resources like light, water, and nutrients.

Interspecific Competition: Plants compete with each other for light, water, and nutrients. Taller plants or those with extensive root systems can overshadow or out compete others.

Allelopathy: Some plants release chemicals into the soil that inhibit the growth of nearby plants, reducing competition.

Merits: Healthy competition among plants can lead to the selection of robust and resilient species.

Demerits: Excessive competition for resources like light, water, and nutrients can hinder growth and reduce yields.

Symbiotic Relationships: Mutualistic relationships, such as those with pollinators or certain animal species, can be crucial for plant reproduction and growth.

Symbiotic Relationships: Mycorrhizal fungi enhance nutrient uptake, particularly phosphorus, by extending root surface area. Rhizobia bacteria fix atmospheric nitrogen in leguminous plants, enriching soil nitrogen content.

Decomposers: Soil microorganisms decompose organic matter, releasing nutrients back into the soil for plant use.

Merits: Symbiotic relationships, such as pollination and seed dispersal, are crucial for plant reproduction and genetic diversity.

Demerits: Dependence on specific biotic interactions can be a vulnerability if those organisms are absent or disrupted

Conclusion

Both abiotic and biotic factors play integral roles in determining the health, growth, and productivity of plants. Effective management of these factors can lead to improved agricultural practices and sustainable ecosystem management.

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ROLE OF FARM MECHANISATION IN MODERN AGRICULTURE

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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.

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ROLE OF BETA-GLUCAN IN HUMAN HEALTH

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Abstract

Introducing natural ingredients of plant and animal origins as nutraceuticals that play a key role in preventing chronic non communicable diseases and maintaining good health is a promising aspects in Food and Health sector.This article explores the nature of Beta-Glucan, a notable Dietary Fibre (DF) with extensive application, the list of rich sources of Beta- Glucan, its Recommended Dietary Allowance (RDA), daily requirement and its characteristics. This article underscores Beta-Glucan's role in immune modulation, cholesterol and glucose regulation.

Introduction

Beta-glucans are a diverse group of polysaccharides found in the cell walls of bacteria, fungi, yeasts, algae, lichens, plants such as oats and barley, and certain mushrooms. Renowned for their immunomodulatory properties and health benefits, beta-glucans have garnered significant attention in both scientific research and consumer interest. This article aims to explore the multifaceted roles and potential applications of beta-glucans in various aspects of health and wellness. Beta-glucans are notable for their ability to stimulate the immune system, modulate inflammation, and promote overall health. They have been studied for their potential in improving cholesterol levels, enhancing wound healing, and even as adjunctive therapy in cancer treatment. With their diverse biological activities and widespread occurrence in nature, beta-glucans offer promising avenues for pharmaceutical, nutraceutical, and functional food applications. This article gives deeper into the structure, sources, mechanisms of action, and therapeutic potentials of beta-glucans, shedding light on their role in promoting human health and well-being. Beta-glucans, as soluble fibers, play a crucial role in regulating gastrointestinal health by modulating gut microbiota and promoting digestive function. Furthermore, their prebiotic properties have sparked interest in their potential application in addressing metabolic disorders such as obesity and diabetes. This article aims to provide a comprehensive overview of the current understanding of beta-glucans, from their structural diversity to their wide-ranging health benefits.

Structure of Beta-Glucan

Beta-glucans are polysaccharides composed of glucose monomers linked together by beta-glycosidic bonds. The structure of beta-glucans can vary significantly depending on their source, degree of branching, and linkage patterns. However, they typically exhibit one of two primary structural configurations: linear or branched.

Table 1 : Difference between Linear and Branched Beta-Glucans

Characteristics	**Linear Beta-Glucans**	**Branched Beta-Glucans**
Structural differences	Linear beta-glucans consist of glucose monomers linked together in a linear fashion, forming a straight chain. The beta-glycosidic bonds connecting the glucose units are typically in the β(1→3) or β(1→4) configuration, although β(1→6) linkages may also be present as branching points.	Branched beta-glucans contain additional side chains or branches attached to the main linear backbone. These branches are often connected to the backbone via β(1→6) linkages, resulting in a more complex three-dimensional structure.
Examples	Cereal grains like oats and barley, as well as in some fungi.	Fungi, mushrooms, and yeast cell walls.

The arrangement of glucose monomers and the presence of branching greatly influence the physical and biological properties of beta-glucans. **For example:**

Solubility: Linear beta-glucans tend to be more soluble in water compared to branched beta-glucans due to their more linear structure.

Viscosity: Branched beta-glucans with higher degrees of branching typically exhibit greater viscosity in solution compared to linear beta-glucans.(

Immunomodulatory Activity: Both linear and branched beta-glucans are known for their immunomodulatory properties, but the specific structural features can impact their interaction with immune receptors and the resulting immune response.

In summary, the structure of beta-glucans is characterized by variations in chain length, linkage patterns, and branching, which contribute to their diverse functional properties and biological activities.

Characteristics of Beta- Glucan

Beta-glucans possess several notable characteristics that contribute to their diverse functional properties and biological activities. Here are some key characteristics of beta-glucans:

Polysaccharide Nature: Beta-glucans are polysaccharides, meaning they are complex carbohydrates composed of multiple glucose molecules linked together. This polysaccharide structure gives beta-glucans their ability to form viscous solutions and interact with biological molecules.

Beta-Glycosidic Linkages: Beta-glucans are characterized by the presence of beta-glycosidic bonds linking the glucose monomers. These bonds can vary in configuration, with common linkages including $\beta(1\rightarrow3)$, $\beta(1\rightarrow4)$, and $\beta(1\rightarrow6)$. The specific linkage pattern influences the physical and biological properties of beta-glucans.

Solubility: Beta-glucans exhibit varying degrees of solubility depending on their structure and source. Some beta-glucans, such as those found in oats and barley, are soluble in water, forming viscous solutions. Others, particularly those with higher degrees of branching, may have limited solubility in water.

Viscosity: Soluble beta-glucans have the ability to form viscous solutions when hydrated. This viscosity contributes to their role in food products as thickeners and stabilizers. Additionally, it influences their physiological effects in the gastrointestinal tract, where beta-glucans can slow down the digestion and absorption of nutrients.

Immunomodulatory Activity: Beta-glucans are renowned for their immunomodulatory properties, meaning they can modulate the activity and function of the immune system. This includes enhancing the activity of immune cells such as macrophages, dendritic cells, and natural killer cells, as well as influencing cytokine production and immune signaling pathways.

Sources of Beta- glucan:

1. Oats and oat products:

Oats are richest sources of beta-glucan, with oat bran containing the highest concentration. Beta-glucan content in oats can range from 2% to 8%, depending on factors such as oat variety and processing method.

2. **Barley and barley products:**

Barley is another significant source of beta-glucan, with hulled barley containing higher amounts compared to pearled barley.Beta-glucan content in barley can range from 3% to 10%.

3. Mushrooms:

Certain mushrooms, such as shiitake, maitake, and reishi, contain beta-glucans in varying amounts.Beta-glucan content in mushrooms typically ranges from 0.1% to 3%, depending on the species and variety.

4. Yeast and yeast extracts:

- Yeast cell walls contain beta-glucans, with yeast extracts often used as dietary supplements.
- Beta-glucan content in yeast extracts can vary widely, ranging from 20% to 60% or higher, depending on the extraction method.

5. Seaweed and algae:

- Certain types of seaweed and algae contain beta-glucans, albeit in smaller amounts compared to other sources. Beta-glucan content in seaweed and algae can range from 0.1% to 3%.

6. Grains and grain products:

Other grains such as rye, wheat, and corn also contain beta-glucans, although in smaller quantities compared to oats and barley. Beta-glucan content in grains and grain products can range from 0.1% to 2%.

These percentages are approximate and can vary depending on factors such as the specific variety of the food, growing conditions, and processing methods. Nonetheless, incorporating a variety of these sources into your diet can help ensure an adequate intake of beta-glucans for potential health benefits.

Role of Beta-glucans in Cholesterol lowering effects:

The cholesterol-lowering effect of beta-glucan is one of its most well-established health benefits. Beta-glucans, particularly those found in oats and barley, have been extensively studied for their ability to reduce blood cholesterol levels, especially LDL cholesterol, which is often referred to as "bad" cholesterol. Here's how beta-glucans exert their cholesterol-lowering effects:

1. Binding to Bile Acids: Beta-glucans have a high affinity for bile acids, which are compounds synthesized from cholesterol in the liver and released into the intestines to aid in fat digestion. Beta-glucans bind to bile acids in the intestines, forming complexes that are then excreted in the feces. This process reduces the pool of bile acids available for reabsorption, leading the liver to use more cholesterol to synthesize new bile acids, thus lowering circulating cholesterol levels.

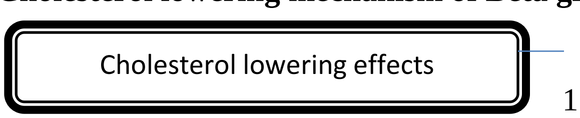
2. Reduced Cholesterol Absorption:In addition to binding bile acids, beta-glucans also interfere with the absorption of cholesterol from the intestines into the bloodstream. By forming viscous solutions in the gut, beta-glucans slow down the digestion and absorption of nutrients, including cholesterol. This results in less cholesterol being absorbed from dietary sources into the bloodstream.

3. Regulation of Hepatic Cholesterol Synthesis: Beta-glucans may also influence the synthesis of cholesterol in the liver. Some studies suggest that beta-glucans can inhibit certain enzymes involved in cholesterol synthesis, leading to decreased production of cholesterol in the liver. This further contributes to the overall reduction in circulating cholesterol levels.

4. Impact on Lipoprotein Metabolism:Beta-glucans can affect the metabolism of lipoproteins, which are particles that transport cholesterol and other lipids in the bloodstream. Specifically, beta-glucans have been shown to increase the production of larger, more buoyant LDL particles, which are less atherogenic (less likely to contribute to the development of atherosclerosis) compared to smaller, denser LDL particles.

Overall, the cholesterol-lowering effect of beta-glucan is multifaceted, involving mechanisms such as binding to bile acids, reducing cholesterol absorption, regulating hepatic cholesterol synthesis, and impacting lipoprotein metabolism. Incorporating beta-glucan-rich foods like oats, barley, and certain mushrooms into the diet can be an effective strategy for improving cholesterol levels and reducing the risk of cardiovascular disease.

Fig 1: Cholesterol lowering mechanism of Beta glucan



MECHANISM

1. Binding to bile acids
2. Excretion in feces
3. Increases bile acid synthesis form cholesterol

REDUCED CHOLESTEROL ABSORPTION

1. Forms viscous solutions in gut
2. Slows cholesterol absorption

REGULATION OF HEPATIC CHOLESTEROL SYNTHESIS

1. Inhibits cholesterol synthesis enzymes
2. Decreases liver cholesterol production

IMPACT ON LIPOPROTEIN METABOLISM

1. Increases the Less atherogenic LDL particles production
2. Modulates lipoprotein transport

Role of Beta-Glucan in Human health :

Beta-glucans, which are polysaccharides found in foods like oats, barley, and certain mushrooms, have been studied for their potential benefits in diabetes control. The key roles played by Beta-Glucan are as follows

1. Improving Insulin Sensitivity: Beta-glucans may enhance insulin sensitivity, helping cells in the body respond better to insulin. This can be beneficial for individuals with type 2 diabetes or insulin resistance.

2. Reducing Glycemic Response: Foods rich in beta-glucans, such as oats, have a lower glycemic index. This means they cause a slower rise in blood glucose levels after meals, which is beneficial for managing blood sugar levels.

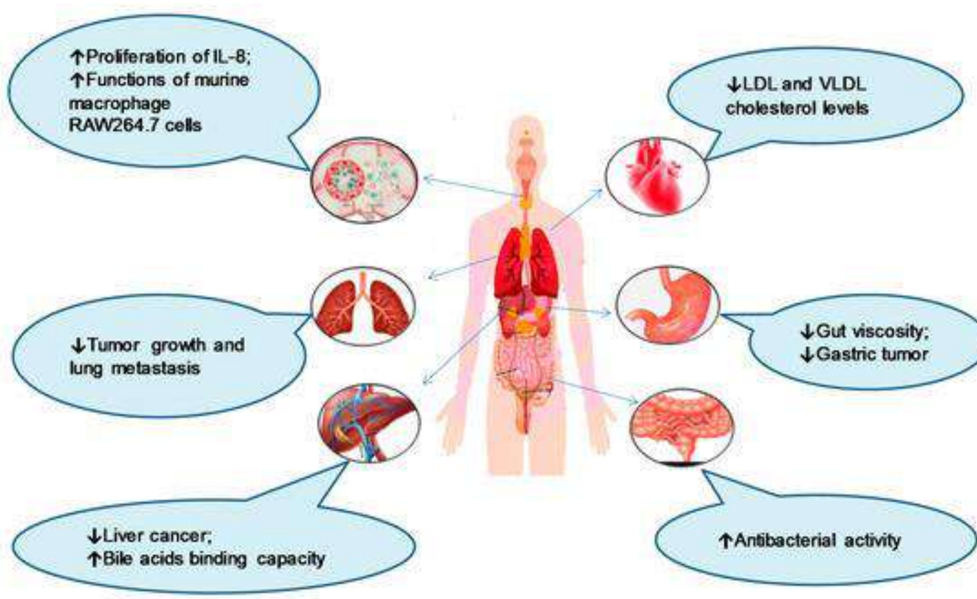
3. Modulating Gut Microbiota: Beta-glucans are prebiotics, which means they support the growth of beneficial gut bacteria. A healthy gut microbiota has been linked to improved glucose metabolism and insulin sensitivity. By promoting the growth of these beneficial microbes, beta-glucans contribute to gut health and overall well-being.

4. Anti-inflammatory Effects: Chronic inflammation is a factor in insulin resistance and diabetes progression. Beta-glucans have anti-inflammatory properties that may help mitigate these effects.

5.Cholesterol-Lowering Effects: One of the most well-established health benefits of beta-glucans is their ability to lower blood cholesterol levels, particularly LDL cholesterol. This effect is attributed to the ability of beta-glucans to bind to cholesterol in the gastrointestinal tract, preventing its absorption and promoting its excretion.

6.Antioxidant Activity: Some beta-glucans exhibit antioxidant properties, meaning they can neutralize free radicals and reduce oxidative stress in the body. This antioxidant activity contributes to the potential health benefits of beta-glucans, including protection against chronic diseases and aging-related processes.

Fig 2. Role of Beta-Glucan in Human health



Overall, the characteristics of beta-glucans, including their polysaccharide nature, beta-glycosidic linkages, solubility, viscosity, immunomodulatory effects, prebiotic properties, cholesterol-lowering effects, and antioxidant activity, make them versatile molecules with significant potential for various applications in food, pharmaceuticals, and healthcare.

RDA of Beta-Glucan

Human consumption of beta-glucan primarily occurs through dietary sources such as oats, barley, mushrooms, yeast, and certain grains. Beta-glucan content can vary significantly depending on the source and processing methods. Oats and barley, for example, are particularly rich sources of beta-glucans, with oat bran and barley bran containing higher concentrations compared to refined grains. Additionally, beta-glucan supplements derived from yeast or fungi are available for those seeking to increase their intake for specific health purposes.

The Recommended Dietary Allowance (RDA) for beta-glucan has not been established by authoritative bodies like the Institute of Medicine or the Food and Nutrition Board. However, various health organizations and scientific studies have suggested daily intake recommendations based on their observed health benefits.

For general health promotion and cholesterol management, consuming approximately 3 grams or more of beta-glucans per day from dietary sources has been recommended by organizations such as the European Food Safety Authority (EFSA) and the American Heart Association. This recommendation aligns with the observed cholesterol-lowering effects of beta-glucans, particularly in the context of reducing LDL cholesterol levels.

In specific health conditions such as diabetes and obesity, higher intake levels of beta-glucans may be recommended. For example, some studies suggest that consuming 4-10 grams of beta-glucans per day may help improve glycemic control and insulin sensitivity in individuals with type 2 diabetes. It's essential to note that individual dietary needs may vary based on factors such as age, gender, health status, and activity level. Therefore, consulting with a healthcare professional or registered dietitian can provide personalized recommendations for beta-glucan intake.

Conclusion

In conclusion, beta-glucans represent a promising component of a healthy diet, offering multifaceted benefits for human health. From enhancing insulin sensitivity and moderating blood glucose levels to fostering a favorable gut environment and reducing cholesterol, these polysaccharides found in foods like oats and barley provide a natural, accessible means to support metabolic health and overall well-being. Incorporating beta-glucan-rich foods into daily nutrition not only aids in diabetes management but also contributes to a holistic approach to health maintenance. In summary, while there is no established RDA for beta-glucan, consuming 3 grams or more per day from dietary sources is commonly recommended for general health promotion .Higher intake levels may be beneficial for specific health conditions, but individual needs should be assessed in consultation with a healthcare professional.

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BIODIVERSITY AND CONSERVATION OF RET SPECIES

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Abstract

Insects, comprising 73% of total animal species, are the most dominant group of organisms on Earth. With an estimated five to eight million undiscovered species, their diversity and species dynamics are influenced by a variety of factors, including habitat range, feeding habits, behavior patterns, and biological adaptations. Given that insects face similar endangerment factors as other animals, the number of endangered insect species is likely significant. Therefore, identifying and conserving Rare, Endangered, and Threatened (RET) insect species is crucial for their preservation.

Keywords: Insect, Biodiversity, RET species, Conservation

Introduction

Biodiversity is fundamental to human survival, as the composition and richness of species assemblages significantly influence ecosystem functioning and stability. However, the commercial revolution, the rapidly expanding human population, and associated economic activities have caused a dramatic loss in global biodiversity, leading to significant disturbances in ecosystems and our living conditions. Consequently, conserving biodiversity has become one of the most important challenges on our planet. Therefore, I provide brief details on biodiversity and the conservation of Rare, Endangered, and Threatened (RET) species.

What is Biodiversity?

"Variety of organisms at all levels, from genetic variants within the same species to arrays of species, genera, families, and

higher taxonomic levels. This includes the range of ecosystems, encompassing communities of organisms within particular habitats and the physical conditions under which they live."

It refers to the variety and variability among living organisms and the ecological complexes in which they occur. This includes diversity within species, between species, and among ecosystems. Biodiversity is defined as the totality of a region's genes, species, and ecosystems. It comprises genetic diversity, species diversity, and ecosystem diversity. Biodiversity encompasses all the different kinds of life found in a particular area.

Evolution of insects

Biodiversity isn't static; it's a system in constant evolution. The typical lifespan of a species is estimated to be between one and four million years, and 99% of the species that have ever lived on Earth are now extinct. Biodiversity is not distributed evenly across the planet; fossilized specimens show that insects have been around for 400 million years. The evolution of insects is categorized into the Silurian, Carboniferous, late Carboniferous or early Permian, Paleozoic, and Cretaceous periods (Gullan and Cranston, 2014).

Insect diversity

Insects represent the single most diverse group of organisms on Earth. Estimates of the total number of insect species, or those within specific orders, vary widely. For clarity, a widely accepted figure of 1,413,000 life forms (including animals, plants, fungi, protozoans, bacteria, and viruses) identified and known to science is considered. Of these, about 751,000, or 54%, are insects. This proportion becomes even more significant considering that insects comprise about 73% of the 1,032,000 known animal species (Wilson, 1993). However, the described insects are an unknown fraction of the total, with no central organized database for life on Earth, making it unclear how many described species exist.

How to explore insect diversity

To study insect biodiversity, it must be able to measure and quantify it (Jayakumar *et al*., 2006)

A. Step 1: Determine which elements of biodiversity are present in the area of interest (e.g., genes, species, and ecosystems)

Step 2: To study the inventory species in the area

Which consist of two alternatives

(a) Rapid assessment of a few groups by experts

(b) Comprehensive collecting and shipment to experts

B. First component of diversity is species richness

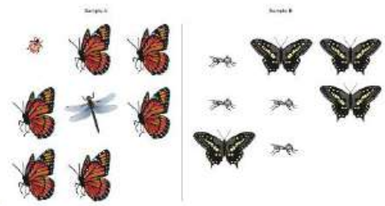
1. This measures species richness

a) Species richness is the number of species present at a site.

C. Second component of diversity is evenness (Distribution of species in sample)

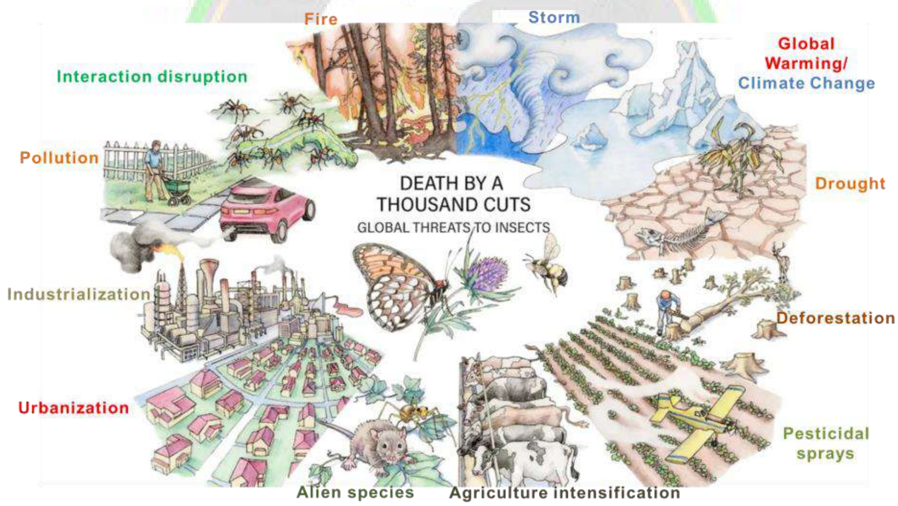
1. Measure of equitability

a) Based on the relative abundance of different species and b) If an ecosystem has similar relative abundance of each species, evenness is considered high (close to 1); if an ecosystem has dissimilar relative abundance of each species, evenness is considered low (close to 0).



Here are two Samples A and B:

- In Sample A, butterflies have more species therefore highest richness.
- In Sample B, greatest evenness as the two populations have similar abundance.

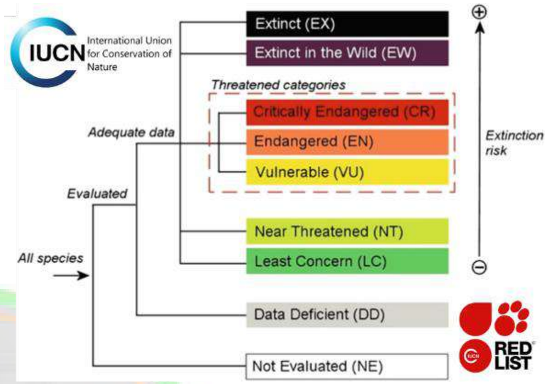


(Source: https://india.mongabay.com/2021/01/are-major-insect-losses-imperiling-life-on-earth/)

Conservation of RET species

Rare, Endangered, and Threatened (RET) species are under varying degrees of threat. The International Union for Conservation of Nature (IUCN) maintains a Red List that categorizes species worldwide by their threat level, from least concern to critically endangered or extinct. Founded in 1948, the IUCN is a global authority on the status of the natural world and conservation measures. Its mission is to influence, encourage, and assist societies in conserving nature and ensuring that the use of natural resources is equitable and ecologically sustainable.

Insects are crucial to ecosystems, but their diversity is rapidly declining worldwide. The World Commission on Environment and Development noted that species are disappearing at unprecedented rates, although accurate extinction figures are lacking, particularly for poorly documented species like insects in tropical forests. While it is agreed that insect species are going extinct, the exact number of lost and at-risk species remains unclear.



The International Union for Conservation of Nature (IUCN) assessed 77,435 species of insects from 1996 to 2020. Among these, 18,180 species (23.47%) are reported to be threatened. The highest number of threatened species are found in Odonata, followed by Orthoptera, Coleoptera, Lepidoptera, and Hymenoptera. Out of 1,843 species listed as critically endangered, endangered, extinct, extinct in the wild, and vulnerable, 596 are predators, 40 are pollinators, 164 are saprophagous, 620 are herbivores, 272 are omnivores, 137 are parasites, and 14 have an unknown ecological role. This data highlights the diversity of insects, their global threat status, and the main factors driving population decline, providing valuable insights to prioritize insect conservation efforts.

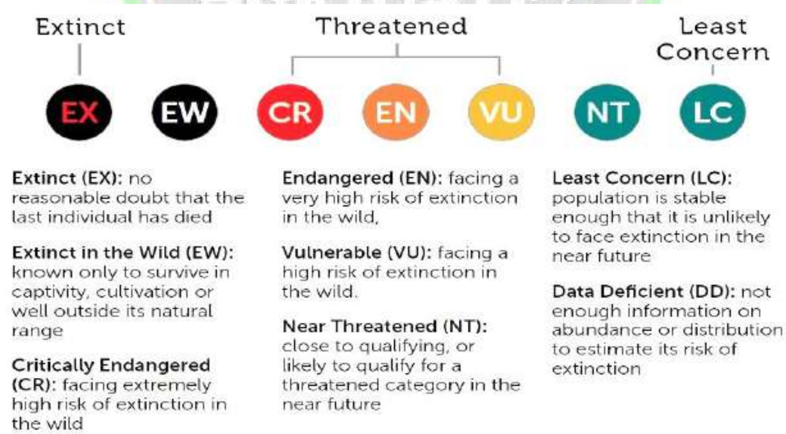


Fig. 1: International Union for Conservation of Nature (IUCN) threat categories of red list (Source: https://www.iucnredlist.org/resources/categories-and-criteria)

Causes of endangerment

Insects become endangered because of the same destructive forces faced by many other animals. Globally the well-known cause of insect decline is attributed to many factors. According to the IUCN, the leading causes of animal endangerment are habitat destruction, displacement by introduced species (Alien Species), alteration of habitat by chemical pollutants (such as pesticides), hybridization with other species (GM crop), overharvesting, climate change and global warming, eutrophication and management techniques for pest management, and even not leaving any pest residue for predators and parasitoids for their survival. (From Wikipedia)

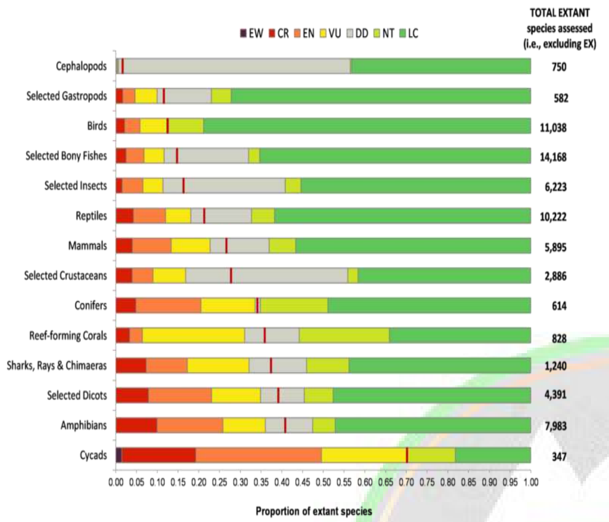


Fig. 2: Proportion of extant species in IUCN Red List of Threatened Categories (https://www.iucnredlist.org/resources/summary-statistics)

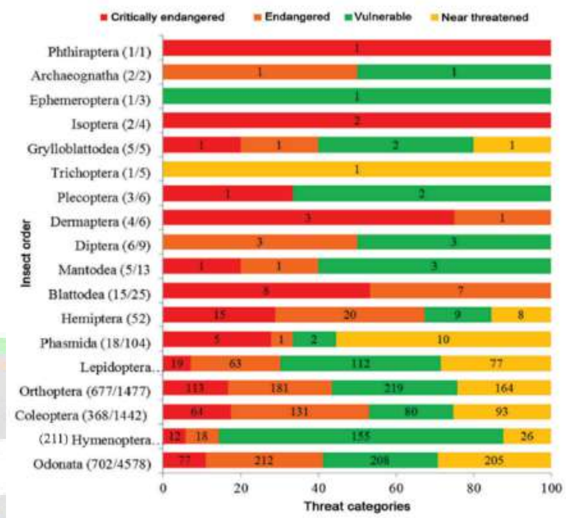


Fig. 3: Proportion of threatened species in different orders of Insect (Raghavendra *et al*., 2022)

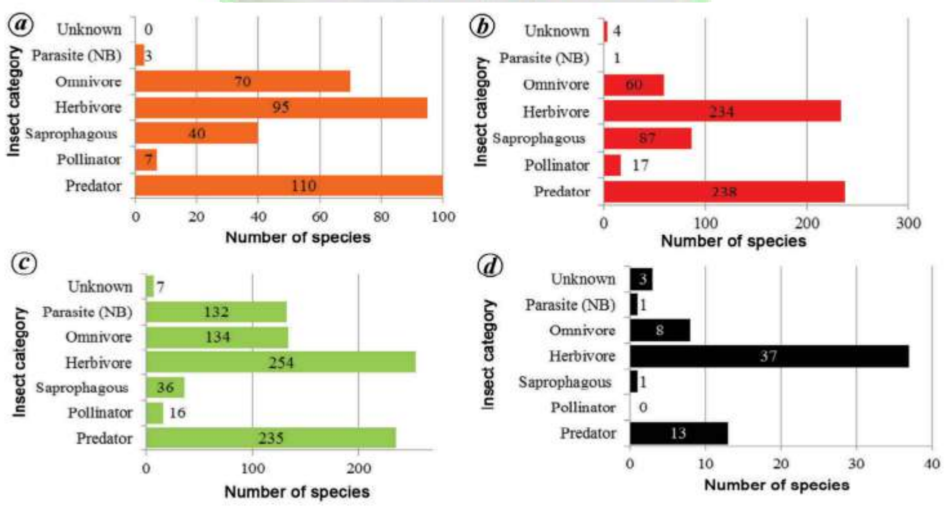


Fig. 4: Number of species under different threat categories: (a) critically endangered, (b) endangered (c) vulnerable and (d) extinct based on different habits (Raghavendra *et al*., 2022)

Conservation measures

The following conservation measures may be adopted to prevent the extinction of insects:

1) Habitat restoration, combined with reduced agrochemical usage and 'redesign' agricultural practices, particularly in areas where intensive agriculture is practiced.
2) More efforts must be taken to estimate insect threat levels to formulate biodiversity policies to improve the status of threatened species.
3) It is necessary to develop and implement conservation strategies for the insect species that are most at risk of extinction.
4) Need to reduce the contamination of water bodies by run-off and leaching of toxic chemicals, particularly pesticides.
5) The IUCN Red List of insects should be updated every 10 years or whenever new information becomes available.
6) Forests should be treated as a valuable natural resource that requires immediate attention, so there will be no more deforestation.
7) Governments must develop policies for preserving and recovering natural habitats, as well as implementing aggressive steps to cut greenhouse gas emissions and curb the deleterious effects of overexploitation of many taxa.
8) The agricultural ecosystem, being most dynamic and unstable, remains a great threat to the loss of many agriculturally important insects, especially in annual crops. So, to minimize this and conserve such insects, entomophage parks must be developed by public-private stakeholders.
9) International organizations and authorities like the Convention on Biodiversity (CBD), International Plant Protection Convention (IPPC), and Sanitary and Phytosanitary (SPS) of the World Trade Organization should be linked to each other and with IUCN for better coordination and future course of action.

Legislation on biodiversity conservation in India

There are several pieces of legislation related to biodiversity in India and, here are some:

Fisheries Act, 1897.	Mining and Mineral Development Regulation Act, 1957
Indian Forests Act, 1927.	Prevention of cruelty to animals, 1960
Wildlife Protection Act, 1972	Water (Prevention and Control of Pollution) Act, 1974

Forest Conservation Act, 1980 Air (prevention and control of pollution) Act, 1981

Biological Diversity Act, 2002 Environment Protection Act, 1986

Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Rights) Act, 2006

Conclusion

Given the factors highlighted, it is essential for researchers studying biodiversity to establish protocols for biodiversity measurement, conduct comprehensive surveys and inventories, and develop sustainable management and population control methodologies. Initiating long-term studies on genetic and environmental variations is also crucial. The diversity of genes, species, and ecosystems represents a valuable resource that can be harnessed as human needs evolve. It's important to recognize that modern technologies can be utilized across all these components with caution, to study, document, utilize and potentially enhance biodiversity where necessary.

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SUMMER BLOOMING TREES - SIGNIFICANCE IN LANDSCAPING

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Introduction

India is home to a rich, dense variety of flora and fauna. The distinct climatic conditions, water bodies, and soil facilitate different kinds of foliage all year long in different parts of the country. Trees are an invaluable part of any landscape and there is nothing more beautiful than a fully blossomed tree. Summer flowering trees play a significant role in this seasonal spectacle, enhancing the beauty and functionality of outdoor spaces during the warm months. The vivid hues of these trees provide brightness to the surroundings and create a mystical aura in landscaping.

Pollinator Attraction: Flowering trees attract bees, butterflies, and other pollinators. Their blooms provide nectar and pollen, supporting local ecosystems.

Windbreaks: Rows of flowering shrubs or trees act as windbreaks, buffering homes from frigid winter winds. This helps maintain a more stable indoor temperature.

Health Benefits: Fragrant flowers from trees like the Indian Cork tree (which blooms twice a year) contribute to overall well-being.

Seasonal Variety: By planting different species of flowering trees, you can ensure that your landscape looks stunning throughout the year. Summer trees complement the other seasonal blooms, providing a dynamic and ever-changing scene.

Wildlife Habitat: Flowering trees attract pollinators such as bees, butterflies, and hummingbirds. These insects play a crucial role in maintaining ecological balance and supporting other plant life. Additionally, they provide shade and shelter for birds and other wildlife while improving air quality through photosynthesis.

Property Value: A well-landscaped property with beautiful flowering trees can significantly enhance its value. Potential buyers appreciate the aesthetic appeal and environmental benefits these trees provide.

Aesthetic Appeal: Flowering trees add vibrant colours to the landscape, creating a visually pleasing environment. Blossoms in rich yellow, red, orange, and pink hues characterize the summer season which create a lively and inviting atmosphere, making your garden or yard more appealing.

Shade and Cooling:

With rising temperatures due to climate change, having shaded areas becomes even more important for outdoor activities or simply finding respite from the scorching sun. Planting large flowering trees near homes provides shade during scorching summers, reducing cooling costs. They shield buildings from direct sunlight, reduce the ambient temperature, making outdoor spaces more comfortable for relaxation and recreation.

Few examples of summer-flowering trees commonly found in India are: *Amaltas*, *Gulmohar*, *Jacaranda*, *Lagerstroemia*, *Rain Tree etc.*

1.**Cassia fistula (Amaltas tree)**

It is also known as the Golden Shower Tree, purging cassia, Indian laburnum, kani konna, or pudding-pipe tree holds impressive significance in landscaping. This beautiful flowering plant belongs to the Fabaceae family and is native to the Indian subcontinent and adjacent regions of Southeast Asia.

Aesthetic Appeal:

Aptly named, the Golden Shower Tree produces abundant bunches of fragrant yellow flowers that drape from its crown. Witnessing this extravagant flower show remains memorable for anyone. The dazzling gold color adds vibrancy to the landscape, making it a popular choice for gardens and outdoor spaces.

Biodiversity Enhancement:

Besides its visual appeal, the Cassia fistula attracts butterflies and birds, enhancing biodiversity in the surroundings. Its sun-loving nature makes it an excellent ornamental plant for shade and beauty in gardens or landscapes.

2. Gulmohar tree (Delonix regia)

It is also known as Royal Poinciana, flame tree, or fire tree, Flamboyant, Phoenix Flower, Flame of the Forest. It holds both aesthetic and environmental significance. It is a popular ornamental tree in India, known for its vibrant, fiery red flowers that bloom during summer. Native to Madagascar region.

Description:

Medium-sized deciduous tree, growing up to about 10 meters (33 feet) tall. Fern-like leaves and large, scarlet or orange-red flowers with a fifth upright petal called the standard. Pods turn dark-brown and woody as they mature.

Cultural Significance:

It serves as the city flower of Selangor and Malaysia. Known as the "May-flower tree," "Gulmohar," or "Gul Mohr" in India. Revered for its beauty and shade-providing qualities. In Kerala, the Gulmohar is considered sacred.

Ornamental Value:

Widely cultivated for its beauty, the Gulmohar tree is often found along roadsides and pavements. Its delicate aroma and stunning appearance, along with excellent shade, make it a popular choice for landscaping.

Ecological Importance:

- Nitrogen-Fixing: The Gulmohar enriches the soil by converting atmospheric nitrogen into a usable form.
- Habitat and Food: It provides habitat and food for birds, insects, and animals.

- Pollinator Attraction: Bees, butterflies, and hummingbirds are drawn to its vibrant flowers, aiding in pollination.

Commercial Uses:

- Wood: Used for fuel (calorific value: 4600 kcal/kg).
- Flowers: Used in bee forage production.
- Gum: Produces a water-soluble gum used in tablet manufacturing and textiles.
- Seeds: Used for making beads and Pangam Oil in the tanning industry.

3. Jacaranda tree

Jacaranda mimosifolia is renowned for its intense beauty and plays a significant role in the ecosystem. It is a stunning ornamental tree known for its beautiful blue-violet flowers and delicate fern-like foliage. Commonly known as Jacaranda tree, blue jacaranda, fern tree. Native to South America.

Description:

Medium-sized deciduous tree with arching branches that form a canopy resembling an upturned umbrella. Fragrant purple panicle-shaped blooms. Delicate, fern-like leaves.

Ideal Growing Conditions:

Full sun (6 to 8 hours per day). Well-draining, moderately sandy soil with slightly acidic pH. Consistent moisture throughout the year.

Aesthetic Charm:

The Jacaranda tree boasts clusters of intense purple-blue trumpet-shaped flowers and attractive fern-like leaves. Its spreading umbrella-like canopy provides dappled shade, making it suitable for medium to large yards.

Wildlife Habitat:

The branches offer perches for birds to rest and build nests, nectar-rich flowers attract pollinators like bees and butterflies.

Growth and Maintenance:

- Fast growth rate: Up to 10 ft. (3 m) in the first year.
- Mature height: Between 25 and 50 ft. (7.5 – 15 m).
- Lifespan: Up to 70 years.

Rain Tree (Samanea saman)

Also known as Monkey Pod, stands as a canopy guardian in tropical regions, symbolizing both natural splendor and cultural heritage. It is a captivating flowering tree native to Central and South America.

Description:

- Canopy: Rain Tree has a wide, symmetrical umbrella-shaped crown that provides ample shade.
- Leaves: Pinnate leaves with 6–16 leaflets, each shaped like a diamond.
- Unique Behavior: The leaflets fold during overcast days and evenings, earning it the name “Rain Tree” and “Five O’Clock Tree.”
- Bark: Velvety and hairy bark on its branches.
- Height: Typically reaches 15–25 meters (49–82 feet) tall.
- Branches: Large branches may break off during rainstorms.
- Leaf Shedding: Sheds leaves during dry periods.
- Crown: Provides shade while allowing rain to fall through to the ground beneath.

Ecological Importance:

- Canopy Shade: The Rain Tree's dense canopy provides shade, reducing soil erosion and maintaining soil moisture levels.
- Pollinator Support: Its flowers attract pollinators, supporting biodiversity in the region.
- Soil Enrichment: Fallen leaves decompose, enriching the soil with organic matter.

Cultural Significance:

Revered for its majestic presence, Rain Trees are associated with cultural traditions and spiritual beliefs. They symbolize resilience, tranquility, and tropical beauty.

Conservation Efforts:

Conservation focuses on preserving tropical habitats and promoting sustainable land management practices.

Lagerstroemia speciosa

Commonly known as Giant Crape Myrtle, holds significance in both natural and cultivated landscapes. Lagerstroemia speciosa, commonly known as Giant Crape Myrtle, is a deciduous tree native to tropical southern Asia.

Description:

It grows to a height of up to 20 meters (66 feet) with smooth, flaky bark. The leaves are simple, oval to elliptic, and deciduous. Flowers are produced in erect panicles, each with six white to purple petals. The fruits are ellipsoid or sub-globose woody capsules that turn from green to brown and finally black.

Other Names:

- Assamese: Ezar
- Bengali: Jarul

- English: Pride of India, Queen Crepe Myrtle
- Hindi: Jarul
- Malayalam: Manimaruthu
- Tamil: Kadali
- Telugu: Manimaruthu

Erosion Control:

Its dense and wide-spreading root system makes it useful for preventing soil erosion. Used in reforestation schemes for degraded hills in Java.

Timber Production:

While not as well-known for timber, it can be utilized for wood production.

Traditional Practices:

In some regions, it serves as a support for rattan canes.

Conclusion

Flowering trees in India add beauty, vibrancy, and a touch of magic to the landscape. These trees enhance the beauty and aesthetics of our surroundings, adding vibrant colors to the landscape. Aside from their aesthetic charm and cultural importance, planting flowering trees has numerous benefits for both humans and nature. Caring for flowering trees requires some attention to ensure their healthy growth. Regular watering, proper pruning techniques, fertilization at appropriate intervals are essential tasks to maintain their well-being throughout the year.

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FROM *CROCUS* TO CUISINE: THE ART AND SCIENCE OF SAFFRON CULTIVATION

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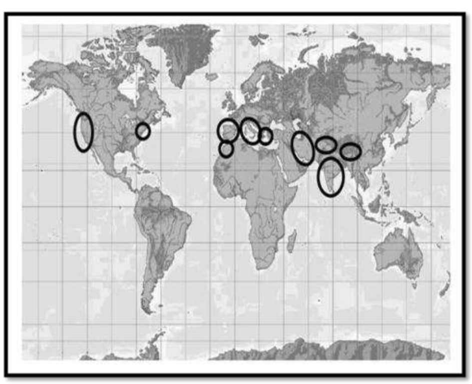
Introduction

Crocus sativus, commonly called as saffron is a most expensive spice in world. India contributes 5% to the total world saffron production and major share of it is from Jammu and Kashmir. In India, the production of saffron from J&K is 3.83 tonnes whereas its annual demand is approximately 100 tonnes. The demand for this spice indicates the scope for cultivation of this crop in a country with diverse agro-climatic conditions. It is highly prized for its medicinal properties owing to presence of principle biochemical compounds *viz.*, crocin and picrocrocin. This can be used as anticancer, antifungal, antiseptic and anti-inflammatory substance.

Saffron is today produced in Europe, North Africa, Iran, India, Spain and Greece; crops are also available from New Zealand, France, Switzerland, England, the United States, and in India.



Principal growing regions of saffron across world

In India, the principal cultivation niches for saffron are temperate climatic conditions that are supported with porous and well-drained soils. Its cultivation in India is concentrated in Jammu and Kashmir due to availability of favourable topographical factors. The ideal temperatures required are 23 C-27 C in summer and -15 C to -20 C in winter for flower development

Despite the prevalence of favourable factors, saffron cultivation and production has observed a 68% decline the past 20 years. Data from the Agricultural Department shows that the area under saffron cultivation decreased by 42% from 1996-97 to 2018-19. Similarly, the production of saffron has fallen from 15.95 metric tonnes in the 1990s to just 2.6 metric tonnes in 2023-24.

Traditional saffron cultivation in outdoor in Kashmir

The possible reasons for this decline might be rapid urbanisation, native farmers switching to other commercial crops such as apple, highly labour-intensive during the initial growth stages, erratic weather conditions prevailing and dependence on regular farming practices. To overcome these obstacles, SKUAST-Kashmir had introduced the technology of indoor cultivation of saffron under controlled environmental conditions. This technology minimizes the usage of various inputs and the produce yield of superior grade and quality.

INDOOR SAFFRON FARMING:

It is cultivation and production of red gold under controlled microclimatic conditions to optimize the growing conditions and maximize its potential. It includes application of smart-farming technology, aeroponics, that bypasses the erratic and unfavourable climatic conditions prevailing in traditional cultivation technique. Initiating saffron cultivation in indoors can be a rewarding enterprise.

DIFFERENT GROWTH STAGES OF SAFFRON

Aeroponics is technique of cultivating plants by supplying the required nutrients and minerals in form of mist without any need for soil of growing media. In this technology the roots of plants are usually suspended in closed conditions, and periodically sprayed with mist enriched with nutrients. Aeroponics aid in obtaining higher yields compared to traditional farming, since it accommodates higher plant densities, and the regular and consistent supply of nutrient-enriched mist ensures adequate and timely availability to plants keeping them potentially active.

To start it proper research and planning are crucial. Various requirements must be met to get proper growth and yield of saffron in indoor. One crucial factor is that the selected indoors have enough supporting R-value. It is the measure of heat flow resistance, that gives an idea about the temperature differences when heat unit passes through it. It's a measure of thermal resistance per unit area. It determines the insulation capacity of selected indoors and a higher R-value indicates greater resistance and vice-versa. The light and temperature requirements of crop are met by artificial lighting and air conditioners, the optimum and desirable relative humidity is maintained through misters. LED lighting offers a cost-effective solution and lasts for long.

Various considerations such as the intensity, colour of light, its duration, installation at appropriated distance from plants are crucial.

- Spectrum Selection: Utilize LEDs that emit specific wavelengths of light beneficial for saffron growth. Research suggests that blue and red light spectrums can enhance crocin production, the compound responsible for saffron's vibrant colour and potent flavour.
- Light Intensity: Maintain optimal light intensity levels throughout the growth cycle. Insufficient light can lead to stunted growth, while excessive light exposure can damage saffron flowers. Light meters can be used to ensure proper light levels.
- Light Cycles: Simulate the natural day-night cycle of saffron-growing regions by providing a specific number of daylight hours followed by a period of darkness. This can influence flower production and overall plant health.

Indoor saffron cultivation with artificial lights and aeroponics system

The collaborative influence of aeroponics and LED lights will boost the growth and productivity of saffron cultivated indoors by

- Faster Growth Cycles: Optimal instances may reduce saffron crocus growth periods, allowing for more frequent harvests.
- Improved Saffron Quality: Proper management over the environment can contribute to the development of consistent, high-quality saffron with brilliant colour and powerful flavour.
- Reduced Labor Needs: compared to conventional harvesting techniques, aeroponic systems eradicate soil care and limit the need for weeding.

POSSIBLE PROBLEMS AND SOLUTIONS FOR INDOOR SAFFRON FARMING

S. No.	Problem	Solutions
1	Temperature: Higher temperature (> 25º C) is an obstacle for flower bud development and flower production, thereby reducing red gold yield and lower temperatures (> 25º C) delay growth and development	• Application of higher precision control units for temperature in indoors. • Air conditioning the surroundings during hot periods, and installing heaters to maintain optimum temperatures during cooler nights is suggested. • One can choose for artificial lights, that produces minimum heat which aid in temperature regulation to a lesser extent
2.	Pest management: Sucking pests *viz.*, thrips and mites are a major threat	• Introduction of beneficial insects such as mealy bugs or lace wings aid in regulating pest population naturally. • Application of neem oil of neem-based soap solutions is an organic way • Regular monitoring and removal of any infected or diseased plant material is a precautionary measure to prevent spread of disease

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"OPTIMIZING SEED PRODUCTION: TECHNIQUES FOR SPROUTING BROCCOLI" (*BRASSICA OLERACEA* VAR. *ITALICA*)

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Introduction

Botany

Broccoli is highly cross-pollinated crop and pollination is entomophilous. Pollen Fertility is maximum on the day of anthesis. Stigma is receptive 2-3 days before to the day of anthesis. Anthesis occurs 8.00 -10.00 hr.

Method of seed production

Broccoli requires two seasons to produce seeds. In the first season the heads are produced and in the following season seed production follows. Two methods are followed.

1. *In-situ* method - for certified seed production (Seed to seed method)
2. Transplanting method - for nucleus seed production (Head to seed method)

1. In-situ method

In this method, the crop is allowed to over-winter and produce seeds in theiroriginal position, where they are first planted.

2. Transplanting method

In this method the matured plants are uprooted and the outer whorls removed. Then the plants are replanted in a well-prepared new field. When it transplanted plant is critically examined for foliage & curd characteristics namely size, shape, colour, texture & sponginess etc.

The diseased, malformed, forked or any other undesirable types are rejected.

Climate and soil

Broccoli is cool season vegetable crop and sensitive to high temperatures. It grown during winter in plains and in summers in high hills. Generally, the plant is hardy, can withstand fairly heavy frosts. They are generally biennial, while the annual cultivars are somewhat sensitive to frost.

Temperature requirements:

- For seed germination: 25-30°C
- For growth and developments- 10-20°C
- Optimum for its cultivation- 15-20°C

Well drained, sandy loam soils, rich in organic matter having good drainage with pH 5.5-6.8 are well suited.

Sowing time

- High Hills: May-June for Summer/Autumn crop
- Mid hills: Sept.–Oct.
- Plains: Nov.–Dec.

The sowing of an autumn crop is limited and sowing is undertaken in autumn to harvest the mid late spring or early summer by over wintering them. The seedlings of 3-4 weeks old are suitable for transplanting. The distance between plant to plant 45 cm and row to row 60-75 cm is kept. The time of transplanting depends upon the climatic condition and the kind of variety.

Source of seed

Obtain nucleus/breeders/foundation seed from source approved by a seed certification Agency, it should be free from seed borne disease and fulfil all certification standards.

Isolation requirement

The seed field must be separated from fields of other varieties at least" by 1600 m for foundation class and 1000 m for certified class seed production.

Seed rate: For preparation of seedlings 500g/ha is sufficient.

Varieties

- Pusa Broccoli KTS-
- Pusa Purple Broccoli-1

- Green Sprouting late
- Palam Hritika
- Palam Samridhi
- Palam Kanchan
- Punjab Broccoli-1
- Green Sprouting Medium
- Pusa purple broccoli-1
- Lucky, Fiesta, Aishwarya

Seed treatment

Some seed borne pathogens such as black rot, black leg and Alternaria leaf spot start invading the seedlings blight from germination of seed. Pre-drying of seeds at 40°C for 24 hr followed by an air treatment at 75 0C for 5-7 days is an effective method to disinfect cabbage seeds infected by black rot without any seed damage. Hot water treatment to seeds at 500c for 30 minutes is done to prevent seed-borne pathogens. Immediately after the treatment, the seeds should be used for sowing within 24 hr. After hot water treatment seed can be treated with a fungicide like Captan before sowing to protect the seedlings from damping – off and downy mildew respectively.

Raising of nursery

1. The seedlings are always raised in raised nursery beds for early varieties specially
2. It should be10-15 cm. High, 3 cm in length and 1 meter in width. For 1 hectare crop 60–80 meter square nursery is required.
3. For this area 3 kg. ammonium sulphate, 1kg each SSP and MOP is needed.
4. Seeds are sown in shallow furrows in 2-3 cm deep, open at 10-12 cm apart by dropping the seed at 5-7cm. distance and1.5-2 cm. depth, if the seeds are sown to be directly.

Spacing

Transplanting should be done in evening hours with 60 x 60cm or 60 x 45cm. At higher spacing, main, and lateral head size is improved.

Transplanting

1. 1.It is essentially a cool season crop and should not be planted at a time in which the crop matures in very hot weather.
2. Healthy and stocky seedlings of 3-4 weeks old for summer crop and 4-6 week old for winter crop.

Gap filling

About 7– 10 days age, there is possibility of mortality of few of seedlings and thus gaps are created, such gaps should immediately be replanted with healthy seedlings.

Staking

After the flower stalks are sufficiently developed, staking is necessary to keep the plants in an upright position.

Foliar spray

50 ppm NAA sprayed twice after two and four weeks of transplanting the broccoli seedlings in the field has beneficial effect on better growth and yield of broccoli varieties. The favourable temperature range for flowering and seed setting is 12.5 -18.5°c.

Irrigation

- Require continuous supply of moisture.
- Irrigate as frequently as required.
- Sudden heavy irrigation after a dry spell cause bursting of heads.

Intercultural operations

2-3 light hoeing and weeding to control weeds and to loosen the soil for better aeration.

Weed Control

- The heavy and frequent irrigation of this crop create conducive condition for the emergence and growth of different weed species, moreover.
- The root system of crop is very shallow, the before damage to the crop with deep hoeing.
- Hence frequent and deep hoeing are avoided; weeds should be controlled with weedicides.

- The weed are common in cabbage and cauliflower and they can be effectively controlled by preemergence application of Fluchloralin at the rate of 1.2 kg. a.i./hectare and or Alachlor at the rate of 1.25 kg a.i./hectare.

Rouging

The first rouging is done at the time of handling the mature heads. All off type plants, diseased or undesirable types are removed at this stage. Second rouging is done before the heads start bursting the loose-leaves poorly heading plants and those having a long stem and heavy frame, most by rogued out at this stage, subsequent rouging for off types, diseased plants affected by phyllody, black-leg, black rot, soft rot, or leaf spot, should be done from time to time as required.

Manure and fertilizer

- FYM: 200 q/ha
- P_2O_5: 50-60 kg/ha
- K2O: 50-60 kg/ha

} Full dose at the time of land preparation as basal dose

- N: 80-100 kg/ha } 50% N as basal dose remaining 50% in 2-3 splits

Certification

- Vegetative stage –leaf characteristics
- Transition stage- too early/late transforming plants removed
- Full curd formation stage –curd characteristics
- Bolting stage – remove early and late bolters

Field Inspection

- First at head initiation stage
- Second at head stage
- Third at flowering stage

Harvesting and processing

The harvesting may be done in two lots. Generally, the early matured plants are harvested first, when the pods turn into brown colour. After harvesting it is piled up for curing. After 4 to 5 days, it is turned upside down and allowed for further curing for 4 to 5 days. Then the pods are threshed with pliable sticks and shifted with hand sifters. Then the seeds are dried to 7% moisture content, cleaned, and treated with Bavistin @ 2 g/ Kg of seed.

Specific requirements

Factor	Maximum permitted (%)	
	foundation seed	certified seed
Off types	0.10	0.20
Plant affected by seed borne disease	0.10	0.50

Seed standards

	Standard for each class	
Factor	Foundation seed	certified seed
Pure seed (minimum)	98.0%	98.0%
Inert matter (maximum)	2.0%	2.0%
Other crop seed (maximum)	5/kg	10/kg
Weed seed (maximum)	5/kg	10/kg
Germination (minimum)	70%	70%
Moisture (maximum)	7.0%	7.0%
For vapour proof container (maximum)	5.0%	5.0%

Plant protection

Pests:

- **Cut Worms:** Set up of light trap in summer months. Spray chlorpyriphos 2 ml/lit in the collar region during evening hours.
- **Aphids:** The incidence is severe during autumn season. Installation of yellow sticky trap

at 12 no/ha to monitor Macropterous adults (winged adult) is necessary. Spraying of neem oil 3 % or dimethoate 2 ml/lit with 0.5 ml Teepol/lit.

- **Diamond back moth**

1. Growing mustard as intercrop at 20:1 ratio.
2. Installation of pheromone traps at 12 No/ha.
3. Spraying of cartap hydrochloride 1 g/lit or *Bacillus thuringiensis* 1g/lit at primordial stage (ETL 2 larvae/plant)
4. Spraying of NSKE 5 % after primordial stage.
5. Release of larval parasite *Diadegma semiclausum* (Ichneumonidae: Hymenoptera) at 50,000/ha, 60 days after planting.

Diseases

- **Club root:** Seed treatment at 10 g/ kg of seeds or soil application @ 2.5 kg/ha or seedling dip in solution of 5g/ litre with *Pseudomonas fluorescens*. Dipping the seedlings in Carbendazim solution (1 – 2 g/lit) for two minutes. Drench the soil around the seedlings in the main field with Carbendazim @ 1 g/lit. Follow crop rotation. Crucifers should be avoided for three years.
- **Leaf Spot:** Spraying of Mancozeb at 2 g/lit or Carbendazim 1 g/lit.
- **Leaf Blight:** Spray of Mancozeb @ 2.5 g/ litre.

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BE A PART OF PLAN ON INTERNATIONAL BIO DIVERSITY DAY: MAY 22

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Introduction

We need and we have to 'be a part of plan' if we want to safeguard life on earth. Safeguarding life on this planet and reversing biodiversity loss is not the job of government alone, it requires action from all segments of the society. Being a part of the plan is infact a call to all the stakeholders to halt and reverse the loss of biodiversity by supporting the implementation of the Kunming-Montreal Global Biodiversity Framework also referred to as the Biodiversity Plan.

The word 'Biodiversity' has been generated from two words 'biological' and 'diversity'. It refers to all the variety of life that can be found on earth like plants, animals, fungi and micro-organisms. Also, it refers to the communities that they form and the habitats in which they live. The article 2 of the Convention on Biological Diversity has given a formal definition of Biological diversity. The Biological Diversity there is defined as the variability among living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems. Thus we can say that 'Biodiversity' is the combination of life forms and their interactions with each other and with the rest of the environment that has made Earth is a uniquely habitable place for humans. Its rich biodiversity has been a source of life to millions and millions of different organisims on this planet. Biodiversity provides us a large number of goods and services that sustain our lives. It encompasses a variety of life on earth and the natural patterns it forms.

The biodiversity we see today is the fruit of billions of years of evolution, shaped by natural processes and, increasingly by the influence of humans. It forms the web of life of which we are an integral part and upon which we so fully depend.

Biodiversity loss:

Unfortunately, when human being today is not looking to fulfill their needs, but has moved towards greed. The large scale destruction of trees, the hunting of animals, the pollution of water bodies, the air we breathe, the degradation of soil and the loss of soil fertility all are the consequences of human being playing with nature. Playing with nature brought havoc on this planet. The most worrisome part is that the human interference with nature has resulted in a loss of biodiversity. In the last hundred years, more than 90 percent of crop varieties have disappeared from farmers' fields. Half of the breeds of many domestic animals have been lost, and all of the world's 17 main fishing grounds are now being fished at or above their sustainable limits. Locally-varied food production systems are under threat, including related indigenous, traditional and local knowledge. With this decline, agro biodiversity is disappearing, and also essential knowledge of traditional medicine and local foods. The loss of diverse diets is directly linked to diseases or health risk factors, such as diabetes, obesity and malnutrition, and has a direct impact on the availability of traditional medicines. Biological resources are the pillars upon which we build civilizations. The loss of biodiversity threatens our food supplies, opportunities for recreation and tourism, and sources of wood, medicines, and energy.

History of ibd:

Keeping in mind the importance of biological diversity and the threats to it, the United Nations celebrate International Biodiversity Day or World Biodiversity day on May 22, every year. It is celebrated to thank nature and what all it bring to us. This global event, which is held on the 22nd of May since year 2000; it was created in 1993 but its first seven editions were held on the 29th of December, aims to promote and raise global awareness of issues related to the planet's biodiversity. When first created by the Second Committee of the UN General Assembly in late 1993, 29 December (the date of entry into force of the Convention of Biological Diversity), was designated 'The International Day for Biological Diversity. In December 2000', the UN General Assembly adopted 22 May as IDB, to commemorate the adoption of the text of the Convention on 22 May 1992 by the Nairobi Final Act of the Conference for the Adoption of the Agreed Text of the Convention on Biological Diversity. This was partly done because it was difficult for many countries to plan and carry out suitable celebrations for the date of 29 December, given the number of holidays that coincide around that time of year.

Theme:

The United Nations does celebrate this day with different themes every year. Celebrating such days with a specific theme aims to leverage knowledge and spread awareness of the dependency of our food systems, nutrition, and health on biodiversity and healthy ecosystems. This all has the ultimate aim of conserving our precious biodiversity. This year the theme of the day is 'Be a part of the Plan'. It means each one of us have to make our own commitments, it is in everyone's best interest to take action and put biodiversity on a path to recovery by 2030. The plan here refers to the Kunming-Montreal Global Biodiversity Framework also referred to as the Biodiversity Plan. The Kunming-Montreal Global Biodiversity Framework GBF framework was adopted during the fifteenth meeting of the Conference of the Parties following a four years consultation and negotiation process. The historic framework which supports the achievement of the Sustainable Development Goals and builds on the Conventions previous Strategic Plans sets out an ambitious pathways to reach the global vision of a world living in harmony with nature by 2050. Among the Framework's key elements are four goals for 2050 and 23 targets for 2030. The implementation of the Kunming-Montreal Global Biodiversity Framework will be guided and supported through a comprehensive package of decisions also adopted at CoP15. In adopting the Kunming-Montreal Global Biodiversity Framework, all parties committed to setting national targets to implement it, while other actors have been invited to develop and communicate their own commitments.

Sustainability now is the new developmental paradigm. Unlike the past, when development aimed only at raising the quality of life of only present generation, sustainable development aims at raising the quality of present generation without compromising with the future generations. Sustainable development refers to the various processes and pathways to achieve it. Many challenges confront sustainable development. These challenges also need to be tackled in a manner which is eco-friendly, conserves natural resources, does not harms our biodiversity or becomes a threat to the life on this planet. Biodiversity conservation can go a long way in sustainable development. It is not wrong to the say that bio-diversity remains the answer to several sustainable development challenges. From nature-based solutions to climate, health issues, food and water security, and sustainable livelihoods, biodiversity is the foundation upon which we can build back better. From ecosystem-based approaches to climate and/or nature-based solutions to climate, health issues, food and water security and sustainable livelihoods, biodiversity is the foundation upon which we can build back better. That is the main message from the CBD, key international instrument for sustainable development.

On this day let all of us also pledge to start from ourselves to make individual commitments to work to prevent biodiversity loss. For halting biodiversity loss, we have to go for practices like organic and natural farming which conserve our biodiversity. At the same time, we have to avoid single-use plastics like plastic straws, coffee cups, plastic cutlery, take out containers or plastic water bottles and promotion of local and indigenous biodiversity for food and nutrition are some of the issues which we have to look into and adopt in our daily life; if we are serious to conserve our biodiversity and our planet.

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NANO NUTRACEUTICALS - A WAY TOWARDS MODERN THERAPEUTICS

Article ID: AG-V04-I06-74

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Introduction

Nano nutraceuticals are a new and innovative approach to therapeutic treatments. They are a combination of nanotechnology and nutraceuticals, which refer to bioactive compounds found in food that have medicinal properties. Nanotechnology involves the manipulation of matter on an atomic and molecular scale, which allows for the creation of nanoparticles that can be used to encapsulate and deliver these bioactive compounds directly to the target cells or tissues in the body. Nano nutraceuticals have several advantages over traditional therapies. They have improved bioavailability, meaning they can be absorbed more easily by the body, and they can be targeted specifically to diseased cells or tissues. This makes them more effective at treating illnesses such as cancer, diabetes, and cardiovascular disease. Overall, nano nutraceuticals represent an exciting new frontier in medicine that has the potential to revolutionize how we treat diseases and improve our overall health.

How Nano Nutraceuticals Work

Nano nutraceuticals are a modern approach to therapeutics that involve the use of nanotechnology to enhance the absorption and delivery of nutrients in the body. These tiny particles, typically less than 100 nanometers in size, are designed to penetrate cell membranes and deliver their payload directly into cells. The unique properties of nanomaterials make them ideal for delivering nutrients and other therapeutic compounds. They have a large surface area-to-volume ratio, which allows for greater interaction with biological systems. Additionally, they can be engineered to have specific properties such as targeting specific cells or tissues. Once inside the body, nano nutraceuticals work by releasing their payload into cells where they can be utilized by the body's metabolic processes. This targeted delivery system allows for more efficient nutrient uptake and utilization compared to traditional supplements.

Benefits of Nano Nutraceuticals

Nano nutraceuticals are a promising field in modern therapeutics. These tiny particles have numerous benefits, such as enhanced absorption and bioavailability. Due to their small size, nano nutraceuticals can easily penetrate cell membranes and reach target tissues, allowing for better efficacy and faster results. Additionally, they can protect sensitive ingredients from degradation during digestion, ensuring that the full dose reaches the intended site of action. Nano nutraceuticals also have the potential to reduce side effects associated with traditional drugs by delivering targeted doses directly to affected cells while leaving healthy cells unharmed. They can be used to improve cardiovascular health, reduce inflammation and oxidative stress, boost immunity, and even prevent cancer.

The Future of Nano Nutraceuticals

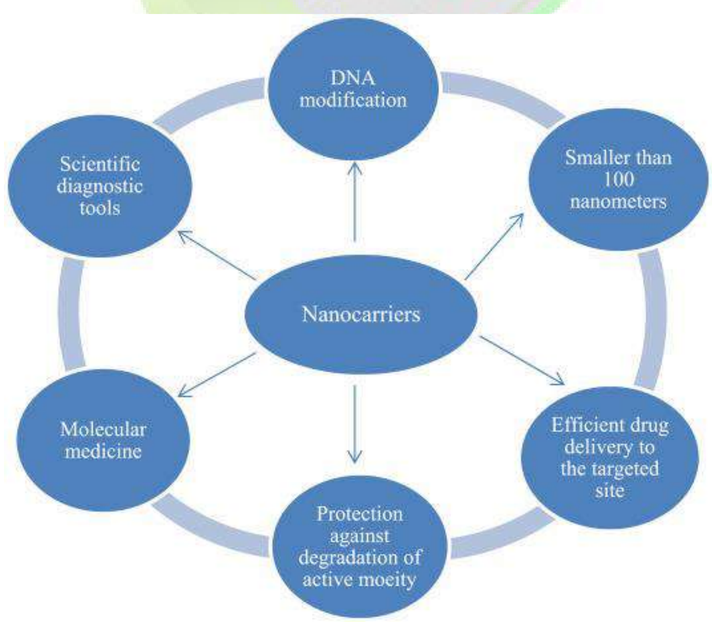
The future of nano nutraceuticals is bright, with researchers exploring new ways to use these tiny particles to improve health and treat disease. One exciting area of research is the use of nanotechnology to target specific cells or tissues in the body, allowing for more precise and effective treatment. Nanoparticles can also be used to enhance the bioavailability of nutrients, making them easier for the body to absorb and utilize. Additionally, nano nutraceuticals may play a role in personalized medicine, as they can be tailored to an individual's unique needs based on their genetic makeup or other factors. However, there are still challenges that need to be addressed in terms of safety and regulation before these products can become widely available. Overall, the potential benefits of nano nutraceuticals make them an exciting area of research with promising applications for improving human health.

Challenges to the Development of Nano Nutraceuticals

The development of nano nutraceuticals faces several challenges that need to be addressed. One major challenge is the lack of standardized regulations and guidelines for their manufacturing and distribution. This poses a risk to consumers as it may lead to inconsistent product quality and safety concerns. Another challenge is the limited knowledge regarding the long-term effects of these products on human health, particularly in high doses or with prolonged use. Additionally, there is a need for more research into the bioavailability, stability, and efficacy of nano nutraceuticals in various delivery systems. The production cost of these products also remains high due to the complex technology involved in their development. Finally, there are ethical concerns related to commercializing nano nutraceuticals, including issues related to access and affordability for all populations. These challenges must be addressed through collaborative efforts between regulators, researchers, manufacturers, and other stakeholders to ensure safe and effective use of nano nutraceuticals in healthcare.

Regulatory Considerations for Nano Nutraceuticals

Nano nutraceuticals are a promising avenue for modern therapeutics, but their regulation is still in its infancy. As these products utilize nanotechnology, they must undergo rigorous testing to ensure their safety and efficacy. Regulatory considerations for nano nutraceuticals include the characterization of the nanoparticles used in the product, as well as determining their toxicity and biocompatibility. Additionally, the regulatory body must analyze any potential environmental impacts of these products. The labeling of nano nutraceuticals is also an important consideration in regulation. The labeling should clearly state the presence of nanoparticles and other active ingredients in the product, along with any potential side effects or interactions with other medications. regulatory bodies must consider whether existing regulations are sufficient to address any new risks posed by nano nutraceuticals or if new regulations need to be implemented. The goal is to ensure that these products are safe and effective for consumers while allowing for continued innovation and development in this emerging fields.



Conclusion

Nano nutraceuticals have emerged as a modern and promising approach to therapeutics. With their unique properties, including their small size and ability to target specific cells or tissues, they offer a range of potential benefits in the treatment of various diseases and conditions. These benefits include improved drug delivery, enhanced bioavailability, and reduced toxicity. nano nutraceuticals can be designed to incorporate natural compounds found in food sources, providing a safer alternative to synthetic drugs. They also offer the possibility of personalized medicine through tailored formulations that can be adapted to individual patient needs. Although there are still challenges to overcome in terms of regulatory approval and scaling up production, the potential benefits offered by nano nutraceuticals make them a highly promising area of research for the future of modern therapeutics. Overall, this emerging field holds great promise for improving health outcomes and enhancing quality of life for patients around the world.

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LADAKH'S CLIMATE CHANGE BATTLE AND THE CALL FOR THE SIXTH SCHEDULE

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Abstract

Mountains all over the world are thought to be indicators of climate change. Climate change has been one of the most hotly debated topics in recent decades, and it will have a particularly negative impact on mountain ecosystems and communities living close to nature, Ladakhi have maintained a harmonious balance with their surroundings. High aridity and low temperature lead to sparse vegetation. Ladakhi farmers have always been dependent on snow and glacier melt water, but the climate change experienced in the last four decades poses a threat to their livelihoods and future. To cope with insufficient or seasonally unreliable availability of water, adaptive techniques and sophisticated designs for water management and distribution have been established in diverse regional contexts. Therefore, the 6th schedule in Ladakh is essential for empowering local communities to collaboratively manage natural resources, foster traditional knowledge systems, and implement climate-smart policies to mitigate the impacts of climate change effectively.

Keywords: Ladakh, Climate change, 6th schedule, glacier,

Introduction

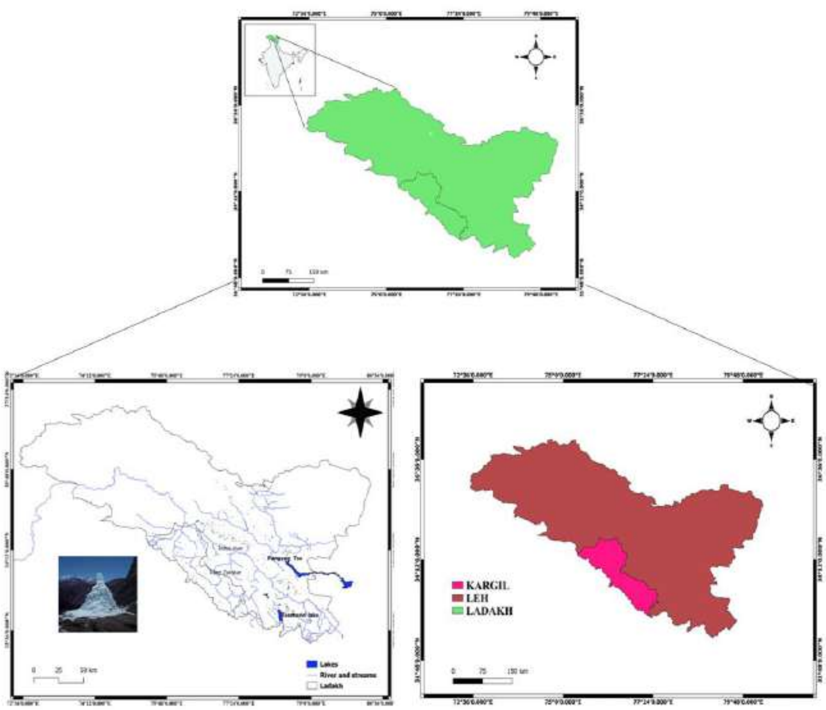
Mountains are believed to be global indicators of climate change. One of the most divisive topics of the last few years has been climate change, which will be especially harmful to mountain communities and ecosystems. In cold, arid alpine locations across the world, the primary supply of water for irrigated agriculture is melting water from glaciers, snowfields, and permafrost. The reasons for the current trends in global warming are linked to changes in land use and cover, as well as increases in greenhouse gases and aerosols (Bhutiyani et al. 2010; IPCC 2013). Climate change is being blamed for variations in temperature and precipitation patterns over the Himalayan region and their effects on glaciers, water resources, ecology, agriculture, etc. Ladakh is a high-elevation, desert borderland that sits next to India's northernmost Trans Himalayan region. Its distinct cold-arid climate is further emphasized by the region's diversified land cover and complex topography. Like in every desert, the radiant settlements, unique animals and birds, and endemic ichthyofauna that live among its numerous rivers, streams, and valleys depend on water to survive.

Conventional earthwork irrigation channels are employed in the majority of Ladakhi settlements to tap meltwater streams that originate from glaciers surrounded by towering mountain ranges rising to a height of over 5,000 msl. Therefore, the availability of water depends on both volume and timing. Most crops will fail if there is insufficient precipitation over the winter and summer, or if the ice does not melt by the start of the single agricultural season, which occurs around May. Concern over the effects of climate change-induced glacier retreat on water availability has grown over the last ten years, both among scientists and the Ladakhi populace (Bhutiyani et al., 2010; Ziegler, 2017; Chudley et al., 2017). Serious indicators include rapidly melting glaciers that are displacing entire towns, the possibility of glacier slip engulfing entire valleys, significantly lower snowfall, and the introduction of unidentified parasites in the high-altitude area. These areas, which have limited water supplies, are extremely sensitive to climate change and need immediate intervention.

The pattern of precipitation has changed. River flow is being impacted by warming temperatures, melting fragile glaciers and permanent snow fields, shifting snow patterns in winter, and shifting the amount of snow to February and March. Water availability is highly dependent on temperature and precipitation variations, which may eventually result in a decrease in water supply but an increase in meltwater discharge. According to scientists, climate change is mostly responsible for this region's water crisis. Between 2013 and 2017, Ladakh witnessed a 50% to 80% yearly precipitation shortfall, with 2016 setting a record low for rainfall. Adaptive strategies and complex designs for water management and distribution have been devised in a variety of regional contexts to deal with low or seasonally unpredictable water supplies (Kreutzmann , 2011; Carey et al. 2017; Mark et al. 2017).

Innovative Solutions: Artificial Glaciers in the Fight Against Climate Change

Land use in the cold-arid region of Ladakh has always been prone to seasonal water scarcity, affecting irrigation and domestic water supply (Dame and Mankelow 2010; Nüsser and Baghel 2016). Due to low temperatures and the high variability of seasonal snow cover (Mukhopadhyay and Khan 2015), there is a typical shortage of water at the onset of the agricultural season for about 2 months until a sufficient and reliable supply of meltwater from high-altitude glaciers becomes available. The innovation of artificial glaciers in Ladakh has been explained as a milestone in the current efforts to adapt to the impacts of climate change. It is also hailed as great mountain engineering. Artificial glaciers are located at much lower altitudes than the naturally occurring glaciers above 5200 masl. (Schmidt and Nüsser 2017), serve to bridge the critical gap in water availability by providing ice reservoirs that melt earlier in the agricultural season. Such ice reservoirs have been constructed in several tributaries of central Ladakh over the past three decades (Fig. 1).



Despite the popularity of the term artificial glacier, the term ice reservoir conveys their character and function more accurately because the ice bodies only exist for a few months, unlike glaciers in the strict sense, which are defined as perennial, moving ice bodies with distinct accumulation and ablation zones. Such ice reservoirs utilize the hydrological process of icing under local conditions of frequent freeze-thaw cycles to capture water for seasonal storage. They are not water storage structures that freeze from the top down, rather they are produced through the sequential, freezing of thin layers of water creating superimposed sheets of ice. These ice reservoirs are maintained as communal infrastructure reliant on local institutions and external technological interventions. Published quantifications of their ice storage capacity differ between 17,000 and 23,500 m^3 (Norphel and Tashi 2015). Recent research has called for an examination of their long-term efficacy and their usefulness as climate change adaptation strategies (Clouse et al. 2017). Artificial glacier technology has proved to be an effective solution to the adverse effects of global warming and extreme climatic conditions, addressing depleting water resources due to retreating glacial cover

Why Ladakh need 6th schedule

Ladakh thrives culturally as well and its rural expanse boasts charming villages that capture the imaginations of travelers and adventurers. Globally renowned for their frugal and sustainable lifestyles, the locals ingeniously cultivate agricultural terraces on mountain slopes to nurture resilient crops for sustenance. Likewise, pastoral communities practice ingenious animal grazing techniques, employing a rotational system that fosters plant regeneration. Water stands as the most precious resource in Ladakh, with its scarcity felt deeply. The populace relies on glacial runoff for drinking, agriculture, and power generation. However, the retreat of glaciers atop mountains is causing the depletion of springs fed by them. Consequently, various wildlife species like the Bharal and Ladakh urial are forced to gather around the Indus River to satisfy their thirst.

This shift highlights the Indus as the primary water source for both wildlife and humans. Sadly, the water quality of the Indus is deteriorating due to pollution. Compounding the issue, thousands of people, including military personnel, tourists, and laborers, camp along the riverbanks, impacting the fragile ecosystem. These camps throw organic wastes into the river, which leads to eutrophication (overloading of water bodies with organic matter), which in turn leads to a population explosion of aquatic invertebrates, which in tandem with global warming deplete dissolved oxygen, thereby making water less fit for irrigation and drinking in downstream areas. These ecological concerns, among numerous others, underscore the necessity of constitutional protections for Ladakh under the Sixth Schedule. Without such safeguards, this region, with its kaleidoscope of multicolored mountains, lush valleys, pristine lakes, and expansive azure skies that draw visitors from far-flung corners of the globe, risks losing its essence and fading into a mere echo of its former self.

Conclusion

Ladakh's fragile ecosystem and cultural heritage necessitate a robust policy framework to ensure a sustainable way of life. With its unique geographical challenges and reliance on scarce resources, such as water, a strong policy foundation like the 6^{th} schedule is vital to preserving its delicate balance while fostering socio-economic development. Implementing sustainable practices through effective policies will not only safeguard Ladakh's environment but also uphold its rich cultural traditions for future generations to cherish and thrive upon.

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IMPACTS OF CLIMATE CHANGE ON THE ICONS OF THE ANTARCTIC

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Abstract

The Icons of the Antarctic, *Aptenodytes forsteri*, face severe threats from climate change, primarily due to the loss of stable sea ice, which is crucial for their survival. This iconic species relies heavily on sea ice for breeding, feeding and protection from terrestrial predators. The article highlights the impacts of climate change on the global population dynamics of Emperor penguins. The species is categorized as “Near Threatened” in the International Union for Conservation of Nature (IUCN) Red List. Multifaceted conservation strategies are needed to protect them. The combined efforts of scientific studies, global public participation and strict policy implementation are vital to mitigate the impacts of climate change and ensure the long-term survival of Emperor penguins in their fragile Antarctic ecosystem.

Keywords: Emperor penguins, Conservation, Climate change, Sea-ice, Antarctic

Introduction

The polar regions: the Arctic (North) and the Antarctic (South) are characterized by extreme cold temperatures and large stretches of sea and frozen landscapes. These regions play an important role in regulating global climate patterns. The Antarctic region consists of thicker ice sheets (about 2000 metres thick) which cover the continent and are surrounded by the Southern Ocean, whereas Arctic is primarily made up of drifting and pack ice (two to three metres in thick), which covers the Arctic Ocean and is surrounded by land masses. The incredible biodiversity found in these regions is specifically adapted to extremely harsh environmental conditions. Seals, walruses and polar bears live in the Arctic, whereas the Antarctic is home to mainly penguins, whales and seals. Keystone species such as Antarctic krill serve as an intermediate between primary producers and top predators in the Antarctic food webs. These organisms are crucial for maintaining the structure and function of an ecosystem. In the past few decades, climate change, including rising temperatures, has caused a significant reduction in sea ice thickness and affected ice-dependent species.

The Emperor penguin, *Aptenodytes forsteri*, also known as “Icons of the Antarctic”, is the tallest and heaviest living penguin species on Earth. They are approximately 110 cm tall, having a mean mass of around 28 kg and a life span of 22.4 years. They are the largest of all the 18 species of penguins found. Among them, the Emperor and Adelie penguins are endemic to Antarctica, making them “true Antarctic resident”. They are well adapted to survive in an extreme cold environment, owing to their dense double-layered feathers, large fat reserves and physical adaptations such as small-sized beaks and flippers for preventing heat loss. Their colonies can be seen around the entire Antarctic coast. The colony is composed of several families, each consisting of a breeding pair and a young one. In addition, they are excellent swimmers, making various movements, twists and turns while swimming. The maximum diving depth and duration of the longest dive were recorded to be 564 metres and 27.60 minutes, respectively. Their colonies live, feed, breed and moult on the sea ice.

However, rising temperatures, melting ice and changing ocean conditions are severely affecting their population. Presently, climate change is the biggest threat to them. Several studies have suggested that Emperor penguin populations will decline rapidly in the future as a result of climate change (Fretwell et al., 2014). Until 2009, this species was listed as Least Concern (LC) in the IUCN Red List, but it was shifted to Near Threatened (NT) in 2012 under criteria A3c (Birdlife International, 2020). The predicted decline in the Emperor penguin population is mainly due to their dependence on sea ice, a crucial habitat that is anticipated to diminish in the future (Turner et al., 2009). Sea ice is vital for them in two aspects: serving as a breeding ground and providing a foraging environment (Forcada and Trathan, 2009). Due to climate change, it is anticipated that the Emperor penguin population will be facing declines, with at least two-thirds projected to have reduced by more than 50% from the present population size. In addition, the global population is projected to have declined by 19% (Jenouvrier et al., 2014).

How has Climate change impacted the Global population dynamics of Emperor penguins?

The Emperor penguin, *Aptenodytes forsteri* has a circumpolar distributional range. The first colony was discovered in 2009 on the ice shelf as Barrier Bay colony (67.22°S, 81.93°E) (Fretwell and Trathan, 2009). As per Trathan et al., 2020, the species has approximately 54 breeding colonies consisting of approximately 256,500 breeding pairs, dotted along the entirety of Antarctica's coastline. Among these colonies, the largest (more than 15000 pairs) are predominantly found in the Ross Sea and Weddell Sea. Some authors suggest that colonies could have undergone shifts geographically (Fretwell and Trathan, 2009). The population trend of this species is forecasted to be strongly linked to the Antarctic sea ice (extent, thickness and duration) in the future (Bronselaer et al., 2018).

These penguins are heavily dependent on the sea ice for various critical aspects of their life cycle. They use stable sea ice masses as their breeding habitat. They form colonies, lay eggs and rear their chicks on the sea ice, thus providing a safe platform away from terrestrial predators (Jenouvrier et al., 2020). An iconic top predator, Emperor penguins feed primarily on fish, krill and squids which are abundant in the waters around and beneath (Ainley et al., 2010). Prey availability is mainly determined by the sea ice extent or sea surface temperatures or both (Barbraud and Weimerskirch, 2001). The loss of sea ice as a result of climate change poses a severe threat to the entire life cycle and survival of these Emperor penguins. The decline in sea ice along with significant reduction in fisheries were reported to affect the prey stocks (fish and krill) of this iconic predator (Rintoul et al., 2018).

The adult penguins mainly rely on the Antarctic silverfish, *Pleuragramma antarcticum* and the Antarctic krill, *Euphausia superba* (Barbraud and Weimerskirch, 2001). The long-term climate change has caused significant changes in ocean circulation patterns which have caused alterations in the nutrients and carbon cycles, thus influencing Antarctic food webs (Lago and England, 2019). All of these factors have caused significant changes in the global population dynamics of Emperor penguins. Furthermore, the loss of suitable breeding grounds is one of the most challenging threats faced by the Emperor penguins (Fretwell et al., 2014). Globally, the Emperor Penguin population was projected to decline by 86% compared to its current size if the colonies could not locate more suitable breeding grounds, resulting in an annual loss of 4.06% per year by the end of this century (a half-life of 17 years) (Jenouvrier et al., 2020).

The current and projected changes in the Antarctic sea ice are complex. While the recent technological advancements have surely improved our understanding of ice volume changes, some uncertainties persist regarding the future trajectories (Intergovernmental Panel on Climate Change; IPCC 2007). Over the satellite observation period from 1979 to 2018, there has been a consistent lack of significant trend in the total Antarctic sea ice coverage (IPCC 2019). Although there was a notable increase in mean ice cover up to 2015, this trend reversed in the subsequent years (2016 to 2018) with below-average cover observed (IPCC 2019). As per IPCC 2023, there have been changes observed in the Antarctic sheet mass loss since the 1990s, with high confidence in the likelihood of these alterations. At sustained warming levels between 2°C and 3°C, the Greenland and West Antarctic ice sheets are likely to be almost entirely and irreversibly lost over multiple millennia (limited evidence).

Figure 1: Strategies for the conservation and management of Emperor penguins

The probability and rate of ice mass loss increase with higher global surface temperatures (high confidence) (IPCC 2023). Numerous scientific studies have been conducted to assess the potential impacts of projected climate change on Emperor penguins. Ainley et al., 2010 suggested that all colony sites located north of 70° South will become uninhabitable and it would affect 40 % of the world's Emperor penguins. However, Fretwell et al., 2012 estimated that 34.8% of the total population breeds north of 70° South and is vulnerable to reduction in sea ice. By using a sea-ice-dependent demographic model, the dynamics of 45 colonies were projected. The model revealed that though dynamics differed among the colonies, all populations were projected to be in widespread decline by the year 2100 (Jenouvrier et al., 2014). As per

Jenouvrier et al., 2014, 43 out of 54 (80 percent) colonies were projected to decline by more than 90% (Quasi-extinct). Only 17 colonies (31%) were expected to become quasi-extinct by 2100 if the global temperature remained limited to 2°C. The global population still projected to be decline by at least 44% under this situation (Jenouvrier et al., 2020). However, if the current climatic factors persist, the global abundance of Emperor penguins was reported to decrease by 86%. Since the criteria for assessing species by their extinction risk rely on global population dynamics, it is crucial to perform global analyses for effective conservation measures (Jenouvrier et al., 2014).

Conservation measures

Currently, the Emperor penguins are listed in the Near Threatened (NT) category in the IUCN Red List (Birdlife International, 2020). Till 2009, this species was listed as Least Concern (LC), but it was shifted to the NT category in the year 2012. Various conservation measures have been implemented to address the challenges faced by Emperor penguins. The establishment of the Marine Protected Areas (MPAs) around their critical habitats is a vital conservation strategy. Human disturbances such as fishing and shipping are restricted in these areas. To date seven active breeding sites are designated as Antarctic Specially Protected Areas (ASPAs) and seven are Ross Sea Region Marine Protected Area (RSR MPA). The ASPAs only protect breeding habitats whereas MPAs are crucial to protect food resources. (Birdlife International, 2020). The RSR MPA, established in 2016, will cover around 1.55 million km^2 of the Southern Ocean (Brooks et al., 2021), prohibiting commercial fishing for the next 35 years (Australian Birdlife 2016). Thus, it provides a safe haven for many Antarctic species including Emperor penguins (Brooks et al., 2021).

Global efforts are needed to mitigate climate change such as the Paris Agreement aimed to limit global warming to 1.5 °C by reducing greenhouse gas emissions (United Nations Framework Convention on Climate Change, 2015). These efforts are needed to protect critical sea ice habitats that Emperor penguins depend on (Ainley et al., 2010; Jenouvrier et al., 2014). These penguins primarily feed on the Antarctic silverfish, *Pleuragramma antarcticum* and the Antarctic krill, *Euphausia superba* (Barbraud and Weimerskirch, 2001). Effective fisheries resource management such as preventing bycatch of prey populations and setting fishing quotas for commercial fishing in the Southern Ocean (Commission for the Conservation of Antarctic Marine Living Resources; CCAMLR, 1982), is a crucial step in maintaining the Antarctic food webs (Agnew, 2004). The Emperor penguin has gained a lot of attention internationally in the past few decades and this species is a subject of ongoing research and monitoring programmes. However, the Southern colonies are lesser known as most of the research works have been limited to the northern part of the species habitat range (Birdlife International, 2020).

Additional efforts are required to understand the underlying causes of the penguin population decline (Fretwell et al., 2012). More scientific studies are needed to develop new and effective remote sensing indices (Fretwell et al., 2012) to monitor the colonies, breeding and foraging grounds, population dynamics, changes in sea ice habitats and the penguin’s response to environmental changes (Birdlife International, 2020). Strengthening of current laws and policies is required on the international level. International collaborations through treaties and agreements improve conservation and management efforts. The CCAMLR works under the Antarctic Treaty System (ATS, 1959) ensuring sustainable management of marine resources and protection of marine species including Emperor penguins (CCAMLR, 1982). Furthermore, raising public awareness and Education play a crucial role in the conservation of a species as they drive action at both individual and community levels thereby gathering global support. Social media campaigns, documentaries (March of the Penguins, Jacquet, 2005) and educational programs can instill a sense of responsibility toward environmental protection. They drive effective changes in laws and policies. For example, the establishment of one of the largest MPAs: the Ross Sea Region Marine Protected Area (RSR MPA) required the efforts of millions of global citizens for more than a decade (Brooks et al., 2021). The synergy among scientific research, public participation and policy makers is essential for the effective conservation of the Iconic Emperor penguins.

Conclusion

A multifaceted approach is needed for the conservation of Emperor penguins. Climate change is a major threat to their survival. These icons of the Antarctic depend heavily on the sea ice for breeding and foraging purposes. The rising temperatures cause a decline in suitable breeding and foraging grounds as well as disrupt Antarctic food webs. Measures such as the establishment of ASPAs and RSR MPA, global treaties and agreements, effective fisheries resource management, international collaborations as well as public awareness and education are critical in mitigating these impacts. Continuous scientific studies and monitoring programs are crucial for understanding the causes of population decline. For the long-term survival of Emperor penguins, the synergies between scientific research, public engagement and policy implementation are imperative. Immediate global efforts are needed to conserve this unique creature and preserve the fragile Antarctic ecosystem.

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INVASIVE RUGOSE SPIRALLING WHITEFLY *Aleurodicus rugioperculatus* (ALEYRODIDAE: HEMIPTERA) MARTIN, A SERIOUS PEST OF COCONUT

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Introduction

The rugose spiralling whitefly, *Aleurodicus rugioperculatus* Martin (Aleyrodidae: Hemiptera), was first reported in coconut (*Cocos nucifera* L.) during 2004 in Belize, Central America (Martin, 2004), South Florida, United States in 2009 (Stocks and Hodges, 2012) and in Pollachi tract (10.491ºN; 76.980ºE), Coimbatore district, Tamil Nadu during August, 2016 (Selvaraj et al. 2016).

Diagnosis

The eggs are laid in a spiralling pattern and have a very short stalk. The emerging nymph is yellowish and develops white waxy filaments later.

Eggs laid in spiral manner

Mobile crawler

Nymphs

Emergence slit of RSW

A. rugioperculatus colonies on coconut leaflets

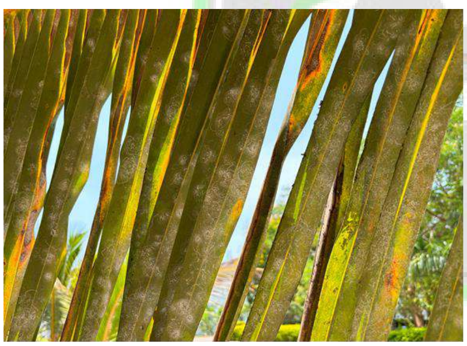
The adult whitefly, though, is quite different from the spiralling whitefly by its much larger size and in having two pale brown wavy markings on the forewings, one medial and one apical. Martin (2008) has given a puparium based illustrated key to separate the genera and species of Aleurodicinae including *Aleurodicus rugioperculatus*

Host plants

The rugose spiralling whitefly has been known to attack about 118 hosts including cultivated crops and weed flora (Stocks, 2012). Coconut and banana are among the most preferred host plants.

Damage symptoms

- Nymphs and adults of the whitefly suck the sap on the under surfaces of the leaflets.
- Extensive feeding of the insect leads to the excretion of honey dew which subsequently gets deposited on the upper surface of the leaves.
- Honey dew excrement, being sweet and watery, attracts ants and encourages growth of the fungus *Capnodium* sp. which causes disfigurement of hosts affecting the photosynthetic efficiency of the plant.



Presence of large number of whiteflies colonies on the under surface of leaf

Black sooty mould growth on the upper surface of leaf

Management Practices

Surveillance and Monitoring

- Regular survey and monitoring at least at weekly intervals should be conducted for early detection of the pest and decision making based on Agro-ecological system analysis (AESA).
- Installation of yellow sticky traps @ 5/acre is recommended to monitor the RSW.

Cultural control

- Avoid transplanting of affected coconut seedlings.
- Adopt proper spacing as per the recommendation.
- Application of optimum recommended doses of fertilizers on the basis of soil health card.

Mechanical Control

- Coconut leaflets can be dislodged by forced water spray, targeting the lower surface of the leaflets.
- Use of yellow sticky traps to trap the adult whiteflies.

Biological Control

- Encourage build-up of parasitoids (*Encarsia guadeloupae*) and re-introduce parasitized pupae to emerging zones of whitefly outbreak.
- Conserve and augment predators of RSW such as *Chrysoperla* and *Coccinellids*, which are available in the field.

Botanicals

- In case of severe infestation, spray neem oil 0.5% and avoid spraying any form of insecticides.

Note: Spraying starch solution (1%) to dislodge the heavy sooty mould deposition on the leaves of infested plants.

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ARTHROPOD PESTS OF HONEY BEES AND THEIR MANAGEMENT

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Introduction

Honey bees hold a revered position in the natural world as these are vital pollinators for many crops, including fruits, vegetables, and oilseeds, contributing significantly to agricultural productivity. They are responsible for maintenance of biodiversity in nature. Beekeeping with *Apis cerana* is being practiced in India since ancient time. Honey and other hive products hold cultural and culinary importance across the country. However, honey bee populations in India, as elsewhere, face threats from habitat loss, pesticide use, and climate change, highlighting the need to safeguard them.

The honey bees face a formidable adversary in the form of insect pests threatening colony health and productivity. The invasion of pests not only jeopardizes honey production but also imperils the crucial pollination services. Understanding the dynamics of insect pests for effective implementation of management strategies is essential to safeguard the well-being of honey bee populations to secure their vital role in sustaining biodiversity and food security. Here are the important pests of honey bees in India:

1. Varroa Mite (*Varroa destructor*)

It is an ecto-parasitic mite that primarily affect hive bee species i.e. *Apis mellifera* and *Apis cerana*. These mites are reddish-brown and oval-shaped, about 1.1 mm long and 1.5 mm wide. They attach themselves to the bees, feeding on their bodily fluids (hemolymph) and causing various health issues.

Impact on colony health

- Infested bees will have weak immune systems making them susceptible to other diseases.

- Transmission of deformed wing virus (DWV) causes developmental problems.
- Infested hives become less productive due to the reduction in bee strength.

  Management:
- Assess the infestation level using alcohol/powder sugar. Sticky paper over Varroa board also helps in this work.
- Organic acids like formic acid and oxalic acid are effective.
- Use of screened bottom boards/ Varroa boards with sticky paper.
- Trapping over drone brood and temporary queenlessness also help in lowering mite population

2. *Tropilaelaps* Mite

Like *Varroa destructor* it is also an ecto-parasitic mite which infest brood. *Tropilaelaps clareae* and *Tropilaelaps mercedesae* are the important mite species. Adult of this mite are comparatively smaller than *Varroa destructor*. Size is 0.9-1.0 mm long and 0.5-0.6 mm wide. Colour of adult is reddish-brown.

Management: Dust sulphur powder over top bars or use formic acid

3. Tracheal mite (*Acarapis woodi***)**

In contrary to above two mite pests, this species develop and reproduce inside trachea of the honey bee. This blocks the exchange of air. This will lead to development of paralytic symptoms in adult bees.

Impact on colony health:

- Infested bees will have 'K' wing conditions
- Bees unable to fly and can be observed crawling in front of hive
- Infested hives become less productive due to the reduction in bee strength.

Management:

- Use formic acid

4. Wax Moth

Damage of wax moth usually appears in severe form during rainy season. It damage the wax combs within hives/stored combs by making tunnels, silken webbing and defecating in tunnels. There are two main species:

Greater Wax Moth (*Galleria mellonella*): Adult moths are greyish-brown, about 10-18 mm long; with a wingspan of 30-41 mm. The larvae are creamy white with a brown head, growing up to 30 mm in length.

Lesser Wax Moth (*Achroia grisella*): The Adult moths are smaller in size, with a wingspan of 12-17 mm and larvae are similar in appearance to the greater wax moth larvae but smaller, growing up to 20 mm in length.

Impact on beehives:

- The wax moth larvae make tunnels in combs
- In case of severe infestation or webbing sometimes emerging bees get stuck into these and consequently die.
- Infested hives get weakened thereby become less productive

Management:

- Maintain strong and healthy colonies
- Regularly inspect and clean the hives. Burn or burry the debris lying on bottom board.
- Store combs in well-sealed containers. Freeze treatment is helpful.
- Use smoldering sulphur in stored combs.
- *Bacillus thuringiensis* (Bt) can be used as biological agent for the controlling the wax moth.

5. Hornets and Wasps (*Vespa magnifica, V. auraria, V. cincta, V. orientalis* and *V. basalis*)

Hornets and wasps also belong to order Hymenoptera. They have slender bodies with narrow waists and distinctive markings, varying in size and colour depending on the species. While hornets are typically larger and more robust, wasps are generally smaller and more slender.

Impact on bee hives:

- Hornets and wasps prey on adult bees, larvae, and pupae, leading to a reduction in bee strength.
- Persistent attacks by hornets and wasps can stress bees, disrupting normal hive activities and potentially causing colony abandonment.

Management:

- Reduce hive entrance to prevent hornets and wasps from entering the hive.
- Set up traps around the hive with bait attractive to hornets and wasps.

- Locate and destroy hornet or wasp nests in the vicinity of the hive.
- Maintain strength of the honey bee colonies.
- Remove alighting board

6. Ants

Ants like honey bees are also social insects which belong to the family Formicidae. They can pose a threat to bees during rainy season when they invade inside hive.

Impact on beehives:

- Ants can enter bee hives to rob honey, pollen, and other resources.
- Some ant species may prey on bee larvae and pupae, leading to brood loss.
- Ant invasions can force bees to abandon their hive.
- Ants can build nests in or around hives, causing structural damage to the hive boxes and equipment.

Management:

- Conduct regular inspections of the hive and surrounding area to detect early signs of ant activity.
- Use water containing few drops of kerosene filled pots under the legs of hive stands
- Keep the area around the hives clean and free from debris, spilled honey, or pollen that might attract ants.
- Use ant-specific insecticides carefully around the hive area.
- Seal any cracks or gaps in the hive to prevent ants from entering.
- Ensure the high strength of bees in hive.

7. Small Hive Beetle (*Aethina tumida*)

It is an emerging threat to Indian honey bee industry. It is native to sub-Saharan Africa but has spread to other regions, including North America, Europe, and Australia. The adult beetles are small, oval-shaped, dark brown to black, and about 5-7 mm in length. The larvae are creamy-white, elongated, and can grow up to 10-11 mm long. They have three pairs of well-developed legs near the head.

Impact on beehives:

- Larvae consume honey and pollen leading to the destruction of combs.
- Larvae defecate in the honey, causing it to ferment and spoil.
- Beetles can kill bee brood directly by feeding on them, reducing the hive’s population.

- Damaged combs and fermented honey create conditions favourable for the attack of other pests and diseases.

Management

- Maintain strong and healthy colonies
- Regularly inspect and remove debris.
- Place hives in sunny location with well-drained soils to prevent pupation in soil.
- The application of the entomopathogenic nematodes to the soil around hives can kill beetle larvae during pupation.
- Regularly disturb the soil around the hive to expose beetle pupae to predators and environmental conditions.

Regular inspection and following above give management strategies can help a beekeeper protecting his honey bee colonies. The judicious use of recommended chemicals will help in harvesting quality hive products.

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BATTLING SOIL EROSION: AGRO-ENGINEERING MEASURES TO PROTECT OUR FARM

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Abstract

Soil erosion is a major environmental concern that affects agricultural production, water quality, and ecosystem health. Every year, large amounts of fertile topsoil are lost as a result of natural processes hastened by human activity. Agro-engineering, which blends agricultural and engineering principles, provides novel approaches to addressing this important issue. We can greatly reduce soil erosion by using various agro-engineering techniques, assuring sustainable farming operations and protecting land for future generations.

Keywords: Agricultural production, Soil erosion, Agro-engineering techniques

Introduction

Soil erosion is the process by which the upper layer of soil is displaced by wind, water, and other natural forces. This phenomenon is exacerbated by human activities such as deforestation, overgrazing, and improper land management practices. The consequences of soil erosion are far-reaching: it reduces soil fertility, leading to lower crop yields; increases sedimentation in rivers and lakes, affecting water quality; and disrupts ecosystems, endangering wildlife habitats.

Soil erosion in India is a severe issue affecting millions of hectares of agricultural land. The diverse topography, coupled with seasonal monsoon rains, makes the country highly susceptible to erosion. According to the Indian Council of Agricultural Research (ICAR), nearly 120 million hectares, or about 36% of India's total geographical area, suffer from various degrees of soil degradation, primarily due to erosion (Dey and Mandal et al., 2023).

The Need for Agro-Engineering Solutions

Traditional farming approaches frequently fail to address the underlying causes of soil erosion. Agro-engineering combines scientific research, technology, and practical solutions to create successful soil conservation techniques (Maetens et al., 2012). Here are several significant agro-engineering strategies that have proven effective in reducing soil erosion.

Contour Ploughing

Contour ploughing is done along the curves of a hill rather than up and down. This approach creates natural barriers to water flow, decreasing runoff and keeping soil from washing away (Farahani et al., 2016). Contour ploughing helps to retain soil structure and fertility by adhering to the land's natural shape as indicated in Fig 01. This strategy is especially useful on mountainous terrain where traditional ploughing methods would aggravate erosion.

Fig 01. Contour Ploughing

Terracing

Terracing is a process that converts steep land into a succession of step-like level regions. These terraces slow water runoff, allowing it to seep into the soil rather than damage it through Fig 02. This not only reduces soil loss but also aids in preserving water, making it available for crops. Terracing is particularly beneficial in mountainous areas where steep slopes are prone to severe erosion.

Fig 02. Terracing

Cover Crops

Planting cover crops, such as clover or rye, during the off-season is a simple yet effective technique to counteract erosion. These crops cover the land and protect it from wind and rain damage as shown in Fig 03. Their roots glue soil particles together, improving soil structure and reducing erosion. Furthermore, cover crops give organic matter to the soil, increasing its fertility. This strategy is both cost-effective and beneficial to soil health.

Fig 03. Cover Crops

Grassed Waterways

Grassed streams are carefully planted sections of grass inside a field designed to divert surface water runoff. These grassy pathways slow down the flow of water, lessening its erosive power and allowing sediments to settle as it will reduce the erosion as shown in Fig 04. This approach not only reduces soil erosion, but it also helps to filter out pollutants, so improving water quality. Grassed streams are especially beneficial in locations with heavy rainfall.

Fig 04. Grassed Waterways

Windbreaks

Windbreaks, also known as shelterbelts, are rows of trees or plants placed to block the wind. These barriers restrict wind speed across the soil surface, reducing wind erosion as Shown in Fig 05. Besides protecting the soil, windbreaks provide shelters for wildlife, minimize evaporation, and can even boost agricultural yields by producing a more favourable microclimate. Windbreaks are especially effective in flat, open places where wind erosion is a major concern.

Fig 05. Windbreaks

Mulching

Mulching entails covering the soil with a layer of organic or inorganic material, such as straw, wood chips, or plastic. This cover shields the soil from rains, reduces surface runoff, and decreases evaporation as shown in Fig 06. Organic mulches also decay over time, delivering essential nutrients to the soil. Mulching is a versatile and successful strategy that may be used to a wide range of crops and soil conditions.

Fig 06. Mulching

Retention Ponds

Building retention ponds on farmland helps to manage extra water after severe rains. These ponds collect and store runoff, allowing it to gently seep into the ground or be used for irrigation as shown in Fig 07. This not only minimizes soil erosion, but also increases water availability during dry periods. Retention ponds are particularly effective in places prone to sudden flooding. This retention ponds store the water and reduce the runoff.

Fig 07. Retention Ponds

The Role of Technology in Agro-Engineering

Modern technology plays an important role in improving the effectiveness of these agro-engineering approaches. Geographic Information Systems (GIS) and remote sensing can map erosion-prone areas, allowing for targeted actions. Precision agriculture technologies, such as automated tractors and drones, ensure that soil conservation activities are carried out correctly and efficiently.

Education and Policy Support

Education and policy assistance are required to ensure widespread adoption of agro-engineering measures. Farmers require information and training on soil conservation measures. Governments and agricultural organizations should encourage and subsidize sustainable methods, as well as provide farmers with the resources they need to put them into action.

Conclusion

Soil erosion is a major hazard to agriculture, the environment, and food security. By embracing agro-engineering solutions, we can conserve our valuable soil and assure a long-term agricultural future. From contour ploughing and terracing to cover crops and retention ponds, these strategies offer practical and effective ways to control soil erosion. With the backing of modern technology, education, and legislative measures, we can conserve our agriculture and the ecosystems it sustains for centuries to come. Soil may appear to be nothing more than soil under our feet, but it serves as the foundation for life on Earth. Let us act immediately to preserve it.

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INDIAN ORIGIN FRUITS FOR NUTRITIONAL SECURITY

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Introduction

India, the rich biodiversity resource country has as many as 139 species of underutilized fruit crops belonging to 42 families 94 Genera . World fruit production is estimated at 676.9 million tonnes, Vegetable production has been estimated at 879.2 million tonnes.. India is second largest producer of fruits and vegetables in the world. Indian origin fruit crops are being recognized as crops of the future, because of their multiple benefits such as neutraceutical values, medicinal properties, climate resilience etc.

Aonla /amla (*Emblica officinalis*)

Aonla is a native deciduous fruiting plant grown in many states of India. The tree is hardy, prolific bearer and a suitable choice for arid regions of the country. Amla is the most concentrated form of vitamin C (500- 600mg/100g) found in the plant kingdom, and when the whole fruit has been found to have great antioxidant properties.

Aonla /amla (*Emblica officinalis*)

It also contains proteins and minerals like calcium, and hypotensive. It is used internally to treat asthma, coughs, bronchitis, oedema, hypertension and diabetes. The bark is anthelmintic and purgative and can be used to expel tape worms. Popular varieties are „Black Persian‟, „Kaestar‟, „Riviera‟, „Shangri-La¸ Banarasi, NA 7, Krishna, Kanchan, Chakaiya, BSR 1.

Jackfruit (*Artocarpus heterophyllus*)

It belongs to the family Moraceae and presently cultivated throughout the tropical low land areas. Trees are large with oblong, oval or elliptical glossy, leathery and dark green leaves. Juvenile leaves are lobed. These evergreen trees attain a height upto 15m. Fruits are rich in carbohydrate, protein, vitamin C and minerals like Fe, P, K and Ca. Immature fruits are used as vegetables. Unripe fruits are made into pickle and slices. Ripe fruits are used for preparation of dried products, canned products, pulp, beverage, jelly, and nectar. The rind may be used for making jelly, the skin of ripe fruits and leaves are used as cattle feed. The seeds can also be boiled or roasted and eaten like nuts. The ripe bulbs are fermented and the distilled, produce potent liquor. Starchy flour is made from seeds. Seeds are popular ingredients in many cooked preparations. The roots and leaves possess medicinal properties. Hot water extracts of leaves are given to diabetic patients. The fruit parts contain pectin, the extracted pectin can be used for food industry. Popular varieties are „Bhadaiyan‟, „Bhusila‟, „Champaka‟, „Gulabi‟, „Handia‟ „„Hazari‟, „Khaja‟, „Rudrakshi‟, „Safeda‟. The hybrids are „Burliar-1‟, „PLR-1‟, „PPI-1‟

Jack- Artocarpus heterophyllus

Phalsa (*Grewia asiatica*)

It is a subtropical plant, can be grown upto an elevation of 900m above sea level. Plants are deciduous, hardy, tolerant to higher temperature upto 44°C and freezing temperature for a few days. High temperature helps in ripening of fruits. Fruits are rich in vitamins A, C and minerals like Fe and P. Fruits contain 55% juice with 11-12% TSS and 3% acidity. Flowers contain grewinol. The seeds contain a bright yellow oil having 8.3% palmitic acid, 11.0% stearic acid, 13.4 % oleic acid, 64.5% linoleic acid. Fruits are eaten fresh or made into syrup and commercially used in the preparation of soft drinks. Leaves are used as fodder. The bark is used as a soap substitute in Burma. The fruit is astringent and stomachic. Unripe fruits are administered against in respiratory, cardiac, blood disorders and fevers. The bark infusion is used as a demulcent, febrifuge and treatment for diarrhoea. The wood is used for golf shaft. The root is effective in curing rheumatism

Wood apple/kaith (*Feronia limonia)*

The tree can be grown upto an altitude of 1000m from sea level. It is said to require a monsoon climate with a distinct dry season. Fruits are rich in in pectin, unsaturated fatty acids. Unripe fruits contain 0.015% stigmasterol. The fruit pulp contains 18% carbohydrate, 7% protein, 4% fat, 5% fibre and 2% mineral matter as well as vitamin C, niacin, thiamin, riboflavin etc. Leaves contain stimasterol and bergaten. The bark contains 0.016% marmesin. Root bark contains aurapten, bergapten, isopimpinellin and other coumarins. The scooped pulp which is sticky is eaten raw with or without sugar, or is blended with coconut milk and palm sugar syrup and drunk as a beverage or frozen as an ice cream. It is also used in chutneys and for making jelly and jam. Nectar can be made by diluting the pulp with water.

Indian Ber- Ziziphus mauritiana

Karonda- *Carrisa carandas*

Kokam *Garcinia indica*

The rind of fruits can be curved and used as a utensil such as a bowl or ashtray. The fruit is used as a liver and cardiac tonic and when ripe, as an astringent to halt diarrhoea and dysentery and as an effective treatment for hiccough, sore throat and diseases of gum. Juice of young leaves is mixed with milk and sugar candy and prescribed as a remedy for biliousness and intestinal troubles of children. Leaves, barks, roots and fruit pulp are all used against snakebite.

Kokam (*Garcinia indica*)

It is native to East Indies. Cultivated in South India and Maharashtra. Trees are large, borne with small apple sized fruits. Fruits are acidic with purple sour taste and made into a vinegar. Seed oil is used to adulterate butter. Fruits are edible and useful in cooling effect during summer. It reduces indigestion, acidity, flatulence, constipation and diarrhoea. This is an important immunity booster because it is rich in anti-oxidants and it possesses anti-viral, anti-bacterial and antihelminthic properties.

Karonda

Carissa carandas is a species of flowering shrub in the family Apocynaceae Karonda is rich in iron, vitamin C, vitamins A calcium and phosphorus. Its fruit is used in the ancient Indian herbal system of medicine, Ayurvedic, to treat acidity, indigestion, fresh and infected wounds, skin diseases, urinary disorders and diabetic ulcer, as well as biliousness, stomach pain, constipation, anemia, skin conditions, anorexia and insanity, Leaf decoction is used to treat fever, diarrhea, and earache, The roots serve as a stomachic, an anthelmintic medicine for itches and also as insect repellents. In India, the mature fruit is harvested for Indian pickles.

It contains pectin and accordingly is a useful ingredient in chutney. Ripe fruits exude a white latex when severed from the branch.The biggest use of this fruit is as a faux cherry in cakes, puddings and other preparations. It is easily available in the market in bottled form as pitted cherries after processing it like traditional candied murabba

Jamun- ***Syzygium cumini*** **(L.)**

Bael-Aegle marmelos **(L.)**

Wood Apple- Limonia acidissima **Groff**

Bael

Aegle marmelos is a deciduous shrub or small to medium-sized tree Rich in vitamin C, the fruits can be eaten either fresh from trees or after being dried and produced into candy, toffee, pulp powder or nectar.

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3D PRINTING IN THE FOOD INDUSTRY

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Introduction

The underlying value of the present conventional food system with its ongoing traditional manufacturing methods, which has been the by-product of the rapid advancements in technology throughout the years is linked to the destruction of the planet and health of individuals. The calculation in productivity in tandem with its ability to produce more commodities in order to meet the growing demands of consumers has led to the unsustainability of the food industry. Accounting for over 26% of the global greenhouse gas emissions (GHG), the food supply remains a measure of high carbon footprint which occurs mainly during the production process where large amounts of energy resources are consumed. Moreover, studies report that food waste or loss is a common challenge reaching levels of one third of the total food production due to lack of progress in tackling the inefficiencies of handling storage and the limited infrastructure for food processing . In addition to harmful environmental impacts, the cells of the human body have experienced many different challenges from this industry such as chronic illnesses caused by the excessive influence of chemical fertilizers, preservatives, and genetic modification induced in various food products.

The profound effect of unsafe food can be observed in all ages of the spectrum from the infants to the elderly where risks such as illnesses affect one in ten people globally as well as a burden of 420,000 premature deaths is exposed annually . The deterioration of health has allowed a shift in consumer behaviour into a healthier diet focused on nutritious valued food products. An example of this can be observed in the population of Latvia where currently the consumption of meat, bread, alcohol, and tobacco on average was greatly reduced compared to 10 years ago . As a result, such food related challenges and trends have become the top priority of many organizations and governments across the globe.

Through its numerous applications, 3D food printing (3DFP) offers a viable alternative solution to the methods of food production creating a renewable and efficient future of food all while providing a new and exciting food experience from this patented technology. This additive manufacturing (AM) technique allows for the fabrication of 3D printed food products using a computer aided design (CAD) model-based printer that simulates a layer-by-layer deposition process . Despite its lack of maturity in the commercialization stage, the equipment can be found applied successfully in different fields of market settings such as in medical , aerospace , automotives , construction , and food applications .

The current progress of 3DFP focuses on its capability to revolutionize the food industry through its various applications. 3DFP provides a broad array of personalized nutritious commodities where an adjusted density, structure, and composition of such products falls in parallel with the health needs of individuals from all backgrounds. Recent research on this application has focused on the designed flexible performance of the technology that helps to supply meals that contain healthy ingredients and acquire soft pureed textures for the elderly that suffer from illnesses challenging their swallowing and chewing activities. In addition, there exists progress of this application targeting children by preparing and presenting nutritious snacks in fun and innovative shapes that helps to increase their willingness for consumption.

A major contribution for the technology stems from the promise of sustainability that it can expose to the system through its current movement in generating different goods and packaging from the valorisation of food waste accumulated from different industries. This application coincides with the recent upsurge in policies targeting such issues and concurrently contributes to the reduction of carbon footprint . Furthermore, present studies were able to yield intricate and stable shapes and designs successfully with 3DFP by combining various macro and micronutrients in order to meet the consumer’s targeted customized dimensions while being able to control its nutritional value . Despite these beneficial applications, further research is required to overcome the technological challenges that make the full launch towards the market slower. Studies reveal the technology has limited technical characteristics such as slow print speed that decreases the demand and adoption into the food industry. In addition, the process lacks consumer acceptance and knowledge, suffers from hygiene and safety problems, acquires short shelf life, and requires high costs financially. Moreover, limited regulations remain processed on this technology on both a national and industrial level.

It can be observed that the field of 3D printing established high characterization in the visualization map during the years 2018–2022 with strong correlations to subject matters in sustainability, personalized nutrition, rheological properties, food, and customized food fabrication.

Despite the strong correlation with sustainability, efforts being made in determining the contribution of 3DFP in achieving the "Sustainable Development Goals" (SDG) established by the United Nations (UN) remains in its infancy. The importance of SDG lies in its ability to prompt the sustainability values for all countries under three pillars, namely (i) prosperity, (ii) people, and (iii) the planet . The technology possesses strong sustainability impact through its ability to achieve some of the 17 goals. The ability of 3DFP to provide personalized nutrition schemes, customized shape fabrication, and food waste utilization allows it to achieve some of the 17 SDGs. For example, personalized nutrition can be provided with textural modifications accustomed to the needs of dysphagia patients who normally suffer from swallowing challenges, facilitates in prompting the utilization of 3D printers in hospitals which in turn increases the health benefits of people and thus achieve its role in satisfying SDG3 successfully as can be seen in Fig.1.

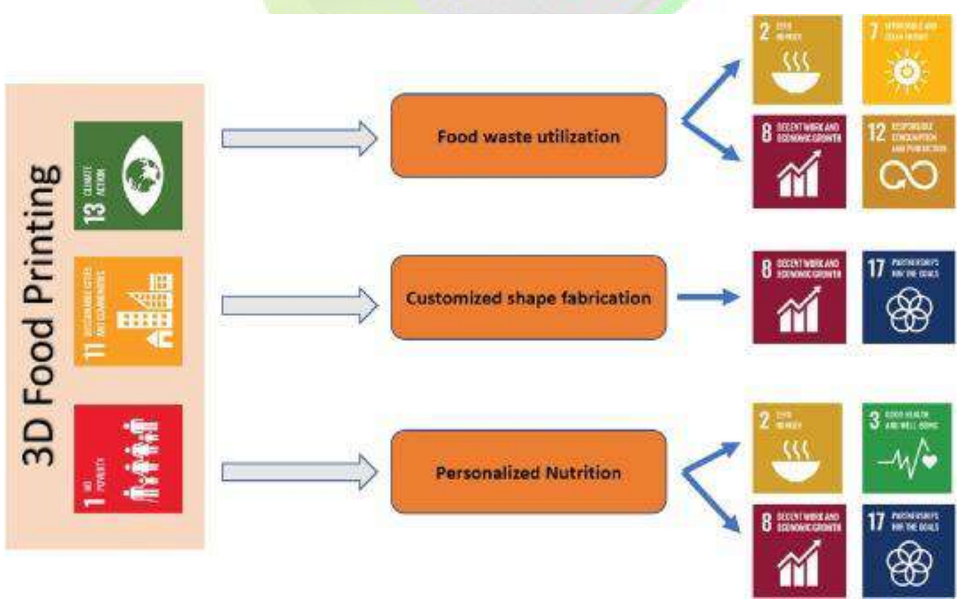

Fig.1. Degree of Impact for each application (Source: Alami et al.,2024)

What is 3D printing technology?

3D printing – or additive manufacturing – creates physical objects from geometrical representations through the successive addition of materials . On the other hand, traditional manufacturing involves casting, molding, and machining – also known as subtractive techniques – where objects are created from the subtraction of material from a workpiece.

Types of 3D printing technology

3D printing, also known as additive manufacturing, processes have been categorised into **seven groups** by ISO/ASTM 52900 additive manufacturing . All forms of 3D printing fall into one of the following types:

Binder Jetting

Binder jetting deposits a thin layer of powered material, for example metal, polymer sand or ceramic, onto the build platform, after which drops of adhesive are deposited by a print head to bind the particles together. This builds the part layer by layer and once this is complete post processing may be necessary to finish the build. As examples of post processing, metal parts may be thermally sintered or infiltrated with a low melting point metal such as bronze, while full-colour polymer or ceramic parts may be saturated with cyanoacrylate adhesive.

Binder jetting can be used for a variety of applications including 3D metal printing, full colour prototypes and large scale ceramic moulds.

Direct Energy Deposition

Direct energy depositioning uses focussed thermal energy such as an electric arc, laser or electron beam to fuse wire or powder feedstock as it is deposited. The process is traversed horizontally to build a layer, and layers are stacked vertically to create a part.This process can be used with a variety of materials, including metals, ceramics and polymers.

Material Extrusion

Material extrusion or fused deposition modelling (FDM) uses a spool of filament which is fed to an extrusion head with a heated nozzle. The extrusion head heats, softens and lays down the heated material at set locations, where it cools to create a layer of material, the build platform then moves down ready for the next layer.

This process is cost-effective and has short lead times but also has a low dimensional accuracy and often requires post processing to create a smooth finish. This process also tends to create anisotropic parts, meaning that they are weaker in one direction and therefore unsuitable for critical applications.

Material Jetting

Material jetting works in a similar manner to inkjet printing except, rather than laying down ink on a page, this process deposits layers of liquid material from one or more print heads. The layers are then cured before the process begins again for the next layer. Material jetting requires the use of support structures but these can be made from a water-soluble material that can be washed away once the build is complete.

A precise process, material jetting is one of the most expensive 3D printing methods, and the parts tend to be brittle and will degrade over time. However, this process allows for the creation of full-colour parts in a variety of materials.

Powder Bed Fusion

Powder bed fusion (PBF) is a process in which thermal energy (such as a laser or electron beam) selectively fuses areas of a powder bed to form layer, and layers are built upon each other to create a part. One thing to note is that PBF covers both sintering and melting processes. The basic method of operation of all powder bed systems is the same: a recoating blade or roller deposits a thin layer of the powder onto the build platform, the powder bed surface is then scanned with a heat source which selectively heats the particles to bind them together. Once a layer or cross-section has been scanned by the heat source, the platform moves down to allow the process to begin again on the next layer. The final result is a volume containing one or more fused parts surrounded by unaffected powder. When the build is complete, the bed is fully raised to allow the parts to be removed from the unaffected powder and any required post processing to begin.

Selective laser sintering (SLS) is often used for manufacture of polymer parts and is good for prototypes or functional parts due to the properties produced, while the lack of support structures (the powder bed acts as a support) allows for the creation of pieces with complex geometries. The parts produced may have a grainy surface and inner porosity, meaning there is often a need for post processing.

Direct metal laser sintering (DMLS), selective laser melting (SLM) and electron beam powder bed fusion (EBPBF) are similar to SLS, except these processes create parts from metal, using a laser to bond powder particles together layer-by-layer. While SLM fully melts the metal particles, DMLS only heats them to the point of fusion whereby they join on a molecular level. Both SLM and DMLS require support structures due to the high heat inputs required by the process. These support structures are then removed in post processing ether manually or via CNC machining. Finally, the parts may be thermally treated to remove residual stresses.Both DMLS and SLM produce parts with excellent physical properties - often stronger than the conventional metal itself, and good surface finishes. They can be used with metal superalloys and sometimes ceramics which are difficult to process by other means. However, these processes can be expensive and the size of the produced parts is limited by the volume of the 3D printing system used.

Sheet Lamination

Sheet lamination can be split into two different technologies, laminated object manufacturing (LOM) and ultrasonic additive manufacturing (UAM). LOM uses alternate layers of material and adhesive to create items with visual and aesthetic appeal, while UAM joins thin sheets of metal via ultrasonic welding. UAM is a low temperature, low energy process that can be used with aluminium, stainless steel and titanium.

VAT Photopolymerization

VAT photopolymerization can be broken down into two techniques; stereolithography (SLA) and digital light processing (DLP). These processes both create parts layer-by-layer through the use of a light to selectively cure liquid resin in a vat. SLA uses a single point laser or UV source for the curing process, while DLP flashes a single image of each full layer onto the surface of the vat. Parts need to be cleaned of excess resin after printing and then exposed to a light source to improve the strength of the pieces. Any support structures will also need to be removed and additional post-processing can be used to create a higher quality finish.

Ideal for parts with a high level of dimensional accuracy, these processes can create intricate details with a smooth finish, making them perfect for prototype production. However, as the parts are more brittle than fused deposition modelling (FDM) they are less suited to functional prototypes. Also, these parts are not suitable for outdoor use as the colour and mechanical properties may degrade when exposed to UV light from the sun. The required support structures can also leave blemishes that need post processing to remove.

The Advantages of 3D Food Printing

With 3D printers now becoming more affordable for the average consumer, 3D food printing stands to gain a lot from this newfound interest in the technology. Food printing manufacturers are already lauding the capability of 3D food printers to boost culinary creativity, nutritional and ingredient customizability, and food sustainability. Some of advantages of 3D food printing include -

- **Saving Time and Effort:** 3D printing food can save both time and energy when it comes to experimenting with cocktail garnishes or chocolate/sugar cake toppers.
- **Innovation in Healthy Food:** Today, 3D printing has gone beyond the kitchen. Chloé Rutzerveld, a Dutch food designer has used food printers to create cracker-like yeast structures that include spores and seeds that sprout with time. He feels that snacks like this and other such natural and transportable products will transform the food industry someday.
- **Food Sustainability:** 3D Food Printing has the ability to supply an ever-growing world population as compared to traditional food manufacturing systems. At the same time, food printers could also minimize waste with the use of hydrocolloid cartridges that form gels when combined with water. Even rarely used ingredients like duckweed, grass, insects or algae can be used to form the basis of familiar dishes.
- **Personalized Reproducible Nutrition:** Since 3D food printers follow digital instructions, the idea of being able to make personalized food containing the correct percentage of nutrients for a particular age or gender does not seem so far off. Food printers can easily help determine the exact quantity of vitamins, carbohydrates and fatty acids as per the input, without any hard work

Food Innovation - Current Applications of 3D Printing

While 3D Systems ChefJet uses crystallized fine-grain sugar for perfect geometric configurations and high-throughput confectionary, there are other companies who prefer using syringes to dispense chocolate into beautiful patterns. Yet another company - Foodini, is using edible ingredients squeezed out of stainless steel capsules to create a wide range of dishes from sweet to savory. A German nursing home, uses a 3D printer to create a food product called Smoothfoods, which is a concoction of mashed peas, carrot and broccoli. This tasty dish is then congealed with edible glue and served to elderly residents who face difficulties in chewing. This has been a huge hit, with over 1,000 such facilities in Germany adopting the technology.

At the Consumer Electronics Show (CES) held in Las Vegas in 2014, the CIA Culinary Institute of America made a partnership with 3D Systems, the inventor of the ChefJet for beta testing their 3D food printers. The CIA plans on using 3D food printing in their internship and fellowship programs. The CIA feels that 3D printing is a boon where ideas can come to life and lot of time too can be saved in the process.

The Road Ahead - The Future of 3D Printing in the Food Industry

At present, 3D printers may not be producing great-tasting food or expertly cooking up elaborate meals from scratch. But they have the ability to do so and are getting better at their promise of better sustainability and nutrition.

Anjan Contractor, an engineer, is working on the development of a pizza-making printer. He hopes his machine can produce food from capsules of oils and powders which have a shelf life of 30 years! Such a machine would not only minimize the environmental impact of cooking, but also present a renewable form of sustenance to a world where population is constantly growing.

Lynette Kucsma, CMO and co-founder of Natural Machines feels that 3D printing can also ensure better nutrition. For instance, a printer like Foodini can not only minimize the amount of chemical additives but also minimize overconsumption. Very soon, people would be waking up in the morning and asking their printers to print a breakfast that has the right amount of fat and protein.

At the same time, 3D printing, though advantageous, has to overcome several challenges, the main one being speed. Several of the common designs that food printers print today require the ingredients to be first cooled, before the application of the next layer, which leads to delay. Consumers as well, need time to get used to the idea of food printers, and not mix it with synthetic foods.

The road ahead for 3D food printing faces several other challenges. It might take some time, but just like every other technology, 3D food printers are getting better every year. The promise of sustainable, affordable nutrition is worth our pursuit, and with the food industry looking at 3D printing to solve its problems, we should soon see it become as mainstream as a microwave oven.

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ENDOPHYTIC AND RHIZOSPHERIC MICROB BASED BIOFORMULATIONS FOR PLANT DISEASE MANAGEMENT

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Introduction

For millions of years, microbes and plants have interacted with one another; this coexistence of diverse organisms is referred to as symbiosis (de Bary, 1866). The terms mutualism, commensalism, and parasitism can all be used to describe different types of interactions. The basis for these interactions is either reciprocal benefit (mutualism), microbial benefit that does not influence the host plant (commensalism), or detrimental effect on host fitness (pathogenic or parasitism). The host plant provides space and novel metabolic capabilities to its microbial associates, leading to the adaptation of niche-specific inhabitants that can either have positive (mutualistic), neutral (commensalism), or deleterious (pathogenic) impact on plant fitness (Thrall *et al.*, 2007). Using endophytic and rhizospheric microbes as biocontrol and/or biofertilizer agents in various crops have become more and more interesting in organic farming due to their richness in bioactive natural products.

They have been reported to possess the potential to produce an array of bioactive metabolites with antifungal properties which enable the host plants to meet possible challenges generated by phytopathogenic fungi. So, the identification of the chemical basis of the antimicrobial property of endophytes can have immense applications to explore them as biocontrol agents to prevent plant diseases in an eco-friendly manner. Endophytes and rhizospheric microbes modulate the plant immune system as they interact with the host. Endophytes to enter the host plant have to pass through the first line of defense of the plant immune system thus inducing systemic resistance (ISR) against phytopathogens in plants (Kloepper and Ryu, 2006) and pre-activation/priming of molecular mechanisms of defence against a broad range of pathogens. Induction of plant gene expression in the presence of endophytes provides clues about their effects on the host plant (Berendsen *et al*., 2015). The modern "omics"- based approaches including genome sequencing, comparative genomics, microarray, next-generation sequencing (NGS), metagenomics, and meta-transcriptomics may provide in-depth detail on endophytic lifestyle in planta.

Recent advancement made in microbial biotechnological tools has helped in understanding the microbial diversity, functional attributes, metabolic route, and genetic potential of soil microbes, and therefore the development and commercialization of efficacious microbial products (bio stimulants, biopesticides, and biofertilizers) with improved crop yield and adaptation against ongoing climatic changes (Umesha *et al*., 2018). Generally, microbes associated with plant systems enhance growth through multiple biochemical pathways (categorized as direct or indirect mechanisms) that may include manipulating the plant's hormonal signalling, nutrient release, and uptake, amelioration of abiotic stresses, preventing the pathogenic challenge (Jacoby *et al*., 2017; Kumar *et al*., 2016a, 2016b, 2018; Mendes *et al*., 2013; Van der Heijden *et al*., 2008; Verbon and Liberman, 2016)

Concept of bioformulation

Biopesticides have been incredibly popular over the past 20 years as a result of systematic, large-scale research that has increased their efficacy. Several organizations have set up a number of bioformulation production units to fulfil the market's demand for biopesticides. Currently, India has about 140 well-equipped biopesticide production units, yet only 1% of the country's total cropped area could be met by them. The only way to close the large gap between supply and demand is to establish an increasing number of biopesticide production facilities. In this aspect, well-planned investment, private participation, and promotion of entrepreneurship may be required. So, there is a scope to enhance the production and use of biological control agents in the days to come as the demand is on the increase every year.

In recent years, a good number of improvised techniques have been developed especially for the mass production, storage, transport, and application of bioformulations. Three basic methods are usually employed to manufacture microbial bioagent-based bioformulations *viz.*, solid fermentation, liquid fermentation, and deep tank fermentation technology. Microbial bioagent-based bioformulations are commonly produced following three basic methods *viz.* solid fermentation, liquid fermentation, and deep tank fermentation technology. Among these, liquid and solid fermentation is an easy, popular, and widely followed mass multiplication technology ideal for small-scale production units.

Bioformulation is defined as any biologically active substances derived from microbial biomass or product containing microbes and their metabolites that could be used in plant growth promotion, nutrient acquisition, and disease control in an eco-friendly manner. Bioformulation is a mixture of an active ingredient in a formulated product made with inert (inactive) substances. Bio-formulated products offer green alternatives to conventionally used chemical fertilizers and pesticides for plant growth promotion, suppression of phytopathogens, maintaining the fertility of the soil, and disease suppression (Arora and Mishra, 2016). The bioformulation constitutes the preparation(s) of microbes or their active gradient that could be utilized as substitutes for chemical pesticides/fertilizer. However, an actual bio formulated product must contain an active ingredient and be comprised of living microbe, spores, or their products, and must be living for successful development of formulation. The most common inert active substances include peat, talc, vermiculite, carboxymethylcellulose, and polymers specially xantham gum and diatomaceous earth.

The inert carrier-based bioformulations have been found useful for incorporating the antagonistic microbial cells in both the rhizospheric region and plant system for a longer duration and could be applied through both foliar and soil application. Additionally, one more added advantage of such carrier-based bioformulations is the stability of the adduct, including antibiotics, siderophores, and phytohormones, volatile metabolites hydrolyzing enzymes in contact with the plant (Ardakani *et al.,* 2010; Jorjani *et al*., 2011). Generally, microbial species employed for bioformulated products contain beneficial rhizospheric microbes that affect plant growth and development either directly or indirectly in their natural environment (Lugtenberg and Kamilova, 2009). Microbial inoculants are formulations that contain specific beneficial microorganisms, such as bacteria, fungi, or viruses, which are applied to plants, seeds, or soil to enhance plant growth, nutrient uptake, and disease resistance. When it comes to plant disease management, microbial inoculants can play a significant role. Here are some examples of microbes commonly used as microbial bioformulations for plant disease management:

i. *Trichoderma* species are widely used as biocontrol agents in microbial inoculants. They can suppress a variety of plant pathogens, including fungal diseases like root rot, damping-off, and wilt. *Trichoderma* species can colonize plant roots, compete with pathogens for nutrients, produce antifungal compounds, and induce plant defense mechanisms.

ii. Several species of *Bacillus*, such as *Bacillus subtilis* and *Bacillus amyloliquefaciens* are most commonly used as microbial inoculants. These bacteria can produce antimicrobial compounds and activate plant defense responses, making them effective against various fungal and bacterial diseases. They can protect plants from pathogens that cause diseases like damping-off, powdery mildew, and bacterial blight.

iii. Certain strains of *Pseudomonas*, such as *Pseudomonas fluorescens* and *Pseudomonas putida*, are beneficial bacteria commonly used in microbial inoculants. They can suppress plant diseases caused by fungal, bacterial, and nematode pathogens. *Pseudomonas* spp. produce antifungal metabolites, compete for nutrients and space, and stimulate the plant's immune system.

iv. Rhizobium species are commonly used as inoculants for leguminous crops to promote nitrogen fixation. Besides nitrogen fixation, some strains of Rhizobium have been found to provide plant disease management benefits. They can induce systemic resistance in plants and suppress certain soil-borne pathogens.

v. Arbuscular mycorrhizal fungi (AMF) are beneficial fungi that form symbiotic associations with plant roots. They enhance nutrient uptake, improve soil structure, and promote plant growth. AMF can also provide disease suppression benefits by inducing plant defenses, competing with pathogens, and improving the overall health of the plant.

These are just a few examples of beneficial microbes used as microbial inoculants for plant disease management. Depending on the specific crops and diseases targeted, different combinations of beneficial microorganisms may be used to create effective microbial inoculant formulations. It's important to note that the efficacy of microbial inoculants can vary depending on factors such as environmental conditions, crop management practices, and the specific pathogen being targeted. Proper application methods and timing, as well as regular monitoring, are essential for maximizing the benefits of microbial inoculants in disease management.

Microbial bio agents for Bioformulation

Biocontrol or biological control represents the reduction of inoculum density or diseases caused by pathogen or parasite in its active or dormant state, by one or more organisms accomplished naturally or through manipulation of environment, host or antagonist, or by mass introduction of one or more antagonists. Bioformulation based on biocontrol agents has been standardized, and mass multiplied in the form of biopesticides. The PGPR-based bioformulations including Biofor PF-2 (Jaiva Kiran), Bioveer, Biozium, Biozin-PTB (Jaiva Kiran-2), Biozin-PTB, and talc-based biopesticide containing three aggressive strains of antagonists such as *Pseudomonas fluorescence*, *Trichoderma harzianum*, and *Bacillus subtillis* with standard adhesive and osmoticant have been developed by Programme on Biopesticides, DBT-NECAB, Assam Agricultural University, Jorhat, Assam, India (http://dbtaau.ac.in/coordinator_pesticide.html).

The biocontrol formulation has been tested and found efficient in the biological control of wilt of ginger, wilt diseases of tomato, chilli, and controls rhizome rot, and also effective against damping off, foot root, root rot, and wilt diseases of pepper, cabbage, and French bean. Similarly, Biofor PF-2 which contains beneficial microbes *P. fluorescence* and *T. harzianum* increases soil nutrients, rejuvenates soil, enhanced plant growth, and combat soil-borne disease (Kumar *et al*., 2017a, b). Met52 is a bioinsecticide, containing spores of the soil fungus *Metarhizium anisopliae*. Taegro is a bacterial-based bio fungicide/bactericide used for suppressing selected soil-borne and foliar diseases (Mehnaz, 2016). Besides this, some of the most common biopesticides under the registration process include TrichoderMax, containing spores of *T. asperellum*. Some biopesticides such as Biollium, Biosona, and Biometa have been developed using microbial consortia, involving plant growth promoting microbe and entomopathogens, namely, *B. thuringiensis*, *M. anisopliae*, *B. bassiana*, and *Verticillium lecanii*.

However, the success of biostimulant or bioformulated products depends on the potency of microbial strains utilized and their mode and method of formulation used. Bioformulations that consist of a combination of PGPRs including *P. flourescences* Pf1, *Bacillus subtilis* Bs10, and biocontrol fungus *T. viridae* (Tv1) were found to be effective in reducing the incidence of peduncle blight under greenhouse conditions (85.50%) (Durgadevi *et al.*, 2018). Among the fungal bioinoculants, most of the registered bioformulated products employ species of *T.*

harzianum, *T. asperellum*, *T. gamsii*, *Coniothyrium minitans*, *Aspergillus flavus*, and *Chondrostereum purpureum* (Auld, 2002)

Formulation and application methods

1. Solid Bioformulation: Basically, the two most common types of bioformulations used are liquids and solids (Burges and Jones, 1998). However, modifications of these two types are frequently used nowadays all over the world. The most common type of solid bioformulations used includes granules (GR), micro granules (MG), wettable powders (WPs), water dispersible granules (WDG), and dusts (Abadias *et al.*, 2005; Guijarro *et al.*, 2007a; Larena *et al.*, 2003). Granular bioformulations include dry particles with active ingredient, carrier, and binder. Based on particle size coarse particles (100–100 µm) and MG (100–600 µm) bioformulated products are used. The concentration of active gradients in GR is 5%–20% (Brar *et al.*, 2006). The most commonly used substrates for GR formation include cornmeal baits, wheat GR (Navon, 2000), GR formed with gelatinized cornstarch or flour (Tamez-Guerra *et al.*, 1996), gluten (Behle *et al.*, 1997), cottonseed flour and sugars (Ridgway *et al.*, 1996), sodium alginate (Guijarro *et al.*, 2007b), gelatin or acacia gum (Maldonado *et al.*, 2002) and diatomaceous earth (Batta, 2008). The wheat-based granular bioformulation of deleterious rhizobacterium *Pseudomonas trivialis* X33d (Mejri *et al.*, 2013) and granular formulation of *Serratia entomophila* (sold under the trade name BioShield) has been reported (Young *et al.*, 2010).

Apart from GR-based formulation WPs have prolonged shelf life and generally contain 50%–80% technical powder, 15%–45% filler, 1%– 10% dispersant, and 3%–5% surfactant by weight (Brar *et al.*, 2006). Some of the most common commercialized *Trichoderma* bioformulations are good examples of WPs (Woo *et al.*, 2014). In contrast, dust-type bioformulated products have a very finely ground mixture of the active ingredient (usually 10%) with particle sizes ranging from 50 to 100 µm. The bioformulated dust containing nonpathogenic *F. oxysporum* is sold under the trade name Biofox C and used in the biocontrol of tomato, basil, carnation, and cyclamen (Kaur *et al.*, 2011).

2. Liquid formulations

Liquid formulations are aqueous suspensions formed in either water, oil, or an emulsion of the two (Schisler *et al.*, 2004). 10%–40% microbe, 35%–65% carrier liquid (oil or water), 3%–8% surfactant, 1%–3% suspender, and 1%–5% dispersion are the typical ingredients in an aqueous formulation. Suspension concentrates (SCs), oil miscible flowable concentrate (OF), ultralow volume (ULV) suspension (SU), and oil dispersion (OD) are the four different liquid formulations that are offered. The hydrolysis of a solid active component with the least water solubility and stability among all of these SCs is used to create them (Tadros, 2013). OF is a stable suspension of active ingredient(s) in a fluid intended for dilution in an organic liquid before use (Singh and Merchant, 2012). ULV SU is prepared formulations delivered through ULV equipment in the form of an extremely fine spray (Singh and Merchant, 2012). In contrast, OD is a stable suspension of active ingredient(s) in a water-immiscible solvent or oil (Michereff *et al.*, 2009). Recently, spores of *T. asperellum* bioformulated on soybean oil-based carrier as OD was used to control cacao black pod disease. Many other *Trichoderma*-based liquid formulations are currently available and used in biocontrol (Woo *et al.*, 2014). It has been reported that oil-based bioformulations delivered in the form of foliar spray are useful and effective in enhancing the activity of entomopathogens (Feng *et al.*, 2004).

Conclusion

From the point of successful marketing, the bioformulated product is not effective until it does not have a good impact on field condition, reliability, and cost-effectiveness. The entire bioformulation process depends on a variety of factors that affect the success of the formulated products, such as formulation type, fermentation processes, microbial population, and delivery system, in addition to the microbes used, their potential applications, functional diversity, physiological attributes, and response mechanism. It has been found that during fermentation processes several factors including media employed in production processes, oxygen transfer, concentration of constituents, incubation temperature, harvesting time and treatment done after harvesting all determine and affect the formulation development. Apart from fermentation processes, microbial delivery is an important factor that greatly influences the bioformulation market as the microbial delivery system defines the utility of the bio formulated products, as the sustainability of the product is highly dependent on the delivery system. At present, for the successful development of bioformulation we need to exploit the microbial machinery at its full potential and the molecular mechanism involved in regulating their genetic flexibility in diverse environments with the collective effort of both microbiological and biotechnological aspects. Besides this, we need to investigate and reevaluate the entire bioformulation process at every step to make it more convenient, reliable, and productive, and plugging of the loopholes

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THE ROLE AND THERAPEUTIC APPLICATIONS OF INTERLEUKIN-2 (IL-2) IN IMMUNE REGULATION AND TREATMENT STRATEGIES

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Introduction

Interleukin-2 (IL-2) is a type of cytokine, a category of signaling molecules critical to the immune system, primarily produced by activated T-cells. Identified by Morgan et al., 1976 [1], IL-2 plays a vital role in regulating the immune response. It is essential for the growth, proliferation, and differentiation of T-cells, particularly regulatory T-cells (Tregs) and cytotoxic T-cells, aiding their expansion in response to antigens [2]. IL-2 also enhances the activity of natural killer (NK) cells, which are crucial in the innate immune response against virally infected cells and tumors [3]. Additionally, IL-2 is crucial for maintaining immune tolerance by supporting Tregs, which prevent autoimmune diseases by suppressing overactive immune responses [4].

Structurally, IL-2 is a protein composed of a single polypeptide chain of 133 amino acids in humans, with its specific sequence dictating its folding and functional properties. Its secondary structure includes several alpha-helices, whose arrangement and connecting loops are crucial for its biological activity and receptor interaction. The tertiary structure, revealed by X-ray crystallography, shows a compact globular protein stabilized by these alpha-helices, essential for its interaction with the IL-2 receptor [5]. While IL-2 does not typically form a quaternary structure on its own, it binds to the IL-2 receptor subunits (IL-2Rα, IL-2Rβ, and IL-2Rγ) to form a functional complex necessary for signaling, thereby mediating its diverse biological effects [6].

Receptor Binding

Interleukin-2 (IL-2) exerts its effects by binding to the high-affinity IL-2 receptor, a heterotrimer composed of IL-2Rα (CD25), IL-2Rβ (CD122), and IL-2Rγ (CD132, the common gamma chain). This interaction induces a conformational change that triggers downstream signaling pathways involved in T-cell proliferation, differentiation, and immune regulation. The IL-2 molecule itself is a compact globular protein, consisting of 133 amino acids forming several alpha-helices, essential for its interaction with the IL-2 receptor and subsequent immune signaling. These receptors are crucial for mediating the biological activities of IL-2, making them vital components in the regulation of the immune system [7].

Composition of IL-2 Receptors

IL-2 receptors are composed of three distinct subunits, each with specific roles in binding IL-2 and transducing its signal. The IL-2Rα (CD25) subunit, a 55 kDa glycoprotein, binds IL-2 with low affinity on its own and primarily increases the binding affinity of the entire receptor complex. CD25 is expressed on activated T-cells, regulatory T-cells (Tregs), and other immune cells. The IL-2Rβ (CD122) subunit, a 75 kDa glycoprotein, is responsible for intermediate affinity binding to IL-2 and, in conjunction with IL-2Rγ, is crucial for signal transduction. CD122 is found on activated T-cells, natural killer (NK) cells, and some other leukocytes. The IL-2Rγ (CD132) subunit, also known as the common gamma chain, is a 64 kDa protein shared by several cytokine receptors, such as those for IL-4, IL-7, IL-9, IL-15, and IL-21. CD132 is essential for high-affinity binding and signal transduction through the receptor complex and is widely expressed on various immune cells. Together, these subunits form the IL-2 receptor complexes that mediate the diverse biological effects of IL-2 [8].

Forms of IL-2 Receptors

IL-2 receptors exist in three distinct forms, each characterized by different combinations of subunits that determine their affinity for IL-2 and their ability to signal. The low-affinity receptor consists solely of the IL-2Rα subunit and binds IL-2 with low affinity, but this form does not transduce signals. The intermediate-affinity receptor is composed of the IL-2Rβ and IL-2Rγ subunits, which bind IL-2 with intermediate affinity and are capable of signal transduction. The high-affinity receptor, which includes all three subunits (IL-2Rα, IL-2Rβ, and IL-2Rγ), binds IL-2 with high affinity and effectively transduces signals essential for various biological functions, including cell proliferation, differentiation, and survival [9].

Signal Transduction

When IL-2 binds to its high-affinity receptor, which includes IL-2Rα, IL-2Rβ, and IL-2Rγ subunits, it triggers a cascade of intracellular signaling pathways critical for immune cell function. This binding activates the JAK-STAT pathway, where Janus kinase (JAK) phosphorylates the signal transducer and activator of transcription (STAT), leading to the transcription of genes involved in cell proliferation and survival. Additionally, the MAPK pathway is activated, regulating gene expression and cell division. Furthermore, the PI3K-AKT pathway is engaged, promoting cell survival and growth through the activation of phosphoinositide 3-kinase (PI3K) and subsequent signaling by AKT. These pathways collectively ensure proper immune responses, cell growth, and survival.

Therapeutic applications

Interleukin-2 (IL-2) is a cytokine that plays a crucial role in the immune system, primarily in the activation and proliferation of T cells. Its therapeutic applications have been extensively studied, particularly in oncology and immunology. Here are some key therapeutic applications of IL-2 [10].

1. Cancer Therapy

IL-2 has been used in the treatment of various types of cancer, particularly metastatic renal cell carcinoma (RCC) and metastatic melanoma, due to its role in stimulating the immune system to attack cancer cells, making it a valuable treatment option in immunotherapy. High-dose IL-2 is approved by the FDA for treating metastatic RCC and metastatic melanoma, capable of inducing durable complete responses in a subset of patients, though its use is limited by significant toxicities [11]. Additionally, IL-2 is often used in combination with other immunotherapeutic agents, such as immune checkpoint inhibitors (e.g., anti-PD-1/PD-L1 or CTLA-4 antibodies), to enhance anti-tumor responses [12].

2. Adoptive Cell Transfer (ACT)

IL-2 is crucial in the expansion and persistence of T cells used in adoptive cell transfer therapies, such as Chimeric Antigen Receptor (CAR) T-cell therapy [13], where it is used to expand CAR T cells ex vivo before infusion into patients to target cancer cells, and in Tumor-infiltrating lymphocytes (TILs) therapy, where IL-2 supports the growth of TILs extracted from tumors and re-infused into patients [14].

3. Autoimmune Diseases

While high-dose IL-2 can be toxic, low-dose IL-2 has immunomodulatory effects beneficial in autoimmune conditions, selectively expanding regulatory T cells (Tregs) to maintain immune tolerance and reduce autoimmune responses, showing promise in conditions such as type 1 diabetes, systemic lupus erythematosus (SLE), and graft-versus-host disease (GVHD) following bone marrow transplantation.

4. Infectious Diseases

IL-2 has been investigated as a potential therapy to enhance immune responses against chronic viral infections, including HIV/AIDS, where clinical trials did not show significant benefits in terms of viral suppression and overall survival, and ongoing research is evaluating its potential in chronic hepatitis B and C infections.

5. Vaccination Adjuvant

IL-2 can be used as an adjuvant to improve the efficacy of vaccines by enhancing the immune response to the vaccine antigen.

Challenges

While IL-2 holds significant therapeutic promise, high-dose IL-2 therapy can cause severe side effects, such as capillary leak syndrome, fever, malaise, and immune reactions, necessitating careful dosing and monitoring. Additionally, there is a risk of overstimulating the immune system, potentially leading to autoimmune diseases. Current efforts focus on developing IL-2 variants or fusion proteins that selectively target specific immune cell subsets to reduce side effects. The variability in IL-2 therapy responses across different species further complicates treatment, highlighting the need for species-specific studies and formulations to ensure efficacy and safety (Poust 2013).

Commercially available formulations

Approved IL-2 agonists and antagonists have been developed to modulate the immune response for therapeutic purposes. IL-2 agonists, such as Proleukin (aldesleukin), are recombinant forms of IL-2 used to boost the immune system, particularly in the treatment of certain cancers like metastatic renal cell carcinoma and metastatic melanoma [15]. On the other hand, IL-2 antagonists, such as basiliximab and daclizumab, are monoclonal antibodies that inhibit IL-2 signaling. These antagonists are primarily used to prevent organ rejection in transplant patients by dampening the immune response [16]. Both types of agents play crucial roles in manipulating the immune system to treat various conditions, highlighting the therapeutic versatility of targeting the IL-2 pathway.

Current Research and Future Directions

Innovative approaches are revolutionizing the delivery and efficacy of IL-2 treatments, especially through advancements in gene editing and biotechnology. These technologies allow for more precise and targeted delivery systems, potentially increasing the effectiveness of IL-2 therapies. Furthermore, the rise of personalized medicine, which adapts treatments to the genetic and immunological profiles of individual animals, is set to enhance therapeutic outcomes and minimize side effects. By leveraging these cutting-edge techniques, veterinary medicine can offer more tailored and effective care, leading to improved overall animal health and treatment success rates.

Conclusion

In conclusion, Interleukin-2 (IL-2) is a crucial cytokine for immune system regulation, notably in T-cell and NK cell functions. Despite its therapeutic potential in cancer and autoimmune diseases, IL-2's clinical use is limited by severe side effects and autoimmune risks. Advances in gene editing, biotechnology, and personalized medicine are enhancing IL-2 therapy's precision and effectiveness, with efforts focused on developing IL-2 variants and fusion proteins to minimize side effects. The availability of IL-2 agonists like Proleukin and antagonists such as basiliximab highlights its therapeutic versatility. Continued research and innovative delivery methods are essential for optimizing IL-2 treatments in human and veterinary medicine, promising improved outcomes and safety.

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OCCURRENCE OF PREDATORY COCCINELLID BEETLES IN MULBERRY ECOSYSTEM UNDER THE SUB-TROPICAL CONDITIONS OF NORTH-WESTERN INDIA, UTTARAKHAND

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Introduction

Sericulture is practiced in about 761 villages of Uttarakhand out of about 16,000 villages. About 10,500 families are engaged in different facets of the silk industry (Yadhav *et al.*, 2018). This state is generally referred as "Bowl of Bivoltine silk of India". Earlier, sericulture activity was mainly taken on mulberry bush plantation throughout the country including Uttarakhand. In the recent years, mulberry sericulture has been transformed from a subsistence type to a modern scientific enterprise in most of the traditional as well non-traditional states.

Mulberry, *Morus* spp., is the sole food for the silk producing insect, mulberry silkworm, *Bombyx mori* L. which is enriched with all the nutrients required for the growth and development of silkworm thereby yielding good quality cocoons. Hence, it is prone to attack by number of pests which causes drastic reduction in leaf yield and deterioration in quality (Sakthivel *et al.*, 2019). Chemical control is the commonly practiced management strategy among sericulture farmers. However, application of insecticide with high toxicity and prolonged residual effects in mulberry garden is restricted because of their hazardous effect on silkworms (Sakthivel *et al.*, 2014). Non-stranded or improper use of pesticides often causes poisoning incidents of silkworm, which is a serious threat to the development of sericulture industry (Jun *et al.*, 2016).

Hence, the best method of management is through conservation of existing natural enemies in the environment as they are highly adapted to the environment against the target pest. Conservation strategy is simple and cost-effective by providing nectar and pollen producing plants adjacent to the habitat. Crop diversification will provide alternate non-prey foods such as pollen, nectar and honeydew to the adult stages of the parasitoids and predators. They may also serve as a shelter to the overwintering stages and also protect the parasitoids and predators at times of adverse weather and insecticidal sprays (Landis *et al.*, 2000; Gurr *et al.*, 2003). The present preliminary study the deals with occurrence of predatory beetles in mulberry ecosystem under sub-tropical conditions for conservation.

Occurrence of predatory beetles in Sub-tropical condition

Uttarakhand is the 27th state of the country carved out of Uttar Pradesh in November' 2000. It is situated in the western sub-latitude belt of the country between 28°43' and 31°28' north latitude and 77°35' and 81°02' east longitude. This Himalayan state has a long tradition and history of silk production. The following predatory beetles were recorded at Regional Sericultural Research Station, Sahaspur, Dehradun, Uttarakhand.

1. Seven –spotted ladybug - *Coccinella septempunctata* (Linnaeus, 1758)

Classification: *Coccinella septempunctata* belongs to the subfamily Coccinellinae, tribe Coccinellini.

Distribution: Europe, Asia, North America.

Habitat: Meadows, fields, steppes, gardens, parks, deciduous and mixed forests.

Description: The 5.2 - 8 mm large Seven-spot Ladybird *C. septempunctata* has red elytra with seven (small) black spots and a bulge at the side edge of the elytra. At the inner eye edges of the black head there are 2 white spots. The pronotum is black, with white side spots on the front corners. The white side spots of the pronotum overlap only as narrow seam to 1/3 to the back of the underside. The legs are black.

Biology: After mating, the females of Coccinella septempunctata lay their eggs in batches of about 10 to 50 pieces on the underside of the leaves of plants infested with aphids. The most important food source of the larvae are aphids, of which a single larva eats more than 400 in the course of its development. In addition to aphids, thrips (Thysanoptera), whiteflies (Aleyrodidae), larvae of psyllids (Psyllidae) and leafhoppers (Cicadellidae) and eggs and larvae of some beetle and butterfly species are eaten. Occasionally, cannibalism occurs among conspecifics. The larvae pass through 4 larval stages until pupation. The development time from egg to adult beetle in Central Europe is about 40 days. It is influenced by environmental conditions such as temperature and food supply. The Seven-spot Ladybird hibernates as an adult in the litter, under tree bark and in other protected places. *C. septempunctata* forms one, sometimes also a partial 2nd generation in Central Europe and 2 generations in Southern Europe.

Prey: The adults of the Seven-spot Ladybird have very few natural enemies. In the event of a threat, toxic secretions from the glands between the femora and tibia can be released by the beetles (reflex bleeding). These secretions are toxic to many predators, such as birds and small mammals. The high-contrast colouring of the beetles is an indication of toxinity and helps to deter predators. Other enemies of *C. septempunctata* are parasitic wasps of the families Eulophidae (Chalcidoidea) and Braconidae, e.g. *Dinocampus coccinellae*.

Figure 1. ***Coccinella septempunctata*** **(From left side pupal stage and adult)**

2. *Parexochomus nigripennis* (Erichson, 1843)

Classification: *Parexochomus nigripennis* belongs to the subfamily Chilocorinae, tribe Chilocorini.

Distribution: Iberian Peninsula, Sicily, Malta, Canary Islands, Afrotropical region, Near East.

Biology: 3.8–4.2 mm; body oval and highly convex; elytra black, without metallic shine; lateral margin of elytra strongly edged, finely dotted; pronotum yellow/red.

Prey: The species feeds on hemipterans of different families, such as *Acanthococcus abaii* (Eriococcidae), *Agonoscena pistaciae* (Psyllidae), *Bemisia tabaci* (Aleyrodidae) and mealybugs (Pseudococcidae).

Figure 2. ***Parexochomus nigripennis***

3. Transverse ladybird beetle - *Coccinella transversalis* (Fabricius, 1781)

Coccinella transversalis, commonly known as the transverse ladybird or transverse lady beetle is a species of ladybird beetle found from India across southern and southeastern Asia to Malesia and Australia. It is not to be confused with *C. transversoguttata*, a widespread species in Europe and North America also known as the transverse ladybird. The alternative vernacular of small transverse ladybird may be used for *C. transversalis* in instances where these two species are discussed together.

Description: Measuring 3.8 to 6.7 millimetres (0.15 to 0.26 in) long and 3.3 to 5.45 millimetres (0.130 to 0.215 in) wide, the transverse ladybird shows little variation across its wide range. It has a black head with predominantly bright red or orange elytra boldly marked with a black band down the midline and two lateral three-lobed markings.

Prey: Like many species of ladybirds, the transverse ladybird plays an important role in agriculture as it preys on a wide array of plant-eating insects which damage crops, particularly early in the growing season. Among those insects hunted include many species of aphids, species of leafhopper, the scale insect species, the Asian citrus psyllid, the cotton bollworm, and oriental leaf worm moth.

Figure 3. *Coccinella transversalis* (From left side larva, pupa and adult)

4. Six-spotted zigzag ladybird - *Cheilomenes sexmaculata* (Fabricius, 1781)

Cheilomenes sexmaculata is a species of ladybird. Although sometimes known by the common name of six-spotted zigzag ladybird, this is misleading as there are several colour morphs and some colour morphs of the species can be confused with *Micraspis discolor* and *Chilocorus nigrita*. The species has a wide distribution range within the Asian tropics and subtropical zones from India to Japan and parts of the Australian region. They have been introduced into the Caribbean islands as a biocontrol agent and their spread to South America was noted in 2019. It is well known as a predator of aphids and other small insects.

Description: This small beetle is about 3 to 4 mm in body length. Body color varies from yellow to canary yellow. Elytra black.

Prey: It is a voracious predator on several whiteflies and aphids such as *Aphis gossypii*, *Myzus persicae*, *Aphis craccivora*, Amrasca, Empoasca and Leptocentrus. In addition to them, it feeds on a wide prey range including, scale insects, and diaspids.

Figure 4. *Cheilomenes sexmaculata*

Conclusion

The occurrence of predatory beetles may be due to the undisturbed nature of the eco system and continuous availability of pollen through diversified crops. Predators with diversified prey will help in sustaining their population thus aiding in biological pest suppression. In addition to that, Conservation of species diversity is advocated to effectively utilize the strength of native predators for bio control in mulberry gardens.

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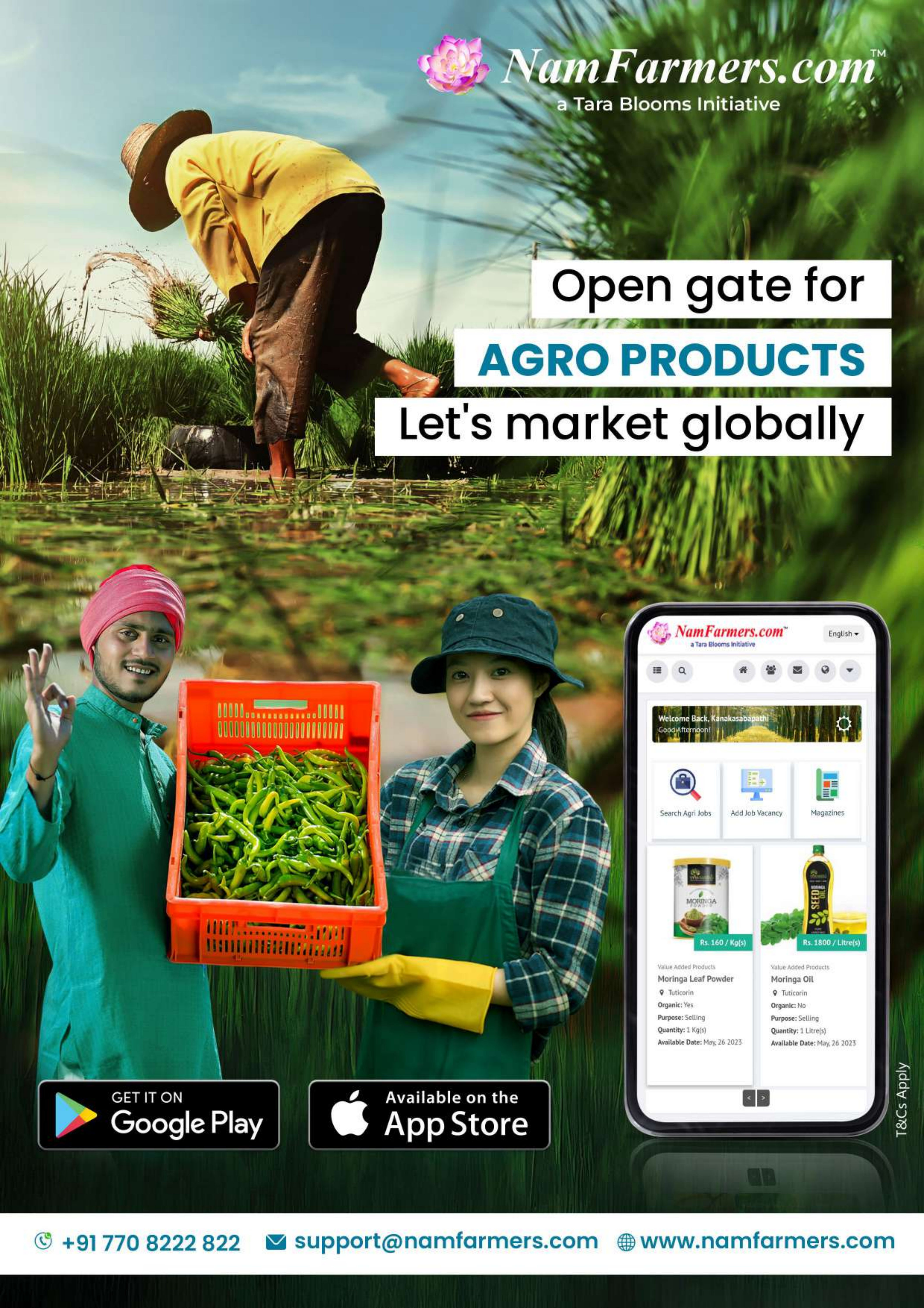
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