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AgriGate

GROW WITH EVERY PAGE!

An International Multidisciplinary Monthly e-Magazine

The rice that needs no cooking

Karimnagar farmer grows this magic rice variety from Assam

THIRUNAGIRI VENKATESHWARA SWAMY

KARIMNAGAR: As the price of domestic gas is increasing day-by-day, here is the good news for those who wish to save money and energy. A young and aspiring farmer, Garla Srikanth replicated cultivation of magic rice known as 'Boka saul' which does not require any kind of cooking. Just soak it in hot water for 15 minutes and enjoy its flavour. Boka saul – is an indigenous variety of rice produced exclusively in lower regions of Assam in Nalbari, Barpeta, Goalpara, Kamrup, Darrang, Dhubri, Chirang, Bongaigaon, Kokrajhar and Baksa areas. It is the latest product from Assam to get the Geographical Indication tag, commonly called the GI tag. First sown by June end, this special variety of Assamese rice is often referred to as 'magic rice'. It requires no cooking, unlike every other variety of rice. This unique variety of Assamese rice is very simple, and equally budget-friendly, to "cook".

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Karanj cake

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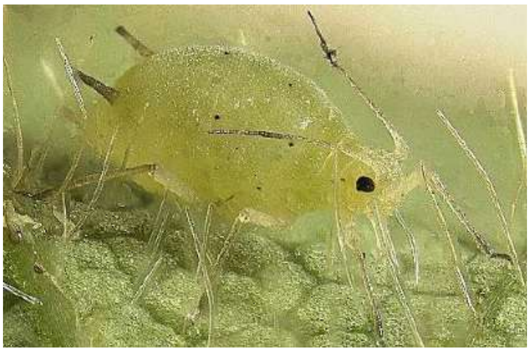

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From the Desk of Editor-in-chief

September 2024| Vol. 04 | Issue 09

I would like to introduce the launch of **"AgriGate - An International Multidisciplinary Monthly e-Magazine Volume 04 Issue No. 09 – September 2024"** with immense pleasure. Our team is privileged to dedicate this issue to the Teachers of our nation. **Teachers' Day in India** is celebrated on 5 September every year to mark the birth anniversary of India's second President **Dr. Sarvapalli Radhakrishnan**. On this day we appreciate and acknowledge the efforts of teachers in making responsible individuals. During 1st to 7th September we observed **National Nutrition Week** to provide knowledge among people about the importance of nutrition and its importance for the human body, for better health.

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: 09

ROLE OF BIOSTIMULANTS IN PLANT GROWTH

Article ID: AG-VO4-I09-01

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Introduction

Biostimulants are materials, other than fertilizers, that promote plant growth when applied in low quantities. Any substance or microorganism applied to the plants in minimal quantities that aims at enhancing the nutrient efficiency, abiotic stress tolerance and crop quality traits regardless of its nutrient content. They are broad line substances between plant protection products and fertilizers. Biostimulant don't show direct action on plants and also called as metabolic enhancers (Fig 1). A biostimulant may be any substance or mixture of substances of natural origin or microorganism which improves the condition of crops without causing adverse side effects (Drobek and Cybulska, 2019).

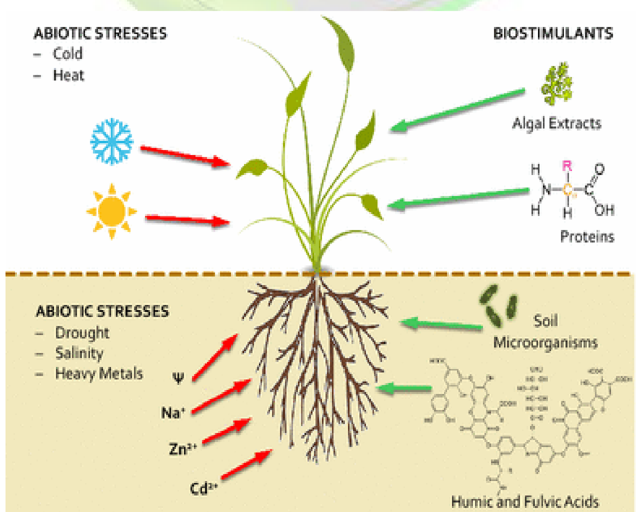

Fig 1. Uses of Biostimulants

Advantages of Biostimulants:

- ✓ Support the uptake of nutrients,
- ✓ Promote plant growth,
- ✓ Increase tolerance to abiotic stress.

Main categories of plant biostimulants:

- ❖ Seaweed extract and botanicals
- ❖ Humic acid and fulvic acid
- ❖ Protein hydrolysates and other N-containing compounds
- ❖ Chitosan and other biopolymers
- ❖ Inorganic compounds
- ❖ Beneficial fungi
- ❖ Beneficial bacteria

Seaweeds:

- ➢ Seaweeds are a diverse assemblage with close to 10,000 species of red, brown and green seaweeds.
- ➢ SWEs is a marine macro algae present in red, green, brown algae (10% marine productivity) SWE contain polysaccharides, laminarin, alginate, carrageenane and other constituents contributing growth promotion include micro and macro nutrients, sterols, N- containing compounds like betaines and hormones.
    - *Ascophyllum nodosum* - Brown algae
    - *Lithothamnium calcareum* - Red algae
    - *Ulva reticulate* - Green algae
- ➢ Polysaccrides in SWE contribute the soil to form gel, water retention and soil aeration. It helps for better germination.

Fig 2. Seaweed (Brown Algae)

Fig 3. Seaweed (Red Algae)

Fig 4. Seaweed (Green Algae)

- Poly-anionsfixes, exchanges cations and fixes heavy metals and for soil remediation. It provides positive effect along with an increase PGPR's in soil.
- The role of SWEs and cold tolerance is now emerging. Very recent work has focused on SWEs and their ability to enhance tolerance to chilling stress.

Humic and fulvic acids:

- ✓ Humic substances (HS) are natural constituents of the soil organic matter, resulting from the decomposition of plant, animal and microbial residues, but also from the metabolic activity of soil microbes.
- ✓ HS are collections of heterogeneous compounds, originally categorized according to their molecular weights and solubility into humins, humic acids and fulvic acids.
- ✓ Biostimulant effects of humic substances are characterized by both structural and physiological changes in roots and shoots related to nutrient uptake, assimilation and distribution (nutrient use efficiency traits).

Protein hydrolysates and other N-containing compounds:

- ❖ Protein hydrolysates (PHs) are a category of plant biostimulants defined as 'mixtures of polypeptides, oligopeptides and amino acids that are manufactured from protein sources using partial hydrolysis'.
- ❖ PHs are mainly produced by chemical (with strong acids or alkali) and enzymatic hydrolysis of proteins contained in agro-industrial by-products from animals (ie, leather, viscera, feathers, blood) or plant origin (ie, vegetable by-products) and in biomass of dedicated legume crops (ie, seeds, hay).
- ❖ PH application has been shown to avoid or reduce losses in production caused by unfavourable soil conditions and environmental stresses. These include thermal stress,

salinity, drought, alkalinity, and nutrient deficiency.

- PHs have been shown not only to improve plant nutrition but also the quality of fruits and vegetables in terms of phytochemicals (i.e., carotenoids, flavonoids, polyphenols).

The higher nutrient uptake in PH-treated plants has been attributed to

(1) An increase in soil microbial activity and soil enzymatic activities,
(2) Improvement of micronutrient mobility and solubility, in particular fe, zn, mn and cu.
(3) Modifications in the root architecture of plants, in particular root length, density and number of lateral roots.
(4) An increase in nitrate reductase, glutamine synthetase and fe-chelate reductase activities.

Beneficial bacteria:

Bacteria interact with plants in all possible ways:

- As for fungi there is a continuum between mutualism and parasitism.
- Bacterial niches extend from the soil to the interior of cells, with intermediate locations called the rhizosphere and the rhizoplane.
- Associations may be transient or permanent, some bacteria being even vertically transmitted via the seed.

Functions influencing plant life cover participation to the:

- ✓ Biogeochemical cycles,
- ✓ Supply of nutrients,
- ✓ Increase in nutrient use efficiency,
- ✓ Induction of disease resistance,
- ✓ Enhancement of abiotic stress tolerance,
- ✓ Modulation of morphogenesis by plant growth regulators.

Beneficial fungi:

- Fungi interact with plant roots in different ways, from mutualistic symbioses (*i.e.* when both organisms live in direct contact with each other and establish mutually beneficial relationships) to parasitism.
- Major limitations on their use are the technical difficulty to propagate AMF on a large scale, due to their biotrophic character.

Fungal-based products applied to plants to promote

- ✓ Nutrition efficiency,

- ✓ Tolerance to stress,
- ✓ Crop yield and
- ✓ Product quality

Chitosan and other biopolymers:

- ❖ Chitosan is not found abundantly in nature, but is produced from chitin, mostlyfrom crab shells, shrimp shells, squid pens and, in some cases, from filamentous fungi, *via* a heterogeneous deacetylation process.
- ❖ Chitinis normally deacetylated to remove over 80% of the acetyl groups from the *N*-acetyl-d-glucosamine residues, converting into d-glucosamine, to yield chitosan.
- ❖ The percentage of the *N*-acetyl-d-glucosamine residues converted to d-glucosamine in chitosan *via* this deacetylation process is normally referred to as the percentage degree of deacetylation (DD) of chitosan.
- ❖ The physiological effects of chitosan oligomers in plants are the results of the capacity of this polycationic compound to bind a wide range of cellular components, including DNA, plasma membrane and cell wall constituents, but also to bind specific receptors involved in defense gene activation, in a similar way as plant defense elicitors.
- ❖ Chitosan can induce resistance to abiotic stresses, including salt, drought and temperature stress.

Inorganic compounds

- ✓ Chemical elements that promote plant growth and may be essential to particular taxa but are not required by all plants are called beneficial elements.
- ✓ The five main beneficial elements are Al, Co, Na, Se and Si present in soils and in plants.

Conclusion

The use of biostimulants as environmentally safe and costless organic substances to encourage the productivity and quality of plants. The application of biostimulators can minimize the environmental pollution by reducing the synthetic fertilizers and chemicals which may lead to supply of safe and high quality vegetable to the market.

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Volume: 04 Issue No: 09

PEMPHERULUS AFFINIS : GALL INDUCING CURCULIONID IN COTTON

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Introduction

Pempheres affinis is a well-known destructive stem-boring weevil pest of cambodia cotton in South India. Area of distribution of the pest was restricted to Coimbatore and the indigenous varieties were free from the attack. As the cultivation of cambodia cotton extended to different parts the pest is also known to reported from Madurai, Ramanathapuram, Tirunelveli and Malabar. It also reported from Bihar, Dehra Dun, and Gujarat (Ayyar and Margabandhu, 1941). The spread of this weevil was associated with the conditions of optimum temperature and moisture, specially the later one. The incidence of this pest was noted on indigenous cottons in tracts situated near garden lands and infestation was heavy when they were grown under irrigation for experimental purpose. This clearly indicated that moisture seems to be the governing factor for incidence of the weevil (Ayyar and Margabandhu, 1941).

Economic importance

Originally it was a harmless native insect known to feed and breed on wild Tiliaceous and Malvaceous plants. Then it started to attack cotton occasionally, later more persistently. It also acquired a taste for country cottons gradually (Ayyar and Margabandhu, 1941). Stem weevil is not a serious threat in regular season cotton crop and only less than 10 % mortality of plants is observed. Of the economically important pest complex in cotton, next to bollworms, the cotton stem weevil has been reported as a major pest in South India (Murugesan, 1988). In the recent years, farmers are growing cotton during the off-season i.e., during winter season in summer irrigated cotton tract in southern Tamil Nadu. Similarly, farmers of winter cotton tract going for an additional summer crop. This resulted in more than 60 per cent mortality of cotton plants becoming menace to cotton growers (Murugesan *et al*., 2010). *P. affinis* has been reported as a major pest of Cambodia cotton in South India. 90 per cent mortality was recorded when it attacks 12 to 15 days old seedlings (Jothi *et al.*, 2011). Cotton sown during the first week of September recorded low infestation of the weevil, while the crop sown during first week of August recorded high infestation. The higher incidence in early sown crop may be due the emergence of adults from the previous crop season (Parameswaran and Chelliah, 1985). Emergence of weevil was observed when the cotton stalks were heaped in the field while no emergence was noticed when they are sundried in-situ (Murugesan *et al*., 2010). Extensive outbreaks have been reported when cultivation of improved varieties of cotton such as MCU5 and MCU9 were taken in large scale (Thirumurthi *et al.*, 1974). The Government realized the seriousness of the pest and imposed legislation to have a cotton free period of at least one month. Madras Agricultural Pests and Diseases Act 1919 was enforced specifying that the previous crop of cotton should be removed not later than 1st August and the succeeding crop should not be sown earlier than 1st September each year (David and Kumaraswami, 1994).

Adult habitus of *Pempherulus affinis*

Identification:

Adult weevils are dark brown in colour. On the surface of elytra white patches are visible. Grubs are creamy white in colour with a distinct head and slightly curved body (Narayanamma *et al*., 2020).

Species described under the genus *Pempherulus*: Genus *Pempherulus* comes under the tribe Mecopini. *Pempherulus affinis* Faust is a type species, an economic pest of cotton, *Pempherulus grewiae* Marshall and *Pempherulus pterospermi* Marshall are described from India. *Pempherulus megaten* Kojima & Morimoto, sp. nov., associated with *Hibiscus tiliaceus* (Malvaceae) is described from the Yaeyama Islands of the Ryukyus, southwestern Japan (Kojima and Morimoto, 2015).

Biology: After emergence adults mate several times. Mating activity is seen maximum at mid-day. Generally, the pre oviposition period ranges between 0.3 to 1.12 days. Female lays smooth, uniform eggs measuring 0.40mm in length and 0.29mm in width. Female weevil in her life time lays as many as 121 eggs. Grubs emerge after 6 to 9 days of oviposition. The grubs feed inside the soft stem and continue to feed till the development is complete in 35 to 37 days. Pupation takes place in the specially made pupal chamber inside the stem. Pupal period is 9 to 12 days. They complete three generations in a year from October to April. Thelytoky is a common phenomenon during adult emergence (Narayanamma *et al*, 2020).

Host plants: They are known to feed on wide range of malvaceous plants. Cotton is the most preferred host plant. Malvaceous hosts other than cotton are *Abelmoschus esculentus*, *Abutilon indicum*, *Althea rosea*, *Hibiscus cannabinus*, *Sida acuta* etc.

Management

- Timely sowing of cotton crop helps to reduce the infestation and plant mortality (Anandhi *et al*.,2020).
- Earthing up keeps the pest under check.
- Regular monitoring, uprooting and removal of infested plants in the field.
- Crop rotation or leaving the land fallow helps to reduce the pest load.
- Remove and burn plant residues after the harvest.
- Intercropping of cotton with Bhendi, Maize, Cluster bean, Green gram recorded less plant mortality due to stem weevil i. e. 2.2 to 2.8 percent (Anandhi *et al*.,2020).
- Application of neem cake 150 kg/ ha and carbofuran (1 kg a.i/ ha) at 10 DAS exerted maximum reduction of weevils (Anandhi *et al*.,2020).
- Spraying of crop with insecticides chlorantraniliprole 18.5 SC at 0.3 ml/l, clothianidin 50 WDG at 0.2 g/l, Chlorpyriphos @ 5 ml/l recorded significant reduction of the pest (Anandhi *et al*.,2020).

Conclusion

The cotton stem weevil represents a significant challenge to cotton production in India, particularly in the southern region. Therefore, the development of effective weevil management strategies is essential to contain the spread and multiplication of this destructive pest.

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COVER CROP IS VERY USEFUL FOR SOIL

Article ID: AG-VO4-I09-03

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Abstract

In recent decades, traditional agricultural practices have become increasingly crucial for promoting sustainable farming and preserving natural ecosystems. Cover crops are integral to improving soil health and fertility through various mechanisms. This growing interest in cover crops highlights their role in sustainable agriculture and underscores ongoing research and innovations in the field.

Introduction

In agriculture, cover crops are planted primarily to protect and enhance the soil, rather than for harvesting. These crops play a key role in managing soil erosion, fertility, and quality, as well as water, weeds, pests, diseases, biodiversity, and wildlife within an agroecosystem—an ecological system shaped and managed by humans. Cover crops can increase microbial activity in the soil, positively influencing nitrogen availability, uptake in target crops, and overall crop yields. They also help reduce water pollution and remove CO2 from the atmosphere. Often planted after the main cash crop is harvested, cover crops act as nurse crops, enhancing the survival of the main crop, and are frequently grown over the winter. They offer a proactive solution to combat soil degradation, an issue exacerbated by conventional farming practices like intensive tillage, monoculture cropping, and heavy use of chemical inputs. In contrast, cover crops naturally address these challenges by improving soil structure and fertility through their root systems, which enhance soil aggregation and organic matter accumulation. By shielding the soil from erosion and improving water infiltration and retention, cover crops contribute to soil conservation, reducing sediment runoff and nutrient leaching into water bodies. Furthermore, cover crops support biodiversity within agroecosystems by providing food and habitat for beneficial insects, microorganisms, and wildlife, thus promoting ecological balance and resilience.

Cover crops also play a significant role in nutrient cycling by capturing excess nitrogen and other nutrients left in the soil after cash crop harvests. When these crops decompose, they gradually release nutrients back into the soil, creating a more balanced nutrient availability profile and reducing the need for synthetic fertilizers. This nutrient cycling not only enhances soil fertility but also supports the long-term productivity and sustainability of agricultural lands.

What are cover crops?

Cover crops are non-commercial plants grown primarily to benefit the soil rather than for harvesting and sale. They are typically cultivated during periods when the main cash crops are not actively growing, such as between crop rotations or during fallow periods, with the aim of improving soil health, fertility, structure, and biodiversity within agricultural systems.

Types of Cover Crops

There are three types of cover crops:

1. **Grasses :-** These cover crops, belonging to the Poaceae family, grow quickly and leave easily managed residues. Their fibrous root systems are strong and help prevent erosion. They accumulate soil nitrogen through symbiosis with *Azospirillum* bacteria. Examples include barley and rye.
2. **Legumes :-** These cover crops are part of the *Leguminosae* family and are characterized by their nodulated root systems, which house Rhizobium bacteria that fix atmospheric nitrogen. Examples include fava beans and cowpeas.

Barley

Cowpea

Turnips

Broadleaf Non-leguminous :- These crops absorb soil nitrogen, stabilize the soil, and can serve as green manure. They usually die off in harsh winter temperatures, eliminating the need for additional termination. For weed control, non-legumes used as autumn cover crops should be treated before setting seeds. Examples include turnips and mustards.

Benefits of Using Cover Crops

1. **Soil Erosion :-** Cover crops, when combined with no-till farming practices, are among the most effective methods for preventing soil loss. They help to reduce soil erosion by improving soil structure, increasing infiltration, protecting the soil surface, dispersing the energy of raindrops, and slowing water movement over the soil. Dense cover crop stands physically slow down the velocity of rainfall before it contacts the soil surface, preventing soil splashing and erosive surface sunoff.
2. **Soil fertility Management** :- Often referred to as "green manure," cover crops are primarily used to boost soil fertility. Their ability to manage nitrogen levels has received significant attention from researchers and farmers, as nitrogen is often the most limiting nutrient in crop production.
3. **Water Management :-** The biomass produced by cover crops acts as a barrier between rainfall and the soil, allowing water to seep into the soil rather than running off. The root systems of cover crops create soil pores that enhance water infiltration and improve soil water storage, which can also recharge aquifers. In water-scarce regions, cover crops can conserve moisture by shading and cooling the soil surface, reducing evaporation and preserving soil nutrients.
4. **Nutrient Management :-** Cover crops like rye and oats absorb excess nutrients, preventing leaching and making them available for future crops. As cover crops decompose, they release these nutrients back into the soil, enriching it for subsequent planting.
5. **Weed Management :-** Dense stands of cover crops can outcompete weeds during their growth period, preventing weed seeds from germinating and completing their life cycles. When flattened on the soil surface, cover crops can form a mat that blocks light, further inhibiting weed growth.
6. **Disease Management** :- In the same way that allelopathic properties of cover crops can suppress weeds, they can also break disease cycles and reduce populations of bacterial

and fungal diseases, and parasitic nematodes. Species in the family *Brassicaceae*, such as mustards, have been widely shown to suppress fungal disease populations through the release of naturally occurring toxic chemicals during the degradation of glucosinolate compounds in their plant cell tissues.

7. **Soil-temperature :-** Residue and cover crops help regulate soil temperature. For example, in eastern Canadian prairies, soil treated with berseem clover cover crops was warmer in autumn and cooler in spring. In warm regions, lower soil temperatures during summer can reduce evaporation and improve soil water storage.
8. **Biodiversity Enhancement :-** Cover crops provide habitat for a variety of wildlife, including birds, insects, and small mammals, promoting biodiversity on the farm. Flowering cover crops offer nectar and pollen for pollinators, supporting their populations and enhancing pollination services for crops.
9. **Economic Benefits :-** By improving soil fertility and structure naturally, cover crops can reduce the need for chemical fertilizers and pesticides. Healthier soil and better pest and weed management can lead to increased crop yields over time.

Conclusion

Cover crops are a vital element of sustainable agricultural systems, offering numerous benefits that enhance soil health, improve crop productivity, and promote environmental stewardship. Their use leads to better soil structure, increased organic matter, improved water retention, reduced erosion, and more effective pest and weed management. Additionally, cover crops contribute to biodiversity and play a significant role in mitigating climate change through carbon sequestration.

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COWPEA BREEDING METHODS AND STRATEGIES

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Introduction

Cowpea is important grain legume grown under low input production system and suitable arid and semi arid condition. Act as major source for dietary protein *ie.*, 19 to 35 per cent, which is rich in two essential amino acid lysine and tryptophan. Nigeria is the largest producer and consumer among the world. However, in Asia India is the leading producer. It is considered as oldest domesticated crop. Since it possesses high protein content and largely grown by small marginal farmers cowpea is termed as "**Poor man's meat**." Also, it is tolerant to shade so preferred for multicropping. It is multifunctional crop cultivated as pulse, vegetable, forage, green manure and cover crop. It has good plasticity under variable environment and performs well in arid condition. Cowpea is important crop for food and nutritional security as it can perform well in drought and with good nutritional value.

Despite its multifunctional use and stability, cowpea productivity is low. The major reason for reduction in productivity includes pest, disease, plant parasitic weeds, drought, heat and cultural practices.

Distinguishing feature of cow pea

- They have kidney shaped seed
- In the seed portion white hilum is surrounded by black ring
- Whole plant exhibit pubescence

Major constrains for cowpea production

1. Insect pest

Among the biotic stress insects causes major yield loss or even crop failure. At least one or more pest affects at each stage of crop plant. Among them aphid and pod borer have high vulnerability. Singh and Allen (1980) divided the cowpea pest complex into three groups based on the time of infestation relative to crop phenology:

1. Pest which is prevalent throughout vegetative growth - leafhoppers, cowpea aphids and foliage beetles. These insects not only feed on leaves but act as vector for viral diseases
2. Pest that damages the flower morphology - flower bud thrips, lepidopterous larvae, and beetles. They cause flower abortion and destroy buds
3. Pest that is prevalent from reproductive phase to storage - legume pod borer, a complex of pod sucking bugs and the storage weevil

2. Diseases

Diseases in cowpea can be grouped in three classes *viz.*, viral, fungal and bacterial diseases. Major viral diseases include, blackeye cowpea mosaic potyvirus, cowpea aphid-borne mosaic potyvirus (CABMV), cucumber mosaic cucumovirus (CMV) and cowpea mosaic (CPMV). About 40 species of fungi have been reported for disease outbreak in cowpea and major are as follows, Anthracnose, Ascochyta blight, Black leaf spot or leaf smut, Brown blotch, Brown rust, Cercospora and Pseudocercospora leaf spots, Powdery mildew, Pythium soft stem rot and Septoria leaf spot. The major bacterial diseases are bacterial blight and bacterial pustule

3. Drought and heat

In arid and semi-arid condition drought is more prevalent and its vulnerability has been increased due to climate change. Warrang and Hall (1984) reported that increase in temperature at night is more detrimental than in day time. Both drought and heat increase the flower drop, male sterility thereby decreases the yield.

4. Parasitic weeds

The important parasitic weeds attacking cowpea are *Alectra vogelii* and *Striga gesnerioides*. Both are flowering plants that parasitize cowpea plants. Generally, *striga* causes major yield loss than the other.

Breeding objectives in cowpea

Breeding for Ideal plant type

1. Short duration

- Determinate plant type and non – photosensitive lines
- Extra early maturing variety – 60 to 70 days
- High harvest index
- Minimum flower drop
- Bushy plants with pod above canopy

2. Long duration

- Indeterminate plant
- Steady growth rate

Breeding for insect pest resistance

Keystone for cowpea improvement is developing varieties resistant to pest, since they cause major yield loss. Genetics and mechanisms of resistance to several insects were studied and have been reported (Singh 2002). Some of national varieties resistant to insect pest are mentioned below

S.No	Name of the varieties (Grain type)	Salient Features
1.	Pant lobia -5	Resistant to aphid, thrips and bruchid
2.	DC 15	Resistant to aphid and pod borer
3.	KBC 9	Resistant to pod borer
4.	Kashi Kanchan	Moderately resistant to aphid and pod borer

(Source- Project Report, Arid Legumes, AINRP on Arid Legumes, ICAR, IIPR, Kanpur)

Breeding for disease resistance

Varieties that exhibit tolerance to diseases are as follows

S.No	Name of the varieties	Salient Features
	Grain Cowpea varieties	
1.	Pant lobia -4	Resistant to major bacterial and viral disease like YMV
2.	Pant lobia -3	Resistant to bacterial blight and YMV
3.	Pant lobia -5	Tolerant to CYMV
4.	KBC 9	Resistant to dry root rot and collar rot

5.	Kashi Kanchan	Resistant to Golden mosaic virus
6.	Kashi Nidhi	Resistant to Golden mosaic virus and *Pseudocercospora cruenta*
	Vegetable cowpea varieties	
1.	Swarna Harita	Resistant to rust and mosaic viral disease
2.	Swarna Suphala	Resistant to rust and cowpea mosaic virus

(Source- Project Report, Arid Legumes, AINRP on Arid Legumes, ICAR, IIPR, Kanpur)

Breeding for drought tolerant plant

Cowpea has ability to grow under drought condition, although it is sensitive to severe drought at pod setting and grain filling stage. Improved cowpea varieties with better adaptation to drought condition and early maturity could be recommended to mitigate the effects of abiotic stresses, Daryanto et al. (2015). According to Hall *et al.*, (1997), yield testing of advance lines over several rainfed location helps to identify stable tolerant line. Some of the national varieties that are to drought *viz.*, Pant Lobia 4, DC 15 (wide adaptability)

Breeding for improving the nutritional quality

Main criteria includes, high protein content in grain, seed coat colour, taste, cooking quality and seed size. Breeding efforts is not specific because of wide differences in consumer needs. For example, large seed type preferred, brown colour is most favoured in southern part of India and it also depends upon the taste.

Breeding for vegetable cowpea

Cowpea is underutilized vegetable legume crop. Antova *et al.*,(2014) reported that protein content in cowpea leaf is about 25.1 to 43.1 percent. Protein content is positively correlated with zinc content in leaves (Gerrano *et al.*2022). Thereby it is potential food to alleviates protein malnutrition. Varieties developed at national level are Kashi Nidhi, Kashi Kanchan, Kashi Unnati, Arka Samrudhi and Pusa Komal.

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DESTRUCTIVE FISHING PRACTICES

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Introduction

All fishing is destructive in some way. The removal of any fish species, particularly in large numbers, will affect the complex web of connections between all marine species. Although fishing always affects the marine environment and ecosystems to some degree, some fishing gear and fishing methods are just too destructive and their use must be controlled. Fishing can be regarded as destructive if it causes physical damage to nearby areas, say by digging up the sea floor or breaking coral kills a large number of species in addition to the ones being fished is so efficient that not enough fish are left in the sea to reproduce.

The following is a list of damaging fishing gear

1. Bottom trawling
2. Longline fishing
3. Dynamite fishing
4. Gill net fishing
5. Fish poison
6. Muroami fishing

Bottom trawling

One of the most harmful techniques is bottom trawling, an industrial method which uses enormous nets weighed down with heavy ballast which are dragged along the sea floor, raking up or crushing everything in their way, from fish to ancient coral. Many species, including those at risk of extinction, are accidentally caught and then thrown back into the sea, often already dead. These collateral losses, known as discards, can reach up to 80% or even 90% of the total catch. Large areas of the seabed, the habitat where fish find food and shelter, are crushed and flattened. Bottom trawling also churns up sediment (sometimes toxic), creating turbid water inhospitable to life. . Living in extreme conditions, deepwater fish grow very slowly and have a long life expectancy and a late reproductive age. As a result, they are particularly vulnerable to disturbances in their environment. At risk marine ecosystems are not only in the high seas; bottom trawling on underwater mountains and the steep continental slopes on the edge of the shelf can also cause serious damage.

BYCATCH

Bycatch refers to all the forms of marine life caught unintentionally while catching other fish. One of the most urgent threats to the world's remaining fish stocks is commercial fishing, especially the indiscriminate capture of non-target organisms, typically referred to as 'bycatch'. Whilst bycatch may be sold, it may also be unusable or unwanted for a variety of regulatory and economic reasons and subsequently thrown backto sea, often dead or dying. A staggering 100 million sharks and rays are caught and discarded each year. An estimated 3,00,000 cetaceans also die as bycatch per year.

How can Bycatch be reduced?

A BRD is any modification designed principally to exclude fish bycatch from a shrimp trawl. Most BRDs are located in the codend of the trawl as this is where the catch is accumulated and the opportunity to escape is high.

Turtle Excluder Devices

TED or 'turtle excluder device' is any modification to a shrimp trawl designed to reduce the capture of turtles. These devices are sometimes called a 'trawl efficiency device' because they can also prevent the capture of other large animals including sharks, stingrays, jellyfish and some large fish. The most common TED designs use an inclined grid to prevent large animals from entering the cod end. A panel or funnel of netting immediately in front of the grid may be used to direct animals away from the escape opening and to maximize the length of grid available to separate large animals from the shrimp and small bycatch .

Square mesh window attachment

A codend constructed entirely from square-mesh netting can allow a substantial amount of small fish and other bycatch to escape. This is because square-mesh netting stays open for the duration of the tow, unlike diamond-mesh netting that closes under the weight of the catch. The selection of mesh size is very important and trial and error is needed to find the mesh size that maximises fish exclusion and prevents shrimp loss.

Fish eye

A fisheye is an elliptical steel or aluminium frame fitted to the cod end through which fish swim to escape. Fisheyes are usually placed in the top or sides of the cod end so that strong swimming fish can escape, while shrimp passively enter the cod end. Fisheyes must be inserted in the codend so that fish swim forward to pass through the escape opening.

Radial Escapement Devices

The RES was developed to exclude large fish bycatch. It consists of a tapered netting funnel attached to the codend surrounded by large escape openings that extend radially around the codend circumference. All animals in the trawl pass through the funnel and are directed toward the middle of the codend. As fish exit the funnel, some turn and swim forward, and escape through the escape openings.Water turbulence around the outside of the funnel helps fish to swim forward and escape.

LONGLINE FISHING

Longline fishing consists of baited hooks on lines up to 80 miles long. Each longline can have more than several thousand hooks at a time. These may catch swordfish, tuna, sharks, birds, and turtles. Worldwide, an estimated 180,000 birds die on longline hooks each year, many of which are endangered and nearing extinction. About 10% of the world's endangered wandering albatross population is killed each year by longlines. According to Bird International, in 1996, just three albatross species were threatened, but today all 21 species are at risk of extinction.. Fishermen can minimize conflicts with seabirds by putting extra weight on lines to make bait sink faster, by setting hooks at night, and by using streamer lines that scare birds away

DYNAMITE FISHING

Explosives such as dynamite (often obtained from mining operations, road works and even police) are used for fishing in some Pacific Islands. Explosives are either thrown from a canoe into a school of fish such as mullet, or set on coral where fish have been encouraged to gather by setting bait. Explosives are many times more damaging to small animals, such as fish larval stages and coral polyps, than they are to large fish. Although the use of explosives is illegal, the practice may be tolerated in isolated communities in which the illegally caught fish are shared. Blast fishing catches food fish in a flash, but it's dangerous to fishermen,devastating to fishes and coral reefs, and even though prohibited in most countries, still used on coral reefs in Asia, Africa, the South Pacific, and the Caribbean. A single blast can destroy thousands of years of coral growth.

GILL NET FISHING

Gill nets are panels of netting held vertically in the water by a series of floats attached to their upper edge (the float line) and weights attached to their lower edge (the leadline). These nets are anchored in shallow water to catch several species of fish including mullet and mackerel. The nets are often made from almost invisible nylon strands, which lock behind the gill covers of fish, and are anchored in shallow water. Problems occur when gill nets are set across narrow reef passages, channels or the mouths of rivers. In these cases, no fish will be able to pass the nets. This method of fishing is particularly damaging in cases where nets are set to catch fish swimming to a spawning aggregation site. Gill net when allowed to drift in the wind and currents enmesh and entangle a wide range of living organisms such as birds, turtles and marine mammals.

FISH POISON

Poisonous plant material is traditionally used to catch fish. Plants used include the climbing vine, *Derris*, and the fish poison tree, *Barringtonia asiatica*.*Derris* is a climbing plant belonging to the pea family. Its roots can be ground to produce rotenone, a poison that can kill insects and fish. Rotenone or derris powder is believed to be extremely toxic and damaging to the environment. The fish poison tree grows in mangrove areas and, as the water-resistant fruit drifts on ocean currents, it is distributed widely across the Indian and Pacific oceans. The seeds, which contain the poison saponin, can be ground to a powder and used to stun or kill fish. Fishers may drive the fish into the shelter of a preselected coral head where two or three parcels of poisonous material have been placed.

Cyanide fishing:

It involves spraying a sodium cyanide mixture in to the desired fish habitat to stun the fish. Grouper, wrasse and coral trout are captured through cyanide fishing.It was used on the nowdevastated reefs of the, Philippines – where an estimated 65 tons of cyanide are poured into the sea each year – and those in eastern Indonesia and other western Pacific countries. Saponins:-break down in the digestive system, enter the blood stream of fishes throughout their gills.Rotenones:-stun fish by impairing their oxygen consumption. Practiced in Brazil and Amazon basin.

MUROAMI FISHING

Its one of the cruelest of illegal fishing that destroys reef.Employed on coral reefs in South East Asia.Through the vigorous smashing of reefs fish are forced to come out of their corals.Uses an encircling net together with pounding nets. Comprise large stones fitted on ropes that are pounded onto the coral reefs. These nets are repeatedly and violently lowered into the area encircled by the net. The crushing effect of the pounding process on the coral heads has been described as having long lasting and totally destructive effects.70% of corals in Philippines are completely dead due to Muroami fishing.

GHOST FISHING

Ghost fishing is the term used for lost or abandoned fishing gear that continues to catch fish.Ghost fishing normally occurs with passive fishing gear such as longlines, gillnets, entangling nets, trammel nets, traps and pots, etc. as opposed to active fishing gear such as trawls and seines. First brought to attention of world at the 16th session of the FAO Committee on Fisheries in April 1985.

IMPACT OF GHOST FISHING

HABITAT

Fisheries operate in many different types of habitats in order to capture their target species, whether it is along the coast in shallow waters, or further offshore in open ocean (pelagic) areas. Coral reefs, like those in Hawai‘i, are one type of habitat that can be impacted by ghost fishing, not only by the loss of organisms dying in DFG, but the physical damage done by the gear itself. get dragged along the reefs by currents and storm action, which can destroy fragile corals and their associated inhabitants. Another habitat type that can be susceptible to impacts from DFG and ghost fishing is the benthos. Teseocean bottom regions, although generally remote in location, can still be damaged signifcantly when DFG, especially trap gear,sinks to the bottom where it can smother organisms that live on top of and just below the sediments, like seagrasses, crabs, and worms.

SPECIES MORTALITY

One of the most signifcant ghost fishing impacts of DFG is the unintended deaths of target and non-target species, which contribute to the overall depletion of populations. DFG that begins ghost fishing poses a threat to a variety of non-target fish turtles, seabirds whales and seals, This is especially problematic when endangered or protected species including marine mammals and sea turtles die as a result of ghost fishing. Protected marine species have already declining populations that can be further set back by DFG.

ECONOMICS

It is difficult to gauge accurate total costs associated with ghost fishing, as this varies across specific fisheries, and can depend on the gear type, weather, and ghost catch rates, among other factors. For the fishers, their direct costs range from the money required to replace lost gear, to increased resources (i.e., fuel, shiptime, more fishing gear, special equipment). needed to capture decreasing target fishery populations. This is especially problematic in deep-sea species that grow slowly. If signifcant numbers of these animals are lost to ghost fishing, this further strains the sustainability of the population. Fishers also lose revenue from target organisms killed due to ghost fishing. Some studies estimate that over 90% of species caught in DFG are of commercial value. Preventive measures would reduce the likelihood that fishermen will discard gear at sea and make gear less likely to ghost fish and could include:

1. Improvement of gear design to reduce likelihood of failure or snagging.
2. Spatial zoning of fisheries to avoid gear conflict and increase navigational awareness of gear in water.
3. Reduced fishing effort (lower soak times, limiting fishing time, less gear per boat).
4. Reducing ghost fishing efficiency of gear (improve biodegradable aspects for release or disabling of lost gear over time).
5. Gear marking, integrated GPS to allow for immediate recovery, port or state monitoring, and inspection of gear.
6. Provide affordable port disposal facilities and incentives to discourage improper disposal at sea.

Gear marking:

The mandatory marking of of specific gear to enable identification by competent authorities.

Onboard technology to avoid or locate gear:

With improvement in seabed imaging technology, some mobile gear can be towed close to the sea bed or known obstacles, enabling reduced direct impact with sea bed or obstacles thereby reducing the risk of gear snagging and loss. For static gear, technology can also enable the more accurate setting and subsequent location and retrieval of gear.

Reduced fishing effort:

reducing overall fishing effort i.e by limiting fishing time or the amount of gear per vessel is a fisheries management measure can also be expected to affect rates of ghost fishing.

MITIGATING MEASURES

Use of biodegradable nets and pots:

The need to reduce the amount of fishing gear that is lost is recognised in the international Codes of Conduct for Responsible Fisheries developed by the Food and Agriculture Organisation (FAO) of the United Nations. The management options for addressing lost gear include: reporting of gear loss prior to subsequent gear recovery campaigns; gear recovery/retrieval campaigns; or opportunistic gear recovery by demersal trawl surveys; the marking of gear; acoustic detection devices; zoning of fishing activities to avoid conflict; the use of bio-degradable gear etc.

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DIRECT EFFECTS OF DIFFERENT ORGANIC MANURES IN SUNFLOWER (*Helianthus annuus.* L) HYBRID KAVERI CHAMP

Article ID: AG-VO4-I09-06

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Introduction

Among the oilseed crops, sunflower (*Helianthus annuus.* L) stands out as a crucial oilseed crop cultivated year-round. This study was on direct effects of different organic manures in sunflower (*Helianthus annuus.* L) hybrid Kaveri champ through organic management practices, with a specific emphasis on growth attributes, yield attributes and yield of sunflower. A field investigation was carried out during March – June 2024 at the Experimental farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar – 608 002.

Materials and methods

The experiment was laid out in a Randomized block design with comprised of nine treatments and replicated thrice. The treatments are T_1 – Control, T_2 - FYM @ 12.5t ha^{-1} + 50% RDF + Panchagavya @ 3% (foliar spray twice at 30 and 45 DAS),T_3 - Vermicompost @ 2.5t ha^{-1}+ 50% RDF + Panchagavya @ 3% (foliar spray twice at 30 and 45 DAS), T_4 - Press mud @ 10t ha^{-1}+ 50% RDF + Panchagavya @ 3% (foliar spray twice at 30 and 45 DAS),T_5 - Enriched FYM @ 7.5t ha^{-1}+ 50% RDF + Panchagavya @ 3 % (foliar spray twice at 30 and 45 DAS), T_6 - Enriched vermicompost @ 1.75t ha^{-1} + 50% RDF + Panchagavya @ 3% (foliar spray twice at 30 and 45 DAS),T_7 - Enriched press mud @ 5t ha^{-1}+ 50% RDF + Panchagavya @ 3% (foliar spray twice at 30 and 45 DAS), T_8 - 100% RDF + Panchagavya @ 3% (foliar spray twice at 30 and 45 DAS) ,T_9 - 100% RDF alone.

Result

The result of the experiment revealed that application of Enriched vermicompost @ 750 kg ha^{-1}+50%RDF+ Panchagavya @ 3 % (foliar spray twice at 30 and 45 DAS) (T_6), resulted as best treatment among all treatments. This treatment recorded the highest growth parameters such as plant height (161.25 cm), LAI (3.45), DMP (7246 Kg ha$^{-1)}$, head diameter (23.16 cm), Total number of seeds head^{-1} (1224), Number of filled seeds head^{-1} (1106), Seed yield (3227 kg ha^{-1}), Stalk yield (5386 kg ha^{-1}), and Oil yield (1268.21 kg ha^{-1}). This was followed by T_7 - Enriched pressmud @ 750 kg ha^{-1}+ 50% RDF + Panchagavya @ 3% (foliar spray twice at 30 and 45 DAS). The nutrient uptake by sunflower was significantly increased with N (90.34 kg ha^{-1}), P (25.25 kg ha^{-1}), K (90.26kg ha^{-1}). With regard to economic, application of Enriched vermicompost @ 750 kg ha^{-1}+50%RDF+ Panchagavya @ 3 % (twice at 30 and 45 DAS) (T_6) recorded the highest net return of Rs.119954.8 ha^{-1} with a BCR of (2.87). The control treatment (T_1) was recorded the lowest value of BCR (1.79).

Conclusion

From the aforesaid facts, it could be concluded that the application of Enriched vermicompost @ 750 kg ha^{-1}+ 50% RDF+ Panchagavya @ 3 % (foliar spray twice at 30 and 45 DAS) (T_6) is an agronomically sound and economically feasible practice for increasing the seed yield, productivity and profitability of sunflower growing farmers in Tamil Nadu.

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DOUBLED HAPLOIDS IN PLANT BREEDING: TECHNIQUES AND APPLICATIONS

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Introduction

A doubled haploid (DH) is a plant that is created when a haploid cell (a cell with only one set of chromosomes) undergoes a process to double its chromosomes, restoring it to the normal state for that species. In plant breeding, the artificial production of doubled haploids is a valuable tool. Haploid cells, which are typically found in pollen or egg cells, can be treated in a lab to induce chromosome doubling. This leads to the formation of a doubled haploid cell, which can then be grown into a doubled haploid plant.

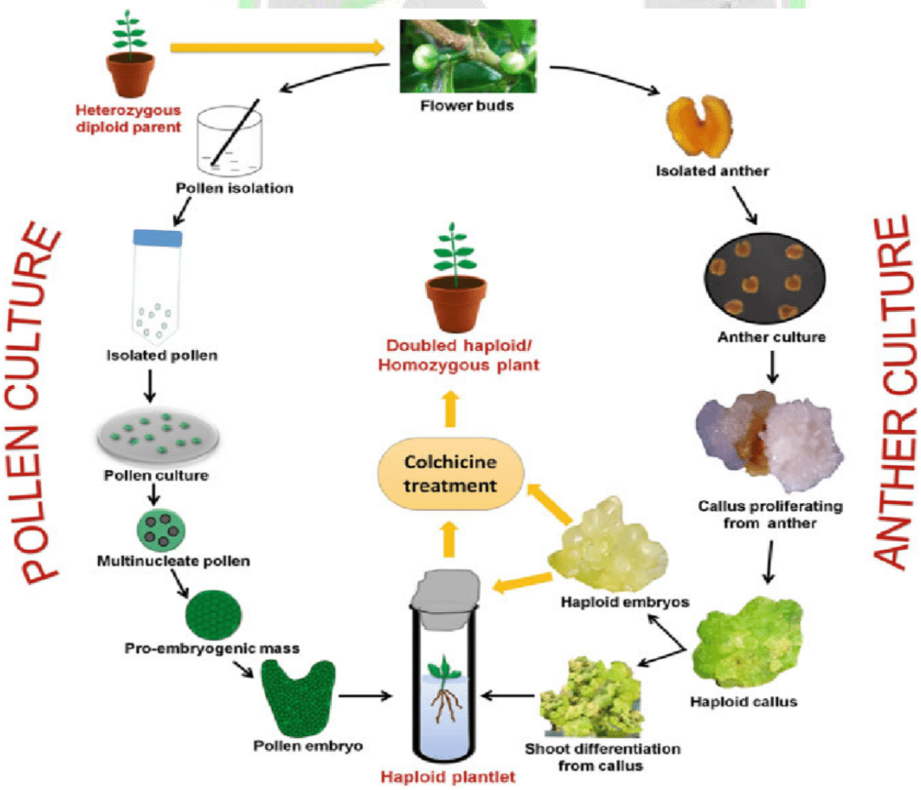
If the original plant is diploid (with two sets of chromosomes), the haploid cells produced are monoploid, and once doubled, these are sometimes referred to as doubled monoploids. In cases where the plant is tetraploid (four sets of chromosomes) or hexaploid (six sets), the haploid cells are called dihaploids, and when doubled, they become tetraploid or hexaploid, respectively. While traditional breeding methods require up to six generations to achieve full homozygosity (uniformity of genes), doubled haploid techniques can achieve this in just one generation. This is especially useful in breeding programs for tetraploid crops, as it allows breeders to work with diploid wild relatives more easily.

History

The first haploid plant was reported by Blakeslee *et al*. (1922) in *Datura stramonium*. Since then, haploids have been observed in many species. In 1964, Guha and Maheshwari developed the anther culture technique to produce haploids in the lab. Haploid production through wide crossing was first reported in barley (Kasha and Kao, 1970) and tobacco (Burk *et al*., 1979). Today, species like tobacco, rapeseed, and barley are highly responsive to doubled haploid production, with the technique now applied to over 250 species.

Production of doubled haploids

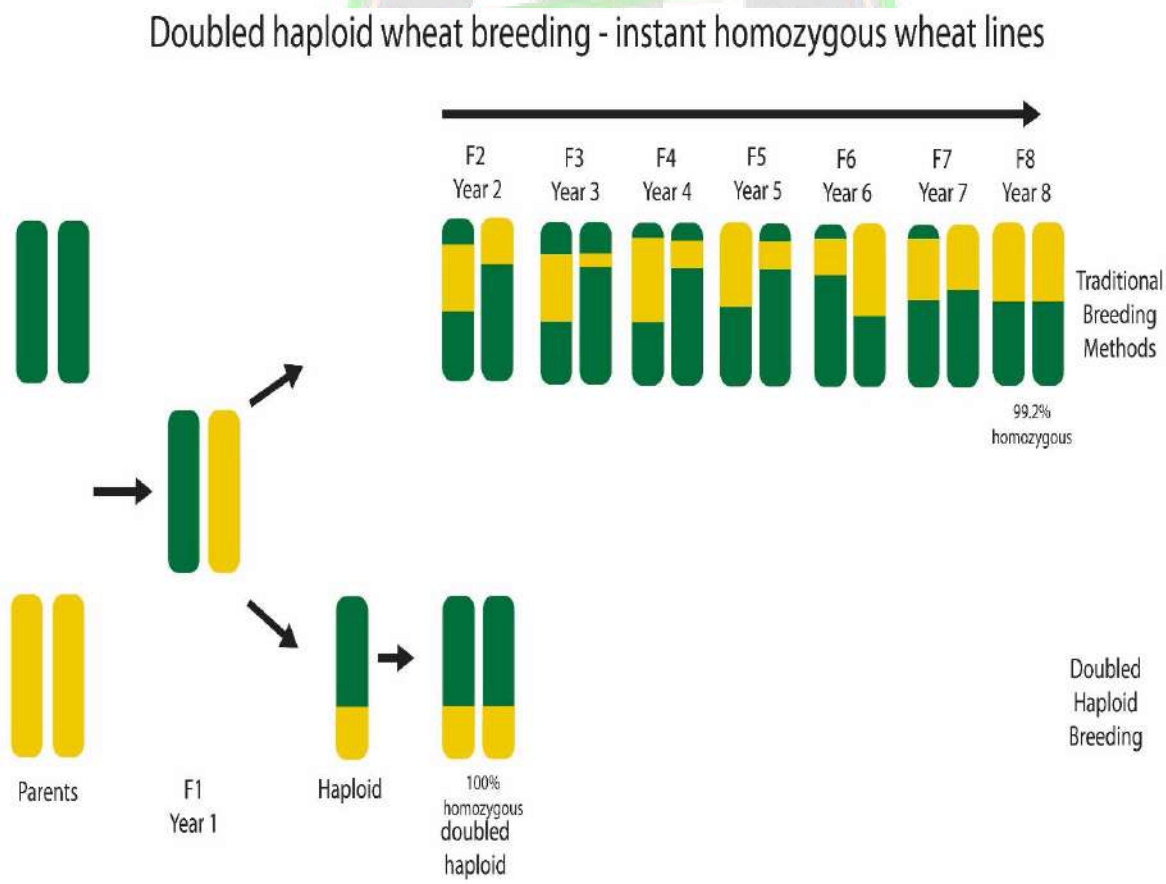
Haploid production is a key technique in plant breeding that allows breeders to quickly create plants with a single set of chromosomes, which can later be doubled to produce completely homozygous, true-breeding lines. Haploids can be produced through various methods, either in vivo or in vitro. In vivo methods involve natural or induced processes like parthenogenesis, pseudogamy, or chromosome elimination after wide crossing between species. The haploid embryos that result from these processes are rescued and grown in culture, where their chromosomes are doubled to form doubled haploids.



Source: Bajpai *et al*., 2018

In vitro methods include androgenesis, where anthers or microspores are cultured, and gynogenesis, which involves culturing ovaries or flowers. Androgenesis is the more commonly used method due to its higher efficiency. Wide crossing is another technique, used in crops like barley and tobacco, where fertilization occurs between species, but the chromosomes of the pollen donor are eliminated, leaving a haploid embryo from the maternal parent. These methods offer efficient ways to produce homozygous lines in a single generation, speeding up the breeding process.

Wide crossing is another method for haploid production. In barley, haploids are produced by crossing with *Hordeum bulbosum*, where the chromosomes of *H. bulbosum* are eliminated during early seed development, leaving a haploid embryo. In tobacco (*Nicotiana tabacum*), crossing with *Nicotiana africana* is commonly used. Although only 0.25 to 1.42% of the progeny survive, the large number of seeds and early death of most seedlings still yield enough viable hybrids and haploids. This interspecific pollination method is an effective alternative or complement to anther culture for producing haploids in tobacco.



Applications of doubled haploids

1. Mapping Quantitative Trait Loci (QTL):

Doubled haploid populations enable precise QTL mapping due to their true-breeding nature, allowing accurate phenotyping across trials. This approach has helped map over 130 traits across nine crop species using 56 DH populations.

2. Backcross breeding:

Combining molecular markers with doubled haploids accelerates the identification of desired traits, even recessive ones, in backcross programs. This shortens the breeding cycle, as shown in barley, where stripe rust-resistant lines were rapidly developed.

3. Bulked segregant analysis (BSA):

True-breeding nature makes DH populations ideal for BSA, where contrasting bulks are used to identify marker-trait linkages. This method has been successfully applied in crops like barley and rapeseed for marker-assisted breeding.

4. Genetic maps:

The homozygosity of doubled haploids simplifies genetic map construction, enabling quick identification of gene locations and relationships. Species like rice, barley, and wheat have benefitted from this approach in producing comprehensive genetic maps.

5. Genetic studies:

Haploid populations allow direct observation of genetic ratios and mutation rates. In barley, for instance, DH populations helped pinpoint the location of a dwarfing gene and analyze segregation patterns.

6. Genomics:

For fine-mapping QTLs, DHs are used to generate recombinant chromosome substitution lines. This technique has facilitated the mapping of resistance genes to diseases in rice, such as rice blast and bacterial blight.

7. Elite crossing:

By eliminating heterozygosity, DHs streamline the selection process in breeding, reducing the time for cultivar development. Elite crosses can be evaluated faster, improving the efficiency of breeding programs.

8. Cultivar development:

DH production ensures uniformity, making it valuable for developing new cultivars. These lines can be used directly, in hybrid production, or for germplasm conservation, as seen with over 300 DH-derived cultivars in crops like barley.

Advantages

Doubled haploids offer significant advantages in plant breeding by enabling the rapid production of completely homozygous lines in a single generation, saving time compared to traditional methods. They eliminate the risk of heterozygosity, provide more efficient genetic analysis, and aid in marker development for useful traits. DHs also improve precision in genetic mapping, accelerate gene pyramiding, and enhance resistance screening. In species with long life cycles or inbreeding challenges, like trees and ornamentals, DHs offer new breeding alternatives, including the potential for seed propagation. Studies show that random DHs are comparable to lines developed through pedigree inbreeding.

Disadvantages

The main disadvantage with the DH population is that selection cannot be imposed on the population. But in conventional breeding selection can be practised for several generations: thereby desirable characters can be improved in the population. In haploids produced from anther culture, it is observed that some plants are aneuploids and some are mixed haploid-diploid types. Another disadvantage associated with the double haploidy is the cost involved in establishing tissue culture and growth facilities. The over-usage of doubled haploidy may reduce genetic variation in breeding germplasm. Hence one has to take several factors into consideration before deploying doubled haploidy in breeding programmes.

Conclusion

Technological advances have enabled the development of doubled haploid (DH) protocols for most plant genera, with over 250 species now amenable to this method. Over the past few decades, the efficiency of DH production has significantly improved as more species have been moved out of the recalcitrant category. These advancements have enhanced the overall efficiency of plant breeding by accelerating the development of homozygous lines, leading to faster and more precise selection of desirable traits.

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EFFECT OF TEMPERATURE AND HUMIDITY ON THE GROWTH OF MULBERRY SILKWORM

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Introduction

The silkworm (*Bombyx mori* L.) is an economically important insect that plays a pivotal role in the production of silk, a highly valued natural fibre. Sericulture or silk farming is a delicate process that involves rearing silkworms for their silk and the success of this industry heavily depends on environmental conditions. Among the various factors influencing the growth and productivity of silkworms, temperature and humidity are two of the most critical. Understanding the impact of these environmental parameters on silkworm growth, development and silk production is vital for optimizing rearing conditions and ensuring high-quality silk output.

Temperature and humidity directly affect the physiology, growth rate and health of silkworms. These environmental factors influence the lifecycle of silkworms including egg hatching, larval development, cocoon formation and silk yield. Deviations from the optimal range can result in poor growth, increased susceptibility to diseases and reduced silk production. This article will explore the importance of temperature and humidity in the growth of silkworms thereby examining their influence on various developmental stages and discussing how to manage these factors in sericulture to maximize productivity and quality.

Effects of Temperature Extremes on Silkworm Growth

Deviations from the optimal temperature range can have detrimental effects on silkworm health and productivity. Extreme temperatures whether too high or too low can impact various physiological processes thereby leading to slower growth, poor cocoon quality and increased mortality. Some of the effects of temperature extremes include:

- **Low Temperatures:** Prolonged exposure to temperatures below 20°C can slow down the metabolic rate of silkworms thereby resulting in delayed growth and development. The larvae may feed less thereby leading to reduced weight gain and smaller cocoon size. In some cases, low temperatures can cause incomplete moulting or moulting disorders further hindering growth. Additionally, low temperatures during the pupal stage can prolong the metamorphosis process and delay the emergence of adult moths.
- **High Temperatures:** Temperatures above 30°C can cause heat stress in silkworms thus leading to rapid respiration and dehydration. High temperatures also increase the risk of diseases such as bacterial and viral infections which thrive in warmer environments. Silkworms exposed to excessive heat may exhibit abnormal feeding behaviour, slower growth and reduced silk production. In extreme cases, heat stress can lead to the death of larvae or pupae thus resulting in significant losses for silk farmers.

Managing Temperature in Sericulture

Temperature management is crucial for ensuring the successful growth of silkworms and maximizing silk production. Sericulture farmers must monitor and control temperature conditions in rearing facilities to maintain the optimal range for each developmental stage. The following strategies can help achieve proper temperature regulation:

1. **Controlled Environment Rearing Houses:** One of the most effective ways to manage temperature is by using controlled environment rearing houses equipped with heating and cooling systems. These facilities allow farmers to maintain a stable temperature within the optimal range, regardless of external weather conditions.
2. **Ventilation and Insulation:** Proper ventilation and insulation are essential for regulating temperature in silkworm-rearing houses. Ventilation helps dissipate excess heat and prevent the buildup of humidity while insulation helps maintain a stable internal temperature especially during cold or hot weather.
3. **Use of Fans and Heaters:** In traditional rearing setups, fans and heaters can be used to adjust the temperature as needed. During colder months, heaters can be employed to maintain the required warmth while fans can help reduce heat stress during warmer months.
4. **Temperature Monitoring:** Regular monitoring of temperature levels using thermometers or digital sensors is essential to ensure that the rearing conditions remain

within the optimal range. Early detection of temperature fluctuations allows farmers to take corrective actions before the silkworms are adversely affected.

Effects of Humidity Extremes on Silkworm Growth

Just as with temperature, deviations from the optimal humidity range can negatively impact silkworm growth, health and silk production. Extreme humidity levels whether too high or too low, can affect various physiological processes and lead to poor growth and cocoon quality. Some of the effects of humidity extremes include:

- **Low Humidity:** Exposure to low humidity levels can cause dehydration in silkworm larvae thus leading to reduced feeding activity and slower growth. Dehydration can also increase the risk of moulting problems where the larvae have difficulty shedding their skin during moulting. In the pupal stage, low humidity can cause the silk fibers to become brittle thus resulting in poor cocoon quality and reduced silk yield.
- **High Humidity:** High humidity levels can create a favourable environment for the growth of pathogens such as bacteria, fungi and viruses. Silkworms reared in excessively humid conditions are more susceptible to diseases like bacterial septicemia and fungal infections. High humidity can also lead to dampness in the rearing environment which can affect the quality of the cocoons and result in poor silk production. In severe cases, excessive humidity can cause the larvae or pupae to suffocate due to inadequate air circulation.

Managing Humidity in Sericulture

Proper humidity control is necessary for ensuring the better growth of silkworms and maximizing silk production. Sericulture farmers must carefully monitor and control humidity levels in rearing facilities to maintain the optimal range for each developmental stage. The following strategies can help achieve proper humidity regulation:

1. **Humidity-Controlled Rearing Houses:** One of the most effective ways to manage humidity is by using humidity-controlled rearing houses equipped with humidifiers and dehumidifiers. These facilities allow farmers to maintain a stable humidity level within the optimal range, regardless of external weather conditions.
2. **Ventilation and Air Circulation:** Proper ventilation and air circulation are essential for preventing the buildup of excess humidity in silkworm-rearing houses. Ventilation helps

dissipate excess moisture while fans can improve air circulation and reduce the risk of fungal growth.

3. **Humidity Monitoring:** Regular monitoring of humidity levels using hygrometers or digital sensors is essential to ensure that the rearing conditions remain within the optimal range. Early detection of humidity fluctuations allows farmers to take corrective actions before the silkworms are adversely affected.
4. **Moisture Control in Bedding and Mulberry Leaves:** Maintaining the proper moisture level in the bedding and mulberry leaves provided to the silkworms is essential for preventing dehydration or excess moisture. The bedding should be kept dry and clean while the mulberry leaves should be fresh and free from excess water.
5. **Use of Humidifiers and Dehumidifiers:** In traditional rearing setups, humidifiers and dehumidifiers can be used to adjust humidity levels as needed. Humidifiers can help maintain the required moisture level during dry conditions while dehumidifiers can reduce excess humidity during wet or rainy weather.

Conclusion

The growth and productivity of silkworms are highly sensitive to environmental conditions, particularly temperature and humidity. These two factors play a crucial role in determining the health, growth rate and silk production of silkworms throughout their lifecycle. Maintaining optimal temperature and humidity levels in rearing facilities is essential for ensuring the successful development of silkworms and maximizing silk yield.By carefully managing temperature and humidity, sericulture farmers can create a favourable rearing environment that promotes healthy growth and high-quality silk production. Controlled environment rearing houses, proper ventilation and regular monitoring of temperature and humidity levels are key strategies for achieving optimal conditions for silkworm growth. Understanding the importance of temperature and humidity in sericulture is essential for improving productivity and ensuring the sustainability of the silk industry.

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FARMER SUCCESS STORY: FARMER TURNS TO ENTREPRENEUR BY CONSERVING TRADITIONAL PADDY VARIETIES

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Introduction

Traditional paddy varieties are indigenous rice strains that have been cultivated over centuries in various regions. They are often valued for their unique flavours, nutritional qualities, and adaptability to local environments. Unlike modern high-yield varieties, traditional paddy varieties are typically grown using traditional farming practices and can be more resilient to pests and diseases, while also contributing to biodiversity.

Name of the women farmer: Garampally Srikanth

Age: 39 Years Education: Intermediate Land holding: 4 acres

Address: Vill – Ellanthakunta, Karimnagar District, Telangana

Introduction/Problem:

G.Srikanth farmer from Karimnagar inherited a small paddy field from his ancestors, where he practiced conventional farming methods. Farming under these methods involves usage of high yielding varieties, chemical fertilizers, pesticides which leads to declining in soil fertility, causing harmful effects to humans and environment. After lot of struggles, discussions with KVK Scientists he decided to focus on Natural farming, Preservation of traditional paddy varieties, which were more resilient and adapted to local conditions.

Interventions:

Then he started researching and reviving of ancient paddy germplasm that had been neglected in favor of high-yielding hybrid varieties. During last 6 years he collected, conserving

400 traditional paddy varieties and cultivating 155 varieties in his field.

By cultivating these traditional varieties, Srikanth not only improved his yields but also enhanced the soil quality and reduced dependency on chemical inputs. Along with these traditional varieties he started millet cultivation under natural farming.

Along with the above activities some other practices adopted by Srikanth were

- ✓ Cultivation of Desi paddy varieties through natural farming
- ✓ Adoption of New technologies in Agriculture
  - Alternate Wetting and Drying system of irrigation management in paddy
  - Following of IPM practices for control of pest and diseases in paddy
- ✓ Cultivation of Cotton with Better management practices
  - Effective water management through Drip and Alternate furrow irrigation
  - Following Stem application technique for sucking pest management
- ✓ Cultivation of millets through natural farming

Impact:

Recognizing the potential of these heirloom varieties, he launched a business by creating value addition to traditional paddy varieties & millet-based products aimed at promoting and selling them. He established a market channel for organic traditional paddy, millets appealing to consumers interested in sustainable agriculture and unique food product.

Output:

KVK Scientists & Department of Agriculture is disseminating the practice of natural farming, conducted more visits to his field by other farmers to get desi paddy varieties, and nearly 60-80 farmers were inspired and adopted some of these practices in their agriculture lands.

By integrating all these activities, he is earning an additional income of Rs 8,25,000/- per year

Significant recognitions:

- ✓ Since last 5 years, he is cultivating Navara, Kalabatti, Mapilisambha, Sirisannalu, Chitti muthyalu & Marketing rice value added products (Mudi biyyam, Dampudu biyyam, Broken rice, Single polished rice & Snacks) and millet value added products
- ✓ Participated district, state, national level exhibitions and promoting importance of desi paddy varieties
- ✓ Focusing on different cooking methods with desi rice varieties for better human health

Photographs:

Best Farmer Award Taken By Me With Karimnagar collector ji

Press clippings:

The rice that needs no cooking

Karimnagar farmer grows this magic rice variety from Assam

THIRUNAGIRI VENKATESHWARA SWAMY

KARIMNAGAR: As the price of domestic gas is increasing day-by-day, here is the good news for those who wish to save money and energy. A young and aspiring farmer, Garla Srikanth replicated cultivation of magic rice known as 'Boka saul' which does not require any kind of cooking. Just soak it in hot water for 15 minutes and enjoy its flavour. Boka saul – is an indigenous variety of rice produced exclusively in lower regions of Assam in Nalbari, Barpeta, Goalpara, Kamrup, Darrang, Dhubri, Chirang, Bongaigaon, Kokrajhar and Baksa areas. It is the latest product from Assam to get the Geographical Indication tag, commonly called the GI tag. First sown by June end, this special variety of Assamese rice is often referred to as 'magic rice'. It requires no cooking, unlike every other variety of rice. This unique variety of Assamese rice is very simple, and equally budget-friendly, to "cook".

Continued on Page 7

వండనక్కర్లేని బియ్యం!

- నానబెడితే చాలు...
- కరీంనగర్ రైతు ప్రయోగం

- ✓ His success stories were telecasted in different tv channels & published in news papers
- ✓ Received **Best farmer appreciation certificate** from department of horticulture on vegetables cultivation.
- ✓ Received **District Best millet cultivator** award-2019 given by **Telangana development forum**
- ✓ Received **Best organic farmer** award -2020 given by NABARD in convergence with ATMA.
- ✓ Recognised as Master trainer for cultivation of millets and desi varieties through organic farming by ATMA and Department of Agriculture.
- ✓ Received **Raithunestham Puraskaram-2022** during Raithunestham 18th Anniversary foundation celebrations on 20th Nov 2022

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THE HIDDEN HEROES: BENEFICIAL VIRUSES AND THEIR SURPRISING ROLE IN SCIENCE AND NATURE

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Abstract

This article explores the surprising benefits of viruses, highlighting their evolution from harmful pathogens to valuable tools in various fields. Beneficial viruses, including bacteriophages, adeno-associated viruses, and plant viruses, play crucial roles in human health, gene therapy, ecosystem sustainability, and bio-nanotechnology. By showcasing their positive impacts—from gut health to agricultural innovation—this piece reveals how viruses can contribute to a healthier and more sustainable future.

Introduction

Since the discovery of plant viruses in the late 1800s, their role has evolved from being harmful pathogens to becoming valuable molecular tools in plant molecular farming (PMF) and bio-nanotechnology. While the term "virus" typically carries a negative connotation, these viruses can be repurposed into environmentally safe and beneficial structures (Zeng *et al* .,2013). When we think of viruses, our minds often go straight to diseases—like the flu, HIV, or the recent COVID-19 pandemic. However, not all viruses are harmful. In fact, many viruses play vital roles in ecosystems, human health, and even cutting-edge scientific research. These "beneficial viruses" are quietly shaping the world in ways you might not expect. Let's dive into the world of helpful viruses and uncover how they're making a positive impact.

1. The Virus Behind Your Gut Health

Your gut is home to trillions of microorganisms, collectively known as the microbiome, which plays a crucial role in digestion, immunity, and even mental health. Among these microbes are viruses that specifically infect bacteria, called bacteriophages (or phages). Far from being harmful, these viruses help regulate bacterial populations in your gut, ensuring a healthy balance of microbes. This delicate equilibrium can prevent harmful bacteria from taking over and may even reduce the risk of infections or digestive disorders. Phages are even being studied as potential therapies for antibiotic-resistant infections, offering a new hope in the fight against superbugs(Abedon *et al* ., 2017 and Wittebole *et al* ., 2014).

2. Viruses in Gene Therapy

Gene therapy, a revolutionary field in medicine, is increasingly relying on viruses for delivering genetic material into human cells. One of the most promising tools in this area is the adenoassociated virus (AAV), which has been engineered to carry therapeutic genes. Scientists have harnessed these viruses, stripped of their harmful components, to treat genetic disorders like spinal muscular atrophy (SMA) and certain types of blindness. By delivering correct copies of malfunctioning genes, AAVs are giving patients a chance at improved health and quality of life(Russell *et al* ., 2017 and Wang *et al* ., 2019).

3. Nature's Recyclers: Viruses in Ecosystems

Viruses are also essential players in maintaining the balance of natural ecosystems. In the ocean, viruses are responsible for breaking down massive amounts of organic material, recycling nutrients back into the environment. Marine viruses, for example, infect and break down algae and other microorganisms, releasing nutrients that fuel the food chain. Without viruses, the ocean's nutrient cycles would slow down, negatively impacting marine life from plankton to whales (Breitbart *et al* ., 2005 and Suttle *et al* ., 2017).

4. Viruses as Nanotechnology Tools

In the rapidly advancing field of bio-nanotechnology, plant viruses are being repurposed for various applications. Plant viruses like the tobacco mosaic virus (TMV) have been transformed into molecular machines, used to deliver drugs, vaccines, or even for imaging cancer cells. These viruses are non-pathogenic to humans, making them safe to use in medical and industrial applications. Researchers are even exploring the potential of viruses to build tiny batteries or solar cells, showing how these microscopic entities can contribute to clean energy solutions (Bruckman *et al* ., 2014 and Loo *et al* ., 2012).

5. Boosting Agriculture: Viruses for Better Crops

In the world of farming, viruses are increasingly seen as valuable allies. Plant viruses, once feared as crop destroyers, are now being engineered to improve agricultural productivity through a technique known as plant molecular farming (PMF). By inserting genes into these viruses, scientists can produce valuable proteins, enzymes, or vaccines directly within plants. This technology is not only cost-effective but also environmentally friendly, reducing the need for chemical fertilizers or pesticides (Gleba *et al* .,2005 and Rybicki *et al* ., 2010).

6. The Future: Phage Therapy and Beyond

Phage therapy is one of the most exciting areas where beneficial viruses may soon become mainstream in medicine. With antibiotic resistance on the rise, phages offer a targeted and natural alternative to traditional antibiotics. Phages can be engineered to infect and kill specific bacteria without harming the body's beneficial microbes, making them a precise and effective weapon against bacterial infections (Chan *et al* ., 2013 and Kortright *et al* ., 2019).

Conclusion

While it's easy to associate viruses with harm, the reality is that they are far more complex and multifaceted. Beneficial viruses are already being used to improve human health, agriculture, and environmental sustainability, offering exciting opportunities for innovation. As we continue to explore the hidden potential of these tiny agents, viruses may turn out to be some of nature's most valuable allies in the fight for a healthier, more sustainable future.

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SCIENTIFIC HYBRID SEED PRODUCTION IN RICE CROP

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Introduction

Rice (*Oryza sativa*) is one of the most important staple crops globally, serving as a primary food source for more than half of the world's population. Understanding its biology and morphology is essential for breeding, cultivation, and crop management practices aimed at improving yield and quality. Hybrid rice production is a transformative approach in modern agriculture, aimed at improving rice yields by exploiting the phenomenon of heterosis, or hybrid vigor. Introduced in China during the 1970s, hybrid rice has since played a crucial role in addressing global food security by increasing productivity, especially in regions where rice is a staple crop. Hybrid rice varieties are created by crossing two genetically distinct parental lines, resulting in offspring with superior yield potential, enhanced stress tolerance, and greater resistance to pests and diseases. This method allows farmers to achieve up to 20% higher yields compared to traditional inbred rice varieties. The hybrid seed production process, while more complex than conventional rice cultivation, offers significant benefits, including better resource efficiency and adaptability to varying environmental conditions. With growing populations and diminishing arable land, hybrid rice production is an essential strategy for meeting future food demands and ensuring sustainable agricultural development.

Key words: Rice, Hybrid, A-line, R-line

Importance of Hybrid Rice Production

1. **Yield Increase**: Hybrid rice has been reported to provide 15-20% higher yields than conventional inbred rice varieties. This yield boost is critical for ensuring food security in

regions where rice is a staple crop.

2. **Better Stress Tolerance**: Hybrid rice varieties are bred to tolerate biotic stresses (such as pests and diseases) and abiotic stresses (like drought, salinity, and water logging). This enhances their performance in suboptimal conditions.
3. **Resource Efficiency**: Due to their higher yield potential, hybrid rice varieties make better use of limited resources such as water, fertilizer, and land.
4. **Market Demand**: Hybrid rice varieties with improved grain quality characteristics are also preferred in markets where grain appearance, aroma, and cooking quality are important factors for consumers.

Hybrid Seed Production in Rice

The production of hybrid rice seed requires careful planning and execution due to the complex biological and environmental requirements. The selection of parental lines is one of the most critical steps in hybrid rice production. The success of hybrid rice breeding depends largely on the quality of the chosen parental lines, as they contribute to the desired traits such as higher yield, disease resistance, stress tolerance, and grain quality. Parental lines in hybrid rice breeding are classified into three main categories: A-line (Cytoplasmic Male Sterile line), B-line (Maintainer line), and R-line (Restorer line). Key steps in the production of hybrid seeds in rice include:

1. **Selection of Parental Lines**: The first and most critical step is selecting suitable parental lines, which consist of three components:

A-Line (Cytoplasmic Male Sterile Line)

- **Definition**: The A-line is the female parent that is cytoplasmically male sterile (CMS), meaning it cannot produce viable pollen, making it unable to self-pollinate. The sterility is controlled by both nuclear and cytoplasmic factors.
- **Role**: The A-line is crucial for producing hybrid seeds. Its sterility ensures that it must be pollinated by the male parent (R-line), resulting in hybrid vigor (heterosis).
- **Selection Criteria**:
  - **Complete Sterility**: The A-line should exhibit complete male sterility to avoid self-pollination, ensuring only hybrid seed production.
  - **Adaptability**: It should be well-adapted to the local environment, with good growth characteristics and disease resistance.

  - **Yield Potential**: The A-line should have good agronomic traits like plant height, tillering ability, and panicle size, which contribute to hybrid yield.
  - **Grain Quality**: It should produce grains with desirable quality traits such as grain size, shape, and cooking quality to meet market preferences.

2. B-Line (Maintainer Line)

Definition: The B-line is the genetic counterpart of the A-line and is used to maintain the A-line. It is a fertile version of the CMS line and has the same nuclear genome as the A-line but a fertile cytoplasm.

- **Role**: The B-line is essential for multiplying the A-line since the A-line cannot produce seeds on its own due to male sterility. When crossed with the B-line, the A-line can be maintained over generations.
- **Selection Criteria**:
  - **Genetic Similarity**: The B-line should be genetically identical to the A-line, except for its fertile cytoplasm, to ensure that the A-line's traits are preserved during multiplication.
  - **Fertility**: The B-line should have high pollen production and complete fertility to ensure effective multiplication of the A-line.
  - **Agronomic Traits**: The B-line should have desirable traits such as high yield, disease resistance, and adaptability similar to the A-line.

3. R-Line (Restorer Line)

- **Definition**: The R-line is the male parent used to pollinate the A-line. It contains a dominant nuclear gene that restores fertility in the hybrid offspring, making it capable of producing viable pollen.
- **Role**: The R-line restores fertility in the hybrid seeds and contributes to heterosis. It determines many of the traits of the hybrid, including yield potential, stress tolerance, and grain quality.
- **Selection Criteria**:
  - **Restorer Gene**: The R-line must carry the dominant fertility restorer gene (Rf), which is responsible for restoring fertility in the hybrid seeds.
  - **Yield Potential**: The R-line should have high yield potential, contributing to the overall performance of the hybrid crop.

- **Stress Tolerance**: It should be resistant to biotic stresses (pests and diseases) and abiotic stresses (drought, salinity, and high/low temperatures).
- **Grain Quality**: The R-line should contribute desirable grain qualities such as grain size, shape, milling recovery, and cooking characteristics.
- **Synchrony in Flowering**: The R-line should flower at the same time as the A-line to ensure successful pollination during hybrid seed production.

2. **Sowing and Raising Parental Lines**: Parental lines must be sown at specific intervals to ensure synchrony in flowering. Different growth rates of the lines require careful planning of sowing dates. This synchrony, or "nick," ensures that the A-line is receptive to pollen from the R-line during its blooming period.
3. **Pollination Management**: In hybrid seed production, pollen from the restorer line must successfully pollinate the sterile line. This process is managed in the field using techniques like hand pollination or natural pollination through wind or insects. Various measures, including planting in isolation plots and using buffer zones, are employed to prevent contamination from unwanted pollen sources.
4. **Supplementary Pollination**: To ensure good seed set, supplementary pollination techniques like shaking of R-line plants, manual transfer of pollen, or even bee-mediated pollination can be utilized.
5. **Roguing**: Removal of off-types or unwanted plants (rogue plants) is essential to maintain the genetic purity of hybrid seeds. This is usually done during the vegetative and flowering stages of the crop.
6. **Harvesting and Processing**: After a successful pollination and seed set, the hybrid seeds are harvested, cleaned, dried, and processed for sale. Special care is taken to preserve seed vigor and purity throughout the post-harvest process.

Challenges in Hybrid Seed Production

- **Cost of Production**: Hybrid seed production is more labor-intensive and expensive compared to conventional seed production due to the need for synchronized flowering, rogueing, and controlled pollination practices.
- **Seed Purity**: Maintaining genetic purity in hybrid seed production is crucial. Contamination from unintended pollen sources or improper rogueing can significantly reduce the quality and yield potential of hybrid seeds.

- **Technical Expertise**: Farmers and seed producers need to be trained in specific techniques for hybrid seed production, such as pollen management and synchronizing parental lines.

Future Prospects

Advances in biotechnology and molecular breeding hold promise for further improving hybrid rice seed production. Techniques such as marker-assisted selection, genetic engineering, and molecular markers are being explored to streamline hybrid development processes. Moreover, the growing global demand for high-yielding and climate-resilient crops will continue to drive innovation in hybrid seed technology.

Conclusion

Hybrid seed production in rice offers immense potential for addressing global food security challenges by providing higher yields and better stress tolerance. However, it requires careful planning, technical expertise, and investment in research and development. By improving hybrid seed production techniques and ensuring the adoption of best practices by farmers, hybrid rice can play a pivotal role in sustainable agricultural development.

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LIVESTOCK TRANSFORMATION: NAVIGATING THE CHALLENGES AND OPPORTUNITIES OF THE 21ST CENTURY

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Introduction

Food security is defined as the availability of a sufficient quantity of food with appropriate quality supplied through domestic outputs or imports to reach a state of nutritional well-being where all physiological needs are always met. Rapid urbanization, increased purchasing power, and dietary change drive demand for richer diets and animal-origin proteins. Food and nutrition security has four dimensions: (i) food availability, (ii) food access, (iii) food utilization, and (iv) food stability. A large population can be guaranteed food security by implementing livestock farming and promotion to sustain food demand. Depending on resource quality, environmental factors, and social and economic contexts, there are various types of livestock production systems, and they vary considerably in sustainability.

Overview of the human population

The global human population has doubled from 1960 to 2010 and is projected to reach about 9.7 billion by 2050, and 10.9 billion by 2100, presenting significant challenges for global food security due to a substantial increase in the global demand for food (Lemaire et al., 2015). The population of India stood at 1.44 billion in January 2024. Data shows that India's population increased by 13 million (+0.9 percent) between early 2023 and the start of 2024. 48.4 percent of India's population is female, while 51.6 percent of the population is male. In addition to insufficient food supply and low income from small farms, unsafe and inadequate nutrient supply from food complicates food security achievement for low-income people.

Requirement of Feed

The world needs 2800 million tons of cereals to properly feed everyone, of which global production amounts to just 2100 million tons. This gap in need and development leaves more than 868 million undernourished citizens worldwide, with 850 million of them living in developing countries (Tiwari et al., 2014). The population is expected to reach around nine billion by 2050 (Kharas, 2010). Global demand for livestock products is forecast to double by 2050, based on projections of world population growth, increasing revenue, and more urbanization. Feeding this large population will be very challenging with daily changing climatic conditions.

Significance of Livestock Production

Globally, the main sources of food have shifted in the past 50 years from grains to animal protein, which has increased livestock production significantly even though this decreases energy efficiency. With global populations rising rapidly, global agriculture faces the challenge of producing enough food to meet increasing demand in conditions of changing climate and resource depletion (Descheemaeker et al., 2016). Misuse of natural resources (excessive and destructive use) results in greater depletion and environmental pollution, which negatively impacts food security in the near and long term for all consumers (NRC, 2010). In the last 70 years, pressure on agricultural land has increased considerably due to agricultural modernization, industrialization, and mechanization which has increased the environmental problems. This industrialization has led to specialized intensive cropping systems, short crop rotations, intensive grazing, overuse of machinery and inappropriate agricultural management practices can result in water pollution, soil erosion, lack of pollinator habitat, and offsite contamination.

The livestock provides food and non-food items to the people-

1. **Food:** The livestock provides food items such as Milk, Meat, and Eggs for human consumption. India is the number one milk producer in the world. It is producing about 230.58 million tonnes during 2022-23. The per-capita available of milk is 459 grams per day. Similarly, it is producing about 138.38 billion numbers eggs and 9.77 million tonnes of meat in a year. The per-capita availability of eggs is 101 eggs per annum. The total fish production in India is estimated at 175.45 lakh tonnes.

2. **Fibre and skins:** The livestock also contributes to the production of wool, hair, hides, and pelts. Leather is the most important product which has a very high export potential. India produces about 33.61 million Kg of wool.
3. **Draft:** Bullocks are the backbone of Indian agriculture. Despite lot of advancements in the use of mechanical power in Indian agricultural operations, the Indian farmers especially in rural areas still depend upon bullocks for various agricultural operations. The bullocks are saving a lot on fuel which is a necessary input for using mechanical power like tractors, combine harvesters, etc. Pack animals like camels, horses, donkeys, ponies, mules, etc are being extensively used to transport goods in different parts of the country in addition to bullocks. In situations like hilly terrains mules and ponies serve as the only alternative to transport goods. Similarly, the army has to depend upon these animals to transport various items in high areas of high altitude.
4. **Dung and other animal waste materials:** Dung and other animal wastes serve as very good farm yard manure and the value of it is worth several crores of rupees. In addition, it is also used as fuel (biogas, dung cakes), and for construction as poor man's cement (dung).
5. **Storage:** Livestock are considered 'moving banks' because of their potential to be disposed of during emergencies. They serve as capital and in cases of landless agricultural labourers many times it is the only capital resource they possess. Livestock serve as an asset and in case of emergencies, they serve as a guarantee for availing loans from the local sources such as money lenders in the villages.
6. **Weed control:** Livestock are also used as biological control of brush, plants, and weeds.
7. **Cultural:** Livestock offers security to the owners and also add to their self-esteem especially when they own prized animals such as pedigreed bulls, dogs and high yielding cows/ buffaloes, etc.
8. **Sports/recreation:** People also use the animals like cocks, rams, bulls etc for competition and sports. Despite the ban on these animal competitions the cock fights, ram fights and bullfights (Jallikattu) are quite common during festive seasons.
9. **Companion animals:** Dogs are known for their faithfulness and are being used as companions since time immemorial. When the nuclear families are increasing in number

and the old parents are forced to lead solitary lives the dogs, and cats provide the needed company to the latter thus making them lead a comfortable life.

Challenges in sustainable livestock production

Overall, the emphasis on livestock sustainability issues in high-income countries including Northern and Western Europe is on the environment, including greenhouse gas reduction as well as animal health and welfare.

1. **Environmental challenges**: Environmental challenges mainly focus on the management of climate change and natural resources as well as the reduction of greenhouse gases. Improved productivity and biodiversity as well as the reduction of greenhouse gases can be accomplished by proper animal health as well as better nutrition and management.
2. **Economic challenges**: Economic challenges mainly relate to trade, markets, and less investment in small-scale farms. The functionality and accessibility of markets for livestock and livestock products are very essential for food security.
3. **Social challenges**: Social challenges are about child labor and gender discrimination. Pastoralist societies often prefer men for work and child labor is very common in these societies. In intensive systems, the conditions for farmers and other workers are unsatisfactory and they have a low social status.
4. **Health challenges**: Health challenges effectively focus on the "one world one health" concept and deal with human as well as animal health. Productivity-reducing animal diseases are a direct threat to food security. The risk of livestock diseases may be immense and is a big reason for poor production in low-income countries.
5. **Animal welfare challenges**: There are very different views on animal welfare across countries. This is therefore a major challenge to reconcile increasing productivity and welfare in the developing, and often uncontrolled, intensive livestock systems around the world.

Future demand for sustainable livestock production

More than 35% of the cereals produced worldwide are currently fed to livestock (Trostle, 2008). In India, the total consumption of concentrated feed was only 47 million tons in 2003, during which food grain production amounted to 174.7 million tons. However, the demand for concentrated feed is estimated to increase marginally to 55.7 million tons in 2050 with a food and feed grain demand of 377 million tons (Dikshit and Birthal, 2010). By 2050, it is estimated that the intake of meat and dairy products will rise by 173% and 158%, respectively. The typical Indian food habit is also turning to livestock products.

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THE RICH HISTORY AND VIBRANT PIGMENTS OF POMEGRANATE DYE

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Introduction

Pomegranate dye is a captivating natural colorant with a storied past and a diverse array of modern applications. This document will take you on a journey through the botanical characteristics, traditional extraction methods, and sustainable uses of this remarkable plant-based pigment.

History of Pomegranate Dye

The use of pomegranate dye can be traced back to ancient Mesopotamia, Persia, and the Mediterranean regions. Archaeologists have found evidence of pomegranate-dyed textiles dating as far back as the 4th millennium BC. In ancient times, the rich crimson hues of pomegranate dye were highly prized and associated with royalty, spirituality, and status. The dye was laboriously extracted from pomegranate rinds, seeds, and flowers, making it a valuable and labor-intensive commodity.

Throughout history, pomegranate dye has been used to color the garments of emperors, nobility, and religious figures. In the Byzantine Empire, the color "Tyrian purple" was reserved exclusively for the imperial court. This luxurious shade was often achieved through a combination of pomegranate and other natural dyes. Pomegranate dye also played a significant role in traditional Indian, Persian, and Turkish textile arts, adorning carpets, shawls, and other cultural textiles.

Botanical Characteristics of Pomegranate

The pomegranate (Punica granatum) is a deciduous shrub or small tree native to the regions surrounding the Mediterranean Sea and the Himalayas. The plant is known for its distinctive, leathery-skinned fruit, which is filled with juicy, ruby-red arils (seed sacs) containing edible, tart-flavored seeds. It is the pigments within these arils that give pomegranate dye its vivid hues, ranging from deep crimson to vibrant pink.

Pigment Composition in Pomegranate

The primary pigments responsible for the color of pomegranate dye are a group of compounds known as anthocyanins. These water-soluble pigments are found in the fruit's arils and peel, and they can exhibit a range of hues depending on the pH of the environment. The specific anthocyanins present in pomegranate include cyanidin, delphinidin, and pelargonidin, which contribute to the dye's rich, red-based tones.

1) **Anthocyanins**

The primary pigments responsible for the color of pomegranate dye are a group of compounds known as anthocyanins.

2) **pH-Dependent**

The anthocyanins in pomegranate can exhibit a range of hues depending on the pH of the environment.

3) **Varied Tones**

The specific anthocyanins present, including cyanidin, delphinidin, and pelargonidin, contribute to the dye's rich, red-based tones.

Traditional Pomegranate Dye Extraction Methods

For centuries, pomegranate dye was extracted using traditional, labor-intensive techniques. The most common method involved crushing the fruit's arils and peel, then boiling the resulting liquid to concentrate the pigments. The dye could then be applied directly to textiles or used to create a mordant, which helped the color adhere more effectively to the fabric. These traditional methods often relied on the use of natural mordants, such as alum or iron, to enhance the vibrancy and durability of the dye.

Crushing Arils

The most common traditional method involved crushing the fruit's arils and peel to extract the pigment-rich liquid.

Boiling and Concentrating

The extracted liquid was then boiled to concentrate the pigments, creating a potent dye.

Natural Mordants

Traditional methods often used natural mordants, such as alum or iron, to enhance the vibrancy and durability of the dye.

Modern Pomegranate Dye Extraction Techniques

While traditional methods are still in use, modern technology has allowed for the development of more efficient and scalable pomegranate dye extraction processes. These techniques often involve the use of solvents, such as alcohol or water, to extract the pigments from the plant material. The extracted dye can then be further purified and concentrated, making it more suitable for commercial applications. Additionally, some modern methods utilize enzyme-assisted extraction or microwave-assisted extraction to enhance the yield and quality of the pomegranate dye.

1) **Solvent Extraction**

Modern techniques often use solvents, such as alcohol or water, to extract pigments from pomegranate plant material.

2) **Purification and Concentration**

The extracted dye can be further purified and concentrated, making it more suitable for commercial applications.

3) **Enzyme-Assisted Extraction**

Some modern methods utilize enzyme-assisted extraction to enhance the yield and quality of the pomegranate dye.

4) **Microwave-Assisted Extraction**

Microwave-assisted extraction is another technique used to improve the efficiency of pomegranate dye extraction.

5) **Supercritical CO2 Extraction**

An advanced extraction method involves using supercritical carbon dioxide (CO_2) to selectively capture the pigments and other valuable compounds from the pomegranate. This technique is environmentally friendly and can yield a highly pure dye product.

Applications of Pomegranate Dye

Pomegranate dye has a wide range of applications, both historical and contemporary. In the past, it was commonly used to color textiles, such as silk, wool, and cotton, as well as to dye leather and paper. Today, pomegranate-based pigments are still used in the textile industry, but they are also finding their way into cosmetics, food coloring, and even as natural dyes for hair and skin. Additionally, the dye's antioxidant properties have led to its use in the development of sustainable and eco-friendly paints and coatings.

1) Textiles

Pomegranate dye has been used historically to color a variety of textiles, including silk, wool, and cotton.

2) Cosmetics

Modern applications of pomegranate dye include its use in cosmetic products, such as lipsticks and blushes.

3) Sustainable Paints

The dye's antioxidant properties have led to its use in the development of eco-friendly paints and coatings.

Sustainability and Environmental Impact

As a natural, plant-based pigment, pomegranate dye offers a more sustainable alternative to synthetic dyes, which can have a significant environmental impact. The use of pomegranate dye supports local economies and traditional crafts, while also reducing the carbon footprint and chemical pollution associated with the textile and cosmetic industries. Additionally, the pomegranate plant is a renewable resource, and its cultivation can contribute to the preservation of biodiversity and the development of circular economies. As the demand for eco-friendly products continues to grow, pomegranate dye is poised to play an increasingly important role in the transition towards a more sustainable future.

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"NANO UREA: REVOLUTIONIZING SUSTAINABLE AGRICULTURE FOR ENHANCED CROP YIELD"

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Abstract

Nano urea is a revolutionary agricultural input based on nanotechnology that offers a highly efficient alternative to conventional urea fertilizers. With a particle size of 20-50 nm, it boasts an absorption efficiency exceeding 80%, significantly enhancing nitrogen uptake by plants when applied as a foliar spray. Nano urea minimizes nutrient losses from volatilization and leaching, thus reducing environmental pollution and contributing to sustainable agriculture. Developed by IFFCO in India, nano urea has demonstrated improvements in crop growth, nutrient uptake, and yield across various crops. A 500 ml vial of nano urea can replace a 45 kg bag of traditional urea, making it a cost-effective, eco-friendly option for farmers. Additionally, its controlled release mechanism, extended shelf life, and reduced carbon footprint further highlight its benefits in modern agriculture.

Introduction:

"Nano Urea is a nanotechnology based revolutionary Agri-input which provides nitrogen to plants." When compared to conventional urea prill, it has a desirable particle size of about 20-50 nm and more surface area (10,000 times over 1 mm urea prill) and number of particles (55,000 nitrogen particles over 1 mm urea prill).

Nano urea has an absorption efficiency exceeding 80%. In its liquid form, it can be sprayed directly on the leaves of crops during two crucial growth stages. A 500 ml vial of nano urea can replace a 45 kg bag of conventional urea. In modern agriculture, the use of nano fertilizers is vital as they are specifically formulated and designed with delivery mechanisms that ensure optimal uptake by plants. In addition to this, Nano urea helps in minimizing the environmental footprint by reducing the loss of nutrients from agriculture fields in the form of leaching and gaseous emissions which used to cause environmental pollution and climate change.

Nano urea was first produced at IFFCO's Nano Biotechnology Research Centre in Kalol, Gujarat, India in 2021. It was developed as a more efficient alternative to traditional urea fertilizers, which can suffer from high losses through volatilization, leaching, and runoff. The nano-sized particles in nano urea are designed to improve uptake by plants, reducing the amount required compared to standard urea.

Mechanism of action of nano urea:

Nano urea, a liquid fertilizer with nano-sized particles, works by enhancing nitrogen absorption directly through plant leaves. Its small particle size allows for quick and efficient entry into the plant's cells, where it is rapidly utilized. This results in an absorption efficiency of over 80%, significantly higher than traditional urea. By delivering nitrogen directly to where it is needed, nano urea minimizes losses due to leaching and volatilization, common issues with conventional urea. This targeted delivery supports healthier plant growth, improves yield, and reduces the environmental impact of excess nitrogen in the soil.

In the context of sustainable agriculture, nano urea helps in reducing the overuse of fertilizers, conserving resources, and protecting soil health. One 500 ml vial of nano urea can replace a 45 kg bag of granular urea, reducing the volume of fertilizer needed. This reduction in input lowers greenhouse gas emissions associated with fertilizer production and transportation. Additionally, the precise application and enhanced efficiency of nano urea contribute to long-term sustainability by decreasing nutrient runoff into water bodies, thus mitigating pollution and promoting ecological balance.

Time & Method of Application:

- Mix 2-4 ml of Nano urea (4 % N) in one Litre of water and spray on crop leaves at its active growth stages.
- For best results apply 2 foliar sprays
- 1st spray: At active tillering/branching stage (30-35 Days after germination or 20-25 Days after transplanting)

- 2nd spray: 20-25 days after 1st spray or before flowering in the crop.
- Use flat fan or cut nozzles for uniform spraying on the foliage.
- Spray during morning or evening hours avoiding dew.
- It is advised to repeat the spray, if rain occurs within 12 hours of Nano urea spray.
- Nano Urea (liquid) is recommended for application only as a foliar spray at critical growth stages of crops.

Note – Don't cut off basal nitrogen supplied through DAP or complex fertilizers. Cut only top-dressed Urea which is being applied in 2-3 splits. Number of sprays of Nano Urea can be increased or decreased depending upon crop, its duration and overall nitrogen requirement.

Price of Nano Urea (liquid) is Rs 240 / 500 ml bottle. Nano Urea (liquid) is available at IFFCO member cooperatives (PACS), Farmer Service centers: IFFCO Bazar centers and retail outlets.

Working of nano Urea:

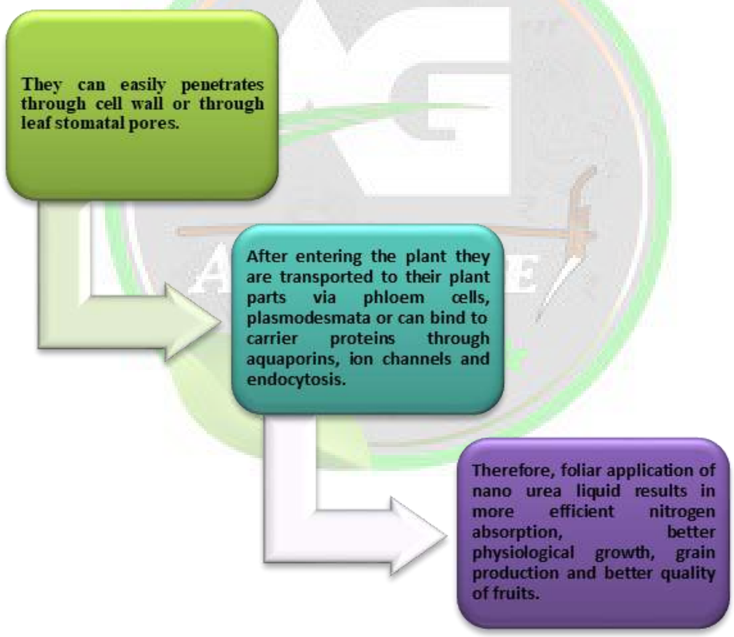

Fig. no. 1 How nano urea works in plants. (Kumar *et al.*, 2023)

Nano urea has been shown to have a positive effect on crop growth and development:

i. Increased plant height: Nano urea can increase plant height in crops like wheat, pigeonpea, and rice.
ii. Improved nutrient uptake: Nano urea's small particle size and large surface area allows it to penetrate the plant more easily, increasing nutrient uptake.
iii. Increased grain yield: Nano urea can increase grain yield in wheat.

iv. Improved growth parameters: Nano urea can improve plant population, leaf area index, and number of tillers per plant.

v. Increased dry weight: Nano urea can increase dry weight in crops like pigeonpea.

vi. Increased number of grains or seeds: Nano urea can increase the number of grains or seeds in crops like rice and maize.

vii. Increased cob length: Nano urea can increase cob length in crops like maize.

viii. Increased leaf length and width: Nano urea can increase leaf length and width in crops like maize.

ix. Increased stover yield: Nano urea can increase stover yield in crops like maize.

Table No. 1 Comparison between nano and conventional urea

Sr.	Characteristics	Nano Urea	Conventional Urea
1.	Year of invention	2021	1823
2.	Particle size	32nm	1mm
3.	Effect on soil	Enhance quality	Acidifies soil
4.	Availability in plants	Throughout the life cycle	3-4 days
5.	Intake medium	Direct through leaves	Through roots
6.	Method of use	Foliar Spray	Soil application as basal dose
7.	Pollution	No	Air, Water and Soil

(Laksman *et al.*, 2022)

Nano urea offers several advantages over conventional urea

i. Efficiency: Nano urea is up to 85% efficient, compared to the roughly 25% efficiency of conventional urea.

ii. Environmental impact: Nano urea helps reduce environmental impact by mitigating soil, water, and air pollution.

iii. Nutrient delivery: The small particle size and controlled release of nano urea ensure more efficient and precise nutrient delivery to crops.

iv. Shelf life: Nano urea has a longer shelf life than conventional urea.

v. Cost: Nano urea can be a cost-effective option for farmers.

Benefits of Nano urea

i. Nano Urea is produced by an energy efficient environment friendly production process with less carbon footprints.
ii. Increased availability to crop by more than 80% resulting in higher Nutrient Use efficiency.
iii. Its application to crops as foliar fertilization enhances crop productivity to the tune of 8% with commensurate benefits in terms of better soil, air and water, and farmers profitability.

Conclusion

Nano urea represents a significant advancement in agricultural technology, offering numerous benefits over traditional urea fertilizers. With its high absorption efficiency, reduced environmental impact, and precise nutrient delivery, nano urea not only enhances crop growth and yield but also contributes to sustainable farming practices. By minimizing nutrient loss and lowering greenhouse gas emissions, nano urea supports environmental conservation while providing a cost-effective solution for farmers. As an innovative tool in modern agriculture, nano urea has the potential to revolutionize nutrient management and promote sustainable agricultural practices for a more productive and eco-friendly future.

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DECODING BANANA DEFENSE: THE ROLE OF NUDIX HYDROLASES IN STRESS RESPONSE AND IMMUNITY

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Introduction

Nudix (Nucleoside diphosphates linked to some moiety X) hydrolases (NUDX) are a family of pyrophosphatases containing a highly conserved amino-acid sequence, the Nudix box GX5Ex7REUXEEXGU, where U is a bulky hydrophobic amino acid such as Ile, Leu or Val. These enzymes are found ubiquitously across all domains of life, including archaea, eukaryotes, and prokaryotes (McLennan 2006; Kraszewska 2008). The first member of the Nudix family to be characterized was the MutT protein of *Escherichia coli*, hence the original name of this group of enzymes, the MutT family. Nudix hydrolases have been identified in many species, including archaea, bacteria, eukaryotes, and viruses (Gunawardana et al., 2009). They were originally defined as housecleaning enzymes, eliminating toxic metabolites from the cells (Bessman et al., 1996). Nudix hydrolases constitute a superfamily of pyrophosphatases catalyzing the hydrolysis of nucleoside diphosphates linked to different X moieties (Bessman et al., 1996).

Members of the Nudix hydrolase superfamily all share a conserved Nudix box. This Nudix motif is formed by a loop–a helix–loop structure, and provides binding sites for divalent cations (usually Mg^{2+} or Mn^{2+}) that play a crucial role in catalysis. The presence of these cations is required for the activity of the Nudix proteins. The substrate specificity and the catalytic reaction mechanism are also determined by regions outside of the Nudix motif (McLennan, 2006; Gunawardana et al., 2009). For example, enzymes acting on Coenzyme A share a motif that is located outside of the Nudix box and is involved in substrate recognition

(Kupke et al., 2009). These regions, together with the Nudix motif, form an α/β/α sandwich structure, which is also known as the Nudix fold (Mildvan et al., 2005). This fold is shared by the isopentenyl diphosphate isomerases, which, together with Nudix hydrolases and other proteins, form a larger group. This group was previously called the Nudix suprafamily (McLennan, 2006), but is sometimes also referred to as the Nudix superfamily or the Nudix homology clan (Srouji et al., 2017).

Substrate of NUDX

NUDX enzymes are categorized into subfamilies based on their major substrates, which include adenosine diphosphate ribose (ADP-ribose), dinucleoside polyphosphates, nucleotide sugars, and deoxynucleoside triphosphates (dNTPs), 7,8-dihydro-8-oxo-deoxyguanosine triphosphate (8-oxo-dGTP), alcohols, dinucleotide coenzymes, NADH, NADPH, Thiamin diphosphate, 7-methyl GTP, Dihydroneopterin, GDP-mannose, CoA, Malonyl-CoA, Lauroyl-CoA, Myristoyl-CoA, ppGpp, ADP-glucose, CoA, Succinyl-CoA, Oxidized-CoA, ppGpp, and capped mRNAs (Yoshimura and Shigeoka, 2015). According to Fonseca and Dong (2014), NUDX may function as housecleaning enzymes to deal with excess nucleoside diphosphate and preserve cellular homeostasis because nucleoside diphosphates are typically regarded as hazardous metabolic intermediates and signalling molecules. Consequently, it was first thought that Nudix hydrolases would clean house by getting rid of extra harmful metabolites or regulating the availability of precursors in metabolic pathways (Bessman et al., 1996 and McLennan, 2006).

Role of Nudix Hydrolase enzymes

NUDX proteins are increasingly recognized for their regulatory roles in various physiological and biochemical processes, including metabolic regulation, plant immunity, and stress responses (**Fig.1**). These proteins adapt to changes in substrate content, degrading harmful substances or accumulating excess metabolic intermediates, and play crucial roles in protection, regulation, and signaling within the organism (Yoshimura and Shigeoka 2015). In recent studies, AtNUDX2 has been shown to maintain NAD and ATP levels during oxidative stress by recovering nucleotides from ADP-ribose, enhancing oxidative stress tolerance (Ogawa et al., 2009). AtNUDX6 and AtNUDX7 are involved in stress response and plant defense, with AtNUDX6 positively regulating the SA signaling pathway and influencing plant immune responses through NADH levels. Knockout and over-expression studies of AtNUDX6 demonstrate its role in modulating genes involved in SA-induced NPR1 activation. AtNUDX7, induced by various abiotic stresses, affects oxidative stress tolerance, seed germination, growth, and development by regulating NAD homeostasis (Ishikawa et al., 2010). In grapes, VvNUDXs play roles in stress detoxification and disease resistance pathways (Wang et al., 2020). AtNUDX1, a cytosolic NUDX protein, is involved in reducing oxidative DNA and RNA damage by hydrolyzing 8-oxo-(d)GTP. Knockout of AtNUDX1 increases 8-oxo-guanosine levels under stress conditions, highlighting its protective role. Other AtNUDX proteins, such as AtNUDX2, -6, -7, and -10, exhibit pyrophosphohydrolase activity, while AtNUDX11 specifically hydrolyzes CoA (Ogawa et al., 2005).

Fig.1: Physiological roles of nudix hydrolase in plants.

Wheat stripe rust (*Puccinia striiformis* f. sp. *tritici*, *Pst*) harnesses the nudx gene (TaNUDX23) to suppress ROS accumulation and contribute to compatibility between wheat and *Pst* (Yang et al., 2020; Li et al., 2022). AtNUDT7 negatively regulates the Enhanced Disease Susceptibility1 (EDS1) signaling pathway, which is one of the pivotal components in plant immunity (Bartsch et al. 2006). AtNUDX7 negatively regulates the plant defense response, and its loss-of-function mutation displays constitutive expression of defense-related genes and results in enhanced resistance against bacterial pathogen *Pseudomonas syringae* (Ge et al. 2007; Ge and Xia 2008). Similarly, *nh* genes have been reported to play a negative regulator in plant immune responses in *Arabidopsis*, where they play crucial roles in plant defenses and can impact the levels of salicylic acid (SA) (Bartsch et al., 2006; Jambunathan and Mahalingam, 2006; Ge and Xia, 2008; Ishikawa et al., 2009; 2010; Jambunathan et al., 2010; Ge et al., 2007; Dong and Wang, 2016).

Nudix hydrolase in banana

In the *Musa* A genomes, 30 putative NUDX genes with a nudix domain have been identified. These NUDX proteins range from 172 to 498 amino acids in length, with molecular weights between 19 and 54 kDa, and isoelectric points (pI) ranging from 5.43 to 9.51. Only a few of these proteins have signal peptides, which are 24 to 46 amino acids long. The NUDX genes in *Musa* are divided into eight subfamilies based on their substrates and are classified by their predicted sub-cellular localization into the cytosol, chloroplast, mitochondrion, nucleus, plasma membrane, vacuole, and extracellular space. These genes are unevenly distributed across all 11 chromosomes, with chromosome 10 containing the most (7 genes). The expansion of NUDX genes in bananas has been driven by segmental and tandem duplications. These genes were found to be differentially expressed upon *Fusarium oxysporum* f. sp. *cubense* (*Foc*) and *Pseudocercospora eumusae* which causes the wilt and leaf spot diseases in banana, respectively.

Conclusion

The physiological roles of NUDXs in plants are diverse and critical, spanning from the sanitization of oxidized nucleotides to the regulation of stress responses, metabolism, and mRNA turnover. These enzymes play essential roles in maintaining cellular homeostasis, enhancing stress tolerance, and modulating plant growth and immune responses. The multifaceted functions of NUDXs highlight their importance in both abiotic and biotic stress adaptation, making them vital for the survival and development of banana under various environmental conditions. Studying NUDXs in banana can provide valuable insights into improving stress resistance, ensuring better crop yield, and enhancing overall plant health.

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REVITALIZING SOIL WITH OIL CAKES: ORGANIC SOLUTIONS FOR MODERN FARMING

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Abstract

Oil cakes, nutrient-dense by-products of oilseed extraction, are becoming increasingly important in organic farming. They are rich in essential nutrients like nitrogen, phosphorus, and potassium, which are crucial for soil fertility, microbial activity, and water retention. They also contribute to pest management by containing natural compounds that deter pests, reducing the need for chemical pesticides. This dual functionality makes oil cakes a cornerstone in organic farming systems, emphasizing natural and sustainable inputs. Oil cakes align with the principles of circular economy and waste reduction, repurposing agricultural waste and contributing to environmental conservation. They foster healthier crops and support soil health restoration, a crucial aspect in combating degradation caused by conventional farming practices. In the context of modern agriculture, oil cakes offer a viable alternative to chemical fertilizers and pesticides, enhancing soil fertility, improving crop yields, and reducing chemical inputs. As global agriculture shifts towards sustainability, the adoption of oil cakes could ensure food security while preserving ecological balance.

Keywords: Oil Cakes, Organic Farming, Soil Fertility, Sustainable Agriculture, Natural Pest Control

Introduction

Organic farming is a sustainable alternative to conventional methods that often rely on synthetic inputs. Natural fertilizers, such as oil cakes, are essential for enhancing soil fertility and promoting environmental sustainability. Oil cakes, derived from seeds like neem, mustard, groundnut, and sesame, are rich in essential nutrients like nitrogen, phosphorus, potassium, and micronutrients essential for plant growth. They improve soil structure and fertility gradually, encouraging microbial activity, enhancing water retention, and contributing to the formation of humus. This results in healthier crops and more resilient farming systems that can withstand environmental stresses. Some oil cakes also possess pest-repellent properties, such as neem cake, which can control a wide range of pests, reducing the need for chemical pesticides. This dual role of providing nutrition and protection makes oil cakes an invaluable resource in organic farming. As modern agriculture faces challenges like soil degradation, climate change, and sustainable practices, oil cakes offer a promising solution by fostering a healthy, balanced, and productive soil ecosystem, ensuring long-term agricultural sustainability.

Need for deoiled seed cakes as Organic Manure

Indian soils being very poor in organic matter and major plant nutrients. Addition of regular doses of organic manures in requisite quantities can help restoration of soil health and compensate the loss of basic nutrients of every year from soil due to uptake of plants. Use of organic manure is extremely essential for better plant productivity and maintaining the fertility of soil to ensure sustainable production. Deoiled cakes are the by-products of oil seed crops or trees. After oil is extracted from oil seeds, the remaining solid portion is called deoiled cakes. It is widely used as animal feed or organic manure. Deoiled seed cakes from various plants have shown promise as organic fertilizers and substrates for enzyme production. Jatropha curcas deoiled cake improved crop yields and soil nutrient content when used as a partial or full replacement for chemical fertilizers in maize, soybean, and chickpea cultivation. Similarly, it enhanced growth and yield in Chinese kale, tomato, and sweet potato without leaving toxic phorbol ester residues in crops or soil. Neem and mustard deoiled seed cakes, combined with bio-fertilizers, significantly increased wheat growth, yield, and soil nitrogen content. Beyond agricultural applications, deoiled Jatropha cake served as an effective substrate for xylanase production by the thermophilic fungus *Scytalidium thermophilum*, yielding an enzyme useful in paper pulp biobleaching. These studies demonstrate the versatility and potential of deoiled seed cakes as sustainable alternatives in agriculture and biotechnology.

Types of Deoiled Cakes

A. Edible Oil Cakes

Are those cakes that are edible in nature. Such oil cakes are used for feeding to animals. Such as: Mustard oil cakes, Groundnut cake, Sesame or Til cake, Coconut cake etc.

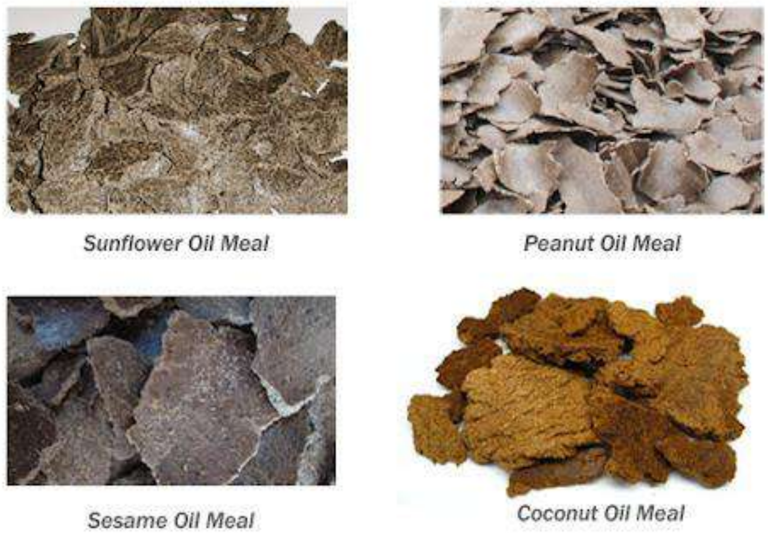

Figure 1 Commonly used edible oil cakes

B. Non-edible oil cakes

These oil cakes are not suitable for feeding to animals Therefore, they are mainly used as manures .These are a good source of nutrients. Such as: Castor cake,Neem cake, Mahua cake, Karanj cake, Sal meal cake etc.

Figure 2 Commonly used non -edible oil cakes

Why they are non-edible?

Non-edible oil seedcakes from plants like neem, mahua, karanj, and castor have various applications due to their unique properties. These cakes are rich in protein, with most containing over 20% crude protein. They exhibit antimicrobial and antioxidant properties, showing efficacy against both clinical and agricultural pathogens. Additionally, these cakes demonstrate termiticidal potential, with neem cake extracts causing 100% termite mortality within 72 hours. In agriculture, non-edible oil cakes can enhance nitrogen response in rice crops, with neem extract-treated urea yielding the highest rough rice production. However, these cakes contain a harmful toxic substance which make them unsuitable for feeding to cattle (Table 1). Various detoxification methods, including water washing, chemical treatments, and biological processing, have been explored to make these cakes safe for use in ruminant diets.

Table 1 Toxin compounds present in different oilseed cakes

Deoiled cakes	**Toxin compound(s)**
Mahua seed cake	Mowrin
Karanj cake	Karanjia, Pongamol, Glabrin
Sal seed cake	Tannic acid , glucosides
Castor cake	Ricin
Neem seed cake	Nimbia, Salamin
Jatropha cake	Jatropine

Importance of oilseed cakes

Oilseed cakes, the residues left after oil extraction, are valuable by-products with diverse applications, particularly in organic farming. Rich in protein, fiber, and bioactive compounds, these cakes are not only nutritious for livestock feed but also hold potential in various industries such as food, cosmetics, pharmaceuticals, and textiles. In agriculture, oilseed cakes serve as concentrated organic fertilizers that enhance soil properties—physically, chemically, and biologically. They are rich in essential nutrients like nitrogen, phosphorus, and potassium (NPK) (Table 2), as well as vital micronutrients necessary for plant growth. The narrow carbon-to-nitrogen (C) ratio of oilseed cakes makes them quick-acting organic manures, which can significantly improve soil reaction and fertility. Despite challenges like allergenicity, toxicity, and the presence of anti-nutritional compounds, oilseed cakes present substantial opportunities for sustainable agriculture, contributing to a circular economy by reducing waste and environmental impact while providing valuable resources across various sectors.

Table 2. **Average nutrient content of oilseed cakes**

Oil-cakes	Nutrient content (%)		
	N	P	K
Non edible oil-cakes			
Castor cake	4.3	1.8	1.3
Karanj cake	3.9	0.9	1.2
Mahua cake	2.5	0.8	1.2
Safflower cake	4.9	1.4	1.2
Neem cake	5.2	1.9	1.6
Edible oil-cakes			
Cotton seed cake	6.4	1.5	1.3
Groundnut cake	7.3	2.9	2.2
Linseed cake	4.9	1.4	1.3
Niger cake	4.7	1.8	1.3
Rape seed cake	5.2	1.8	1.2
Sesamum cake	6.2	2.0	1.2

Effects of oil cakes on soil quality

Soil quality is the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation (USDA Natural Resources Conservation Service). Incorporation of oilcakes in soil improves the soil health and quality as it positive influences the soil physical, chemical and biological properties.

Physical properties

Soil application of oilcakes produces organic acids as well as humus by decomposition process. These products bind the adhering soil particles together and thus by facilitate soil aggregation process. The bulk density of soil is decreased due to increased pore space whereas no influence on particle density is reported.Increased soil porosity provides enough space for both air and water to stay in the soil. The addition of oil cake significantly increased the ability of soils to retain water under all applied tensions because of increased porosity as well as organic matter content in soil.

Chemical properties:

Oil seed cake as manure has been shown to influence the chemical properties of soil such as soil reaction, electrical conductivity, nutrient tranformation and availability, buffereing capacity, etc., desirably. Addition of oil cakes serves as a source of organic matter and both major and micro nutrients and hence it enhances the organic carbon as well as nutrient in soil significantly. Organic matter supplied by oilcakes to the soil keeps the plant nutrients bound on it and supply to the plant slowly for longer time and restricts nutrient immobilization in soil. Addition of cotton seed cakes in acid soil is reported to increase the soil pH and brings it towards neutral conditions .The pH of the soil treated with Pongamia seed cake was considerably increased and this property can be suitably exploited for acidic soil reclamation. Increase in electrical conductivity and exchangeable cations in association with oilcake application is also reported besides enhancing micronutrient content in soil .

Added organic matter through oilcakes releases organics acids as well complex organo-humus complexes which acts as a chelating agent for metal ions and improves micronutrients availability. In addition, humus and other organic acid produced from oilcakes enhances the buffering capacity by virtue of increasing CEC. Soil humus and organic acids has H+and OH- is part of the carboxyl (-COOH) group . When the soil become acidic OH- to be removed from humic acids and to react with H+ to form water and stabilize the soil pH. When the soil pH is increased, the release of H+ from carboxyl groups helps to buffer the increase in pH and at the same time creates the CEC. Due to this phenomenon, oilcakes are recommended for better nutrient management in alkali and acid soil besides its reclamation. Organic matter also counteracts the adverse effect of heavy metals supplied to the soil through pesticides and also neutralizes acidity or alkalinity created by fertilizers.

Effects on biological properties

Soil microorganisms are primary indicator of soil quality. Application of non edible oilcakes increased the organic matter of soil their by accentuate the microbial load in the soil as organic matter serves as energy source for microbes. The increased microbial leads to more metabolic activity that increase soil respiration significantly. Microbial load is directly determined by biomass carbon and nitrogen estimation whereas indirectly assessed by quantifying soil enzymes. Significantly higher amount of microbial biomass C and N were produced in oilcakes amended soils over control .The oil-seed cakes of neem *(Azadirachta indica)*, castor *(Ricinus communis)*, linseed *(Linum usitatissimum)*, groundnut *(Arachis hypogaea)*, mustard *(Brassica campestris)* and duan *(Eruca sativa)* were tested for their efficacious nature against plant-parasitic nematodes and soil-inhabiting fungi .The population of plant-parasitic nematodes such as *Meloidogyne incognita, Rotylenchulus reniformis, Tylenchorhynchus brassicae, Helicoty-lenchus indicus etc.*, and the frequency of pathogenic fungi *Macrophomina phaseolina, Fusarium oxysporum f. lentis, Rhizoctonia solarii, Septoria leguminum, Sclerotium rolfsii, etc.*, were significantly reduced by the incorporation of oil-seed cakes. A several-fold improvement was observed in plant-growth parameters such as plant weight, percent pollen fertility, pod numbers, chlorophyll content, nitrate reducíase activity in leaves and root-nodulation.

Improvement of problem soils:

The improvement of soil sickness associated with biological problem is also well known with oilcakes amendment in soil. The possible mechanisms involved in suppressing harmful pathogen in soil are:

(1) Release of pre-existing antibiotic compounds

(2) Generation of specific compounds, such as ammonia and fatty acids, during degradation

(3) Enhancement and/or introduction of antagonistic microorganisms

(4) Changes in soil physiology that are unsuitable for pathogens

Oil cakes act as absorbent for many pollutants especially heavy metals in soil. The low C: N ratio in certain oilcakes is considered as an eco-friendly bio sorbent.

Method of application

Oilcakes are very rich in nutrient contents and though insoluble in water, are quick acting organic manures. Their nitrogen becomes quickly available to the plants in about a week or ten days' time after application. Accordingly, it is essential to apply oil cakes 10-15 days before sowing as top dressing. Mahua cake, however, takes two months to decompose. Oilcakes need to be well powdered before application. Oil cakes are more effective in moist soil and wet weather conditions than in dry soil and dry weather conditions. The use of oilcakes on production of food grain crops such as wheat and rice is not recommended now on economic grounds. Neem cake is widely used as basal application for all the crops.

Constraints / limitation for non-edible oilcake exploitation

Oil cakes are relatively more costly compare to organic manures as well as inorganic fertilizers in many cases. Because of its costly nature, it increases the cost of farming considerably and reduces farm income compared to other regular manure usage. Most of the oilcake possesses certain bioactive compounds specific to the particular plant species. These compounds act as an allelopathic agent, which restricts it use as a fertilizer agent. In fact, several studies have reported phytotoxic and antimicrobial effects of different oil cakes due to its phenol, organic acids and other complex constituents . Many oil cakes are not yet studied completely for its use as fertilizer. The availability of oilcake is also problem in many regions. The oilcakes available in local market are in cake form that needs to be further processed towards uniform application in field. Besides all, the wide scope of oilcakes in soap making, cosmetics, botanical pesticide, etc prevents its use as nutrient source purposes.

Future thrust

More systematic studies on oilcakes usage as fertilizing agents is needed along with cost economics studies. The ready to use fertilizer products needs to be developed from oil cakes towards better marketing as well as availability. The allelopathic effects of certain oilcakes need to be identified and compatibility to commercial crops needs to be tested.The quality improvement in respect to oilcake amendment is to be quantified. Climate change mitigation potential especially carbon sequestration potential of of different non edible oilcakes in differnt soil ecosystem need to be explored.

Conclusion

It can be concluded that the application of deoiled cakes as organic manures enhances the growth and biomass production of tree seedlings. Also low C: N ratio its decomposition rate is faster than easily available for plant nutrients and reduces population of plant- parasitic nematodes. Among various deoiled seed cakes mahua, neem, castor, sal, karanj, mustard etc. proved that the good potentiality of deoiled seed cakes as an effective and much cheaper source of plant nutrients.

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PAPAD MAKING IS A PROFITABLE ENTERPRISE FOR RURAL WOMEN

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Introduction

In past days our great grand mother, grand mother, mother and neighbour women foke together used to plan and prepare the papad for the whole year. Summer is the best time to do papad because during summer temperature is high which helps to dehydrate the materials quickly . in turn which helps for long duration of storage. Papad is one of favorite snack for small childrento old people. Various types of papad are prepared during festivals, marriage and for small parties.In rural areas many young girls have disconutied their studies . they were not allowed to go cities for their further studies such people these kinds of enterprises are inherent with them ,so there is one of the best enterprise suited for rural women. Which needs very less resources and finance.Many of women are working get in papad preparing industries. Some of the papads which can be prepared and taken as an enterprise are listed below,

- Rice papad
- Ragi papad
- Sago papad
- Potato papad
- Ash guard papad
- Tomato papad
- Moong dal papad

- Palak papad
- Raw jack fruit papad

Documentation of different papad preparation

1. **Rice papad**:-Generally papad are prepared all over the country, but rice papad is special in South India.

Ingredients

- Rice flour -2 cup
- Sago flour-¼ cup
- Water- 4 cup
- Green Chilli- 4 to 6
- Jeera- 1 teaspoon
- Hing – ¼ teaspoon
- Oil – 1 spoon
- Salt as per taste

Procedure:-

Boil water in a wide vessel with one tablespoon of oil and salt . When the water starts to boil, add rice flour, sago flour, green chilly paste, hing, cumin and salt sim it and dunk it for 30 seconds. Then knead the dough so that it does not become lumpy. Bake it in low flame and let cool. Knead it and make it into small balls. Take two thin sheets and spread oil on one sheet and put small ball on sheet and spread oil on the other sheet and roll it. Dry the papad in the sun for two days. After drying well on both sides, take it out in airtight containers. We can take it out and fry it in oil whenever we want. We may also prepare a chat from rice Papad.

2. **Ragi papad**:- Ragi papad is called Nachnipapad or Naglipapad. It is mostly prepared in Maharashtra. It is brown in color and has a slightly coarse texture. Apart from this unique color, texture and taste, the use of ragi has additional health benefits

.**Ingredients**

- Ragi flour - 2 cup
- Black gram flour- ½ cup
- Sago flour – ½ cup
- Chilli powder –1 tea spoon

- Oil- 2 tea spoon
- Salt as per taste

Procedure:- :- Sift together ragi flour, black gram flour and sago flour. Add salt and properly grounded pepper, cumin and crushed powder to the dough. Add some oil to the mixture and add water to make a stiff dough. Leave the kneaded dough for half an hour. Then add some oil and knead again. Make small balls of the dough and pat it flat and dry it in the sun.

3. Sago papad:- This papad is mostly eaten on festival occasions or fasting. It is usually prepared with a small amount of spices so that you can enjoy the healthy flavor of sago with every bite of this dish. It fills the stomach quickly and gives fullness.

Ingredients

- Sago – ½ cup
- Water-2 ½ cup
- chilly– 2
- cumin seeds- 2 teaspoon
- Salt as per taste

Procedure:- :- Soak sago for four to five hours. Then put the soaked sago in a pan and add some water and boil it. Then add chili paste, black pepper powder and salt to taste. Let this mixture cook for about ten minutes. There should be some manual handling. Choose the oven so that this mixture gradually thickens. Then put the mixture of sago papad on a thin sheet with the help of a spoon in the shape of small papad and dry it in the sun.

4. Potato papad:- potato papad is made with boiled and mashed potatoes. Potato papad is popular in places like Delhi, Uttar Pradesh and Punjab.

Ingredients

- Chilli powder- ½ spoon
- Cumin seeds- 1 to 2 teaspoon
- Oil- 1 teaspoon
- Salt as per taste

Procedure:- Boil the potato and remove its peel and mash it, add chilly powder, salt , oil and cumin to it and make the mixture into dough. Then take small balls from the dough and roll them on a thin sheet and dry them.

5.Ash guard papad:-this is the recipe for a traditional fritter from Andhra Pradesh called budida gummadikaya vadiyalu. Gummadikaya vadiyalu savory in taste with abundant antioxidant rich nutrients to help boost immune system and promote overall health.

Ingredients

- Urad dal – 1 cup
- Red chilly- 5 to 6
- Green chilly- 2 to 3
- Hing – 2 pinch
- Salt as per taste

Procedure:- Soak the urad dal for 3 hours. Cut the ash guard into small pieces. Grind soaked gram, chopped ash guard, green chillis, red chilllis, little salt to taste as hing. Spoon the ground mixture onto a plastic sheet and let it dry in the sun.

- ➢ Ash guard has a significant fiber content which helps to prevent instances of constipation bloating and cramping of the stomach

6.Horse gram papad:-Horsegram papad or Huruli happala is the most unique and flavourful Karnataka papad. Prepared using horse gram , this spicy papad can either be roasted or fried . it is typically consumed as an accompaniment during lunch and dinner.

Ingredients

- Horse gram – 1 cup
- Urad dal – ½ cup
- Garlic – 1
- Curry leaves – 4 to 5
- Coriander leaves
- Cumin powder- ½ tablespoons
- Block pepper–½ tablespoon
- Butter milk- ¼ cup
- Turmeric powder – ¼ tablespoon

- Hing - 2 pinch

Procedure

Soak 1 cup of horse gram overnight. Wash the horse gram with water and put it in a cloth, tie a tight knot and keep it closed in a pot. Keep the horse gram like that for a day or two and let the horse gram sprout. By sprouting the pods, the husk can be removed quickly. Dry the sprouted pods in the sun. To make papad we need only gram from which that sun-dried kernel can be separated very easily. Remove the husk of the grain and grind the horse gram to prepare the flour. If the peel is not removed, the papad will turn black. Separate the pods and take half a cup of urad dal and make powder and papad flour is ready. Then add garlic, curry powder, coriander leaves, cumin powder, chili powder, buttermilk and turmeric and grind it. Add savory powder, salt to taste and hing to the flour. Then add the ground mixture to the flour and mix. Teach them not to pour water. Knead the dough hard. Keep that dough in a bowl and let it soak. Then knead the dough and make small balls and roll the papad one by one. Papad should not be dried in the sun, it should be dried in the shade first by placing it on a cloth. Then stack all the plates on top of each other in one plate and cover the other plate and place a weight on it. Keep it like this all night and dry it in the sun.

- Consuming horse gram in meals can reduce asthma and indigestion problems. Due to fiber content in bean kernels, it reduces stomach problems.

7. Tomato papad:-It is a delicious and crispy Indian snack that is made from a combination of tomato paste and blend of spices. This unique variation of papad adds the tangy and savory flvour of tomatoes to the traditional papad, resulting in a delightful taste experience.

Ingredients

- Sago- 1cup
- Tomato- 4
- Chilly powder – 1 teaspoon
- Salt as per taste

Procedure:- First put sago in boiling water and cover it. Grind the soaked sago after 2 to 3 hours. Then chop the tomato and grind it. Add crushed tomato juice to the ground sago. and saute for 2 to 3 minutes. Put the taught mixture in a pot and add 2 cups of water from the cup of sago and boil it till it boils. It turns red. Then turn off the stove and let it cool for

4 to 5 minutes. Then put the papal in a circle with a spoon on a plastic sheet and dry it in the sun. If the papad is placed on a plastic sheet, it can be easily removed after drying.

8. Moong dal papad:-A papad is a thin Indian wafer. It is crisp,round flat bread. This papad has the goodness of moong flavoured with a blend of spices, block pepper and salt .

Ingredients

- Moong dal
- Urad dal
- Block pepper
- Hing
- Salt as per taste

Procedure:- First, put the moong dal in a mixer jar and make it into a powder. Similarly, make the urad dal into a powder. If you are doing it in a small quantity, grind it in a mixer. If you have a large quantity, put it in a mill. Mix moong dal powder and urad dal powder and add black pepper, hing and salt to taste. Add little water to the flour and knead the dough hard. Make the kneaded dough into small balls. Then take one ball at a time and roll it in the shape of a papad. Similarly, roll the all balls and dry them in the shade. While drying, put the papad on top of each other and dry them. Dry these papad in the shade for one day and in the sun for another day. Dried can be eaten fried in oil or roasted on fire.

9. Palak papad:- Palak is a green leafy vegetable that is high in nutrient such as fibre , vitamins and minerals .palak has a high antioxidant activity and help to reduce the risk of chronic diseases.

Ingredients:

- Rice:- ¼ cup
- Green chilli:- 1
- Palak leaves:- 3
- White sesame seeds:- 1 tea spoon
- Salt as per taste

Procedure:- Soak the rice for 2-3 hours. Wash and grind with green chilli, salt and keep for fermentation for 8-10 hours. Wash the palak leaves and grind the leaves along with the ground paste again. pour into a container. the consistency should be slightly watery.

Add the sesame seeds. The batter is ready. Now heat water in a kadai. Keep a jali plate in it. Take two small stainless steel plates. Pour one tsp of batter in it and spread. Keep the plate on the jali plate, cover and steam cook the same for two plates. Take out from the kadai, allow to cool for a minute. Apply little oil and start peeling from the sides to remove the papad from the plate. Put it on a plastic sheet. Repeat the process for the remaining batter and dry the same under the fan. Later you can sun dry the same for an hour or two, when it cools down, store it in an airtight container.

10.Raw Jackfruit papad:-Halasinakayihappala or jack fruit papad is very popular and very common in malnad and Karavali region of Karnataka.

Ingrdients:

- 1 medium sized raw jack fruit
- Chilly powder:- 2 tsp
- Coriander seeds:-2tsp
- Salt as per taste

Procedure:- First cut the raw jackfruit and remove the pulp, remove the white fiber from the pulp and remove the seeds. Then steam the washed pulps for 20 minutes. After 20 minutes, grind the dried beans in a grinder or pebble. While grinding add some coriander seeds, savory powder and salt to taste and grind without adding water. Make small balls out of the ground flour and make balls by applying water to your hands . Take the papad making mishionand put a plastic sheet on it and oil it then put the ball on it put another oiled sheet on it and press the mishion and now the jackfruit Papad is ready. Similarly, make a papad from all the balls.Dry these papad in the sun for two days. Tie the dried papad on a thread and keep them closed in a container so that there is no air. These papad can also be consumed up to two years.

As per the taste of the individual these preparation of papad can be altered. Sundried papad are fried in oil and eaten with meal. it enhance the taste of the meal. Some people don't fry the papad in oil, they burn them in the fire, its taste is also good. Even the papad prepared in summer are processed by the women in an airtight container but that are eaten in rainy and winter season . Papad have health benefits in addition to increasing the taste of the tongue.

Conclusion

Everyone has a knowledge about papad making by observing their ancestors. Papad making is an employment providing activity from women from home. A woman without any qualifications does the papad. Some ladies an young stars can start papad making as an business in small scale through self help group and availe financial benefit from different banks and help them to lead a quality life. Even the government also encouraging and assisting small scale businesses. Government implementing many schemes for empowerment of women. Women has to make use of this schemes and her knowledge and to become an success full entrepreneur.

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GENOME EDITING: UNLOCKING THE FUTURE POTENTIAL IN FARMER'S FIELD

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Abstract

Plant genome editing has revolutionized agriculture by allowing precise modifications in plant DNA, offering immense potential for crop improvement. Technologies like CRISPR-Cas9 enable targeted changes such as gene knockout, replacement, or insertion with preciseness and high efficiency. This has profound implications for enhancing crop traits such as yield, nutritional quality, and stress tolerance. Genome editing can address critical challenges in agriculture, including pest resistance, disease resilience, and environmental sustainability. By targeting specific genes associated with desired traits, researchers can develop crops better suited to withstand biotic and abiotic stresses, reducing the need for chemical inputs and promoting sustainable practices. The future of plant genome editing holds immense potential for further innovation and advancement. Ongoing research into novel editing techniques like base editing and prime editing will expand the range and precision of genetic modifications. Adoption of genome editing in breeding programs and industries is expected to accelerate, driven by the demand for resilient and sustainable crop varieties. However, challenges such as regulatory frameworks and public acceptance require careful consideration to understand full potential of plant genome editing and its impact on global agriculture.

Key words: Genome editing, CRISPR Cas9, India

Introduction:

Genome editing, a revolutionary technology in modern biotechnology, has transformed the landscape of crop improvement by offering precise and targeted modifications to the genetic makeup of plants (Jinek et al., 2012; Cong et al., 2013). The process of targeted DNA alterations initiates with the creation of nuclease-induced double-stranded breaks (DSBs) which can undergo repair through one of two primary mechanisms found in nearly all cell types and organisms: homology-directed repair (HDR) and nonhomologous end-joining (NHEJ) (Li et al., 2020). As a result, targeted integration or gene disruptions occur, depending on the repair pathway employed (Figure 1). A subsequent collaboration of the Charpentier and Doudna laboratories resulted in the landmark 2012 Science paper, which kick-started the era of CRISPR-Cas9 genome editing (Deltcheva et al., 2011; Doudna, & Charpentier, 2014) Since the development of the Nobel prize winning CRISPR-Cas9 genome editing technique for plants, many researchers have adopted worldwide genome editing in research and breeding activities to develop improved crop varieties. Unlike traditional breeding methods, genome editing allows scientists to precisely edit specific genes, enabling the development of crops with enhanced traits such as improved yield, nutritional content, disease resistance, and environmental adaptability.

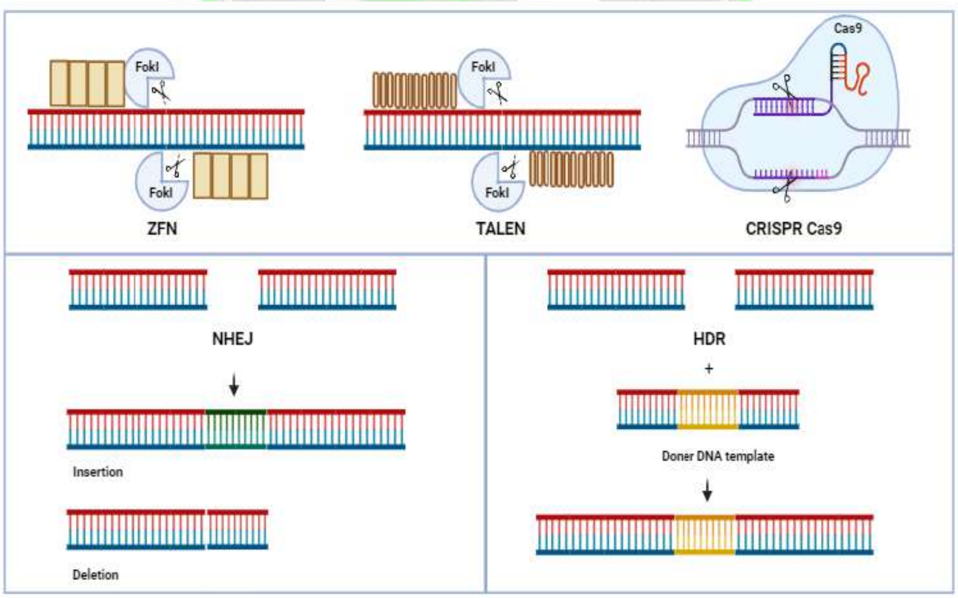

Figure 1: Most used genome editing tools.

Widely adopted genome editing tools:

CRISPR-Cas9 (Clustered Regularly Interspaced Short Palindromic Repeats-CRISPR associated protein 9), has emerged as a versatile genetic engineering tool, making it more accessible and efficient than ever before (Chen & Gao, 2013; Cong et al., 2013). This technology enables researchers to make targeted modifications to the DNA of crops by introducing precise changes at desired locations within the genome. As a result, genome-edited crops can be developed more rapidly and with greater precision compared to traditional breeding methods or earlier genetic engineering techniques. The potential of genome-edited crops to address global challenges in agriculture is vast (Manghwar et al., 2019). By improving crop resilience to biotic and abiotic stresses, such as pests, diseases, drought, and soil salinity, these crops offer a promising solution to food security issues in a changing climate. Moreover, genome editing holds the key to enhancing the nutritional value of crops, thereby addressing malnutrition and improving human health worldwide.

Recent advancements in genome editing technologies have further expanded the scope of crop improvement efforts. Novel CRISPR systems, such as CRISPR-Cas12 and CRISPR-Cas13, offer additional capabilities for precise genome editing, including base editing, epigenome editing, and RNA editing (Ahmad, 2023; Nigro et al., 2023). These advancements enable researchers to tackle more complex genetic modifications and develop crops with even more tailored traits to meet evolving agricultural needs. Furthermore, the application of genome editing in crop improvement has led to significant breakthroughs in various staple crops, including rice, wheat, maize, and soybean (Shimatani et al., 2017). These studies demonstrate the potential of genome editing to address specific challenges faced by different crop species, such as yield improvement, disease resistance, and nutritional enhancement.

India's status quo on commercialisation of genome edited crops:

In April 2022, the Union Ministry of Environment, Forests and Climate Change (MoEFCC), Government of India has made a landmark decision to allow with significant implications for the nation's agricultural progress. They have issued an order exempting specific gene-edited plants from strict biosafety regulations, signaling a potential shift in approach to agricultural development. The decision specifically waives the stringent regulations governing the commercialization of genetically modified transgenic crops (Rules 7-11 of the Environment Protection Act), for SDN1 and SDN2 plants. Instead, regulators will be based on the Institutional Biosafety Committee to confirm that the gene-edited crop is devoid of any foreign DNA. This decision permits field trials of crops developed through processes known as SDN-1 and SDN-2, which result in plants devoid of exogenously introduced DNA. These trials pave the way for potential commercial release. SDN-1 and SDN-2 involve modifying or enhancing specific traits within a gene without introducing new genetic material. However, products derived through

SDN-3, which does introduce foreign genes, are still categorized as GMOs. Insect-resistant Bt cotton was approved in 2002, is the only GMO crop currently allowed for cultivation.

Products/Research under consideration

- **Pest and disease resistant mustard, 2023**: Scientists at the Delhi University's Centre for Genetic Manipulation of Crop Plants (CGMCP) and the Indian Council of Agricultural Research used CRISPR-Cas9 to develop a less pungent mustard with significantly higher glucosinolate. Multiple homologues of glucosinolate transporter *GTR1* and *GTR2* genes were targeted to generate low-seed but high-leaf glucosinolate oilseed mustard with uncompromised defence and yield potential. Field testing is set to begin in 2024. (Mann et al., 2023)
- **Drought resistant rice, 2022**: Expected to be commercially available by 2026. The gene drought and salt tolerant (*OsDST*) was targeted leading to the development of drought resistant rice at the Indian Agricultural Research Institute. (Santosh et al., 2020).
- **Vitamin A-fortified banana, 2020**: National Agri-Food Biotechnology Institute researchers used CRISPR to biofortify bananas to help address vitamin A deficiency in developing countries (Kaur et al., 2020). The gene for *lycopene epsilon-cyclase* was mutated which modulates metabolic flux for β-carotene biosynthesis up to 6-fold and lowering of α-carotene and lutein contents.

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ROLE OF REMOTE SENSING IN MAPPING OF ATMOSPHERIC CONTAMINANTS

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Abstract

Remote sensing technology is used as an important tool used in mapping of atmospheric pollutants and offers an effective way of getting information about the environment without necessarily coming into contact with it. This paper aims at examining the role of remote sensing in identification and modelling of various gaseous, particulate and aerosol pollutants in the atmosphere. Through the use of satellites and drones to cover the length and breadth of geographical areas, the technology allows for a broad understanding of the distribution of the pollutants and general pattern of air quality. Some of the most recognized remote sensing methods include the optical remote sensing, radar remote sensing, and LIDAR, where the employment of every methodology has capabilities of observing the environment in different ways. This paper then supports these ideas by explaining how remote sensing data has been incorporated in the provision of case studies that demonstrate how it has affected policy making and raised public awareness of air quality issues. Despite challenges like data accuracy, lower resolution, and funds the developments in technology and the utilization of innovative approaches offer hope for better application of remote sensing in environmental policy making. The findings also highlight the importance of continued funding towards Remote Sensing applications that would instill advanced Air Quality information and Health welfare.

Keywords : Remote sensing, Mapping, Atmospheric contaminants

Introduction to Remote Sensing

Remote sensing embodies a sophisticated technological paradigm that facilitates the collection of data regarding entities or geographical locales from significant distances, primarily through the application of satellite or aerial imagery. This non-intrusive methodology has surfaced as an increasingly vital resource within the domain of environmental science, furnishing critical insights into ecological changes, land use dynamics, and atmospheric phenomena. By employing a variety of sensors, remote sensing permits data acquisition without necessitating direct interaction with the subject matter, thereby establishing itself as an efficient and comprehensive tool for environmental observation. A principal utility of remote sensing is situated in the monitoring of atmospheric pollutants. In response to growing global concerns regarding air quality, remote sensing functions as a mechanism for the observation and analysis of contaminants within the atmosphere. This is accomplished through techniques such as multispectral and hyperspectral imaging, which differentiate specific wavelengths of light reflected or emitted by atmospheric particulates. Through the examination of these wavelengths, researchers are able to identify and quantify pollutants including sulfur dioxide, nitrogen dioxide, and particulate matter.

Satellites and drones serve as crucial instruments within this monitoring apparatus. Satellites, equipped with advanced sensors, orbit the Earth, gathering extensive data across vast geographical areas, thereby enabling continuous atmospheric monitoring and the identification of long-term pollution patterns. In contrast, drones offer localized, high-resolution imagery and data collection over smaller geographic regions, proving particularly beneficial in emergency response situations or targeted investigations of pollution sources. In summary, remote sensing technology emerges as an essential asset in the effort to alleviate atmospheric contamination, empowering scientists and policymakers to make informed decisions based on accurate, large-scale environmental data.

Types of Atmospheric Contaminants

Atmospheric contaminants can be systematically classified into three primary categories: gases, particulates, and aerosols, each of which presents distinct challenges and ramifications for public health and environmental integrity. A comprehensive understanding of these classifications is imperative for the development of effective monitoring strategies and mitigation initiatives.

Gases

Gaseous pollutants, including carbon dioxide (CO2), nitrogen oxides (NOx), sulfur dioxide (SO_2), and volatile organic compounds (VOCs), play a pivotal role in the deterioration of air quality. CO_2 serves as a greenhouse gas that is fundamental to the phenomenon of climate change, whereas NOx and SO_2 act as precursors to the formation of ground-level ozone and acid rain, respectively. The presence of elevated concentrations of these gases is correlated with adverse respiratory and cardiovascular conditions in humans, thereby underscoring the necessity for ongoing surveillance facilitated by remote sensing technologies.

Particulate

Particulate matter (PM) is classified according to its size, with PM2.5 (particles measuring 2.5 micrometers or smaller in diameter) being particularly alarming due to their capacity to infiltrate deep lung tissues and subsequently enter the systemic circulation. The origins of PM2.5 encompass vehicular emissions, industrial effluents, and natural phenomena such as wildfires. Prolonged exposure to fine particulate matter has been associated with serious health consequences, including asthma, lung cancer, and cardiovascular diseases, thereby rendering remote sensing techniques essential for monitoring these pollutants, particularly within urban environments.

Aerosols

Aerosols consist of minuscule solid or liquid particles dispersed within the atmosphere, emanating from both natural processes and human activities. Typical examples include dust, smoke, and sea salt. Aerosols have the potential to modulate climate conditions by influencing cloud development and atmospheric radiation patterns. Furthermore, they present direct health hazards, as inhalation can lead to respiratory and cardiovascular ailments. Remote sensing methodologies are proficient in differentiating various aerosol types and their concentrations, thus facilitating thorough examinations of their origins and consequent effects.

Remote Sensing Techniques for Monitoring

Remote sensing methodologies are essential for the proficient cartography and surveillance of atmospheric pollutants. Among the most prevalent techniques are optical remote sensing, radar, and LIDAR, each presenting distinct advantages and constraints that address various monitoring requirements.

Optical Remote Sensing

This methodology utilizes visible, near-infrared, and thermal infrared wavelengths to identify atmospheric pollutants, depending on the absorption and scattering of electromagnetic radiation by contaminants. Satellites such as the Moderate Resolution Imaging

Spectroradiometer (MODIS) are capable of discerning concentrations of gases including ozone and carbon monoxide. Nevertheless, optical remote sensing may be impeded by meteorological conditions such as cloud cover and fog, which can obscure observational data.

Radar Remote Sensing

Radar remote sensing employs microwave signals to observe atmospheric phenomena, proving particularly efficacious for the detection of precipitation and wind dynamics. This technique is valuable for investigating the distribution of aerosols and their implications for weather patterns. For example, Doppler radar has been pivotal in monitoring airborne particulates during episodes of dust storms. However, radar may not deliver the same granularity in identifying specific gaseous pollutants in comparison to optical methodologies.

LIDAR (Light Detection and Ranging)

LIDAR technology employs laser pulses to ascertain distances, yielding highly accurate data regarding atmospheric components. It is particularly adept at mapping aerosols and greenhouse gases, as it can penetrate cloud cover and provide vertical profiles of atmospheric strata. Applications of LIDAR encompass the monitoring of particulate matter in urban environments and the evaluation of pollutant dispersion from industrial activities. The principal limitation of LIDAR is its relatively elevated cost, along with the necessity for specialized apparatus and expertise. The techniques, characteristics, and applications of the most frequently utilized remote sensing technologies are delineated in Table 1..

Technique	Features	Applications
Optical Remote Sensing	Uses light wavelengths; affected by weather	Mapping gases like CO2, NOx
Radar Remote Sensing	Uses microwave signals; tracks precipitation	Monitoring aerosol distribution
LIDAR	Employs laser pulses; provides vertical profiles	Assessing urban pollution, aerosol mapping

Table 1- Commonly used Remote sensing technologies

These techniques collectively enhance the understanding of atmospheric contaminants, offering complementary data that supports comprehensive environmental monitoring and management strategies. By leveraging the strengths of each method, researchers can develop a more nuanced picture of air quality dynamics and their implications for public health and the environment.

Challenges and Future Directions:

Although remote sensing functions as a powerful tool for the monitoring of atmospheric contaminants, a multitude of challenges may undermine its effectiveness. A significant issue relates to the accuracy of the data. The complex characteristics of atmospheric phenomena indicate that sensor outputs can be affected by a variety of factors, including atmospheric conditions, sensor calibration, and the presence of additional pollutants, leading to discrepancies in the data acquired. Moreover, different sensors may yield divergent results for the same pollutants, thereby complicating the processes of data interpretation and integration. Limitations in spatial resolution also pose considerable challenges. Although satellites have the capability to cover vast areas, their spatial resolution frequently lacks the precision necessary to identify localized pollution events, particularly in urban environments where pollution sources are closely clustered. In addition, the temporal resolution associated with satellite overpasses may constrain the ability to monitor dynamic changes in air quality, especially those occurring during episodic pollution events.

One of the factors that may adversely affect the utilization of sophisticated remote sensing technologies is the incurred costs. There exist two principal challenges linked to enhancing the quality of sensors and satellites, specifically substantial financial expenditures, and numerous regions, including those in Less Developed Economies and Developing Countries (LDEDCs), may simply lack the requisite financial resources to implement and sustain the necessary supportive infrastructure. Such a situation results in disparities in monitoring capabilities, which complicate international efforts aimed at addressing air quality concerns. Certain future developments in prospective trends and technologies hold promise for the enhancement of remote sensing efficiency. The integration of advanced methodologies, such as machine learning and artificial intelligence, into data analytical models can augment the efficacy of contaminant detection in terms of both accuracy and speed, thereby improving real-time monitoring.

Additionally, advancements in sensor technology have resulted in smaller sensors that are capable of capturing greater detail and exhibiting increased accuracy. Current technological innovations, which can be characterized as initiating strategies, seek to further decentralize remote sensing data through, for example, the deployment of compact satellites or CubeSats, thereby expanding monitoring networks. It is also noteworthy that such satellites present an opportunity and provide added value by addressing coverage gaps of major systems. Furthermore, the utilization of crowd-sourced data collection facilitated by mobile applications will encourage citizen participation in pollution monitoring, thereby enhancing public awareness. Given that remote sensing is actively engaged in overcoming these challenges, it is well-positioned to significantly enhance its effectiveness in identifying atmospheric pollutants, which will ultimately contribute to improved air quality and the health of the populace.

Conclusion

Remote sensing constitutes an indispensable component in the comprehension and management of atmospheric pollutants, functioning as a foundational element for efficacious environmental surveillance and safeguarding public health. The capacity to acquire extensive air quality data remotely enables researchers to pinpoint pollutant origins, monitor their distribution, and examine longitudinal patterns, which is essential for formulating effective strategies aimed at alleviating air pollution. Through the utilization of technologies such as satellites, unmanned aerial vehicles, and sophisticated imaging methodologies, scholars are able to procure real-time data that informs policy formulation and elevates public consciousness regarding air quality challenges. The advantages of remote sensing transcend mere environmental monitoring; they exert direct influence on public health and ecological sustainability.

As we persist in addressing the challenges engendered by atmospheric pollution, it is crucial to allocate resources towards further research and technological progress in the domain of remote sensing. Enhanced funding and collaborative initiatives among governmental bodies, academic institutions, and the private sector can catalyze innovation in sensor technologies and data analytic techniques. Additionally, cultivating public engagement and awareness regarding the advantages of remote sensing can foster greater community participation in monitoring initiatives, ultimately amplifying the overall effectiveness of air quality management. In conclusion, the significance of remote sensing in delineating atmospheric contaminants is of paramount importance. It is imperative that we dedicate ourselves to advancing these capabilities, thereby ensuring a more salubrious future for our planet and its denizens.

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PLANT BREEDERS AND FARMERS RIGHT

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Introduction

In order to provide for the establishment of an effective system for the protection of plant varieties, the sights of farmers and plant breeders and to encourage development of new varieties of the plants of the formers in respect their contributions made conserving, improving resources of new and making at any time in available plant genetic of traditional varieties and for the development plant varieties. Hence the Government of India enacted "The protection of plant Varieties and Farmer's Rights (PPV &FR) Act, in 2001.

OBJECTIVES OF THE PPV & FR ACT, 2001

1) To establish an effective system for the protection of traditional plant varieties, the rights of farmers and plant breeders and to encourage development of new varieties of plants.

2) To recognize and protect the rights of farmers in respect of their contributions made at time in conserving, improving and making available plant genetic resources for the development of new traditional plant varieties

3) To accelerate agricultural development in the country, protect plant breeder’s rights, simulate investment sector for the development of new plant varieties

4) Facilitate the growth of seed industry in the country which will ensure the availability of high-quality seeds and planting materials to the farmers.

GENERAL FUNCTIONS OF THE AUTHORITY

1. Registration of new plant varieties, essentially and traditional varieties.
2. Developing DUS (Distinctiveness, Uniformity and Stability) test guidelines for new plant species.

3. Developing characterization and documentation of varieties registered.
4. Compulsory cataloguing facilities for all variety of plants.
5. Documentation, indexing and cataloguing of farmer's Varieties
6. Recognizing and rewarding farmers, community of farmers, particularly tribal and rural community engaged in conservation, improvement, preservation resources of plant generic resources of economic plants and their wild relatives,
7. Maintenance of National Register of plant varieties and
8. Maintenance of National Gene Bank

RIGHTS UNDER THE ACT

Breeder's Rights.

Breeders will have exclusive rights to sell, market, distribute, import or export the protected variety. Breeder can appoint agent/ licensee case and may exercise for civil remedy in case of infringement of rights.

Researcher's Rights.

Researcher Can Use any of the registered variety under the Act for conducting research. This includes the use initial source of variety for the purpose of another but repeated use needs. developing variety Prior permission of the registered breeder.

Farmer's Rights

- A Farmer who has evolved or developed a new variety is entitled for registration and protection in like manner as a breeder of variety.
- Farmers variety can also be registered as extant variety.
- A framer exchange, share, save, use, sow, re-sow, sell his foam produce including seed of a variety protected under the PPV &FR Act, 2001 in the same manner as he was entitled before the coming into force of this Act provided farmer shall not be entitled to sell branded seed of a variety protected under the PPV & FR Act 2001.
- Farmers cultivating traditional varieties eligible for recognition and rewards for the conservation of plant genetic resources of land races and wild relatives of economic plants
- There is also a provision for conservation to the farmers for non-performance of variety under section 39(2) of the Act and

- Farmers shall not be liable to pay any fee in any proceeding before Authority or Registration or the tribunal or the high court under the act

REGISTRATION

A variety is eligible for registration under the Act if it essentially fulfils the Criteria of Distinctiveness, Uniformity, and Stability (DUS). The Central Government issues notification in official Gazettes specifying the for the purpose of registration of varieties. So far, the Central Government has notified species for the propose of registration of varieties

So far, the central Government has notified 57 for the purpose of registration. The PPV & FR Authority has developed "Guidelines for the Conduct of Species-Specific Distinctiveness, Uniformity and Stability "Specific Guidelines for individual crop species. These include bread wheat rice, maize, Sorghum, Pearl millet, chickpea, pigeon pea, green gram, black gram, Pea / garden pea, Kidney boon / Franch bean lentil, diploid cotton (two species), tetraploid Cotton (two species), jute (two species), Sugarcane, ginger, turmeric, Indran mustard, Karan rai, rapeseed, sunflower, safflower, castor, linseed, groundnut, soybean, gobhi season, Sesame, black Pepper, Small Cardamom, rose, chrysanthemum, mango, Potato, eggplant, tomato, lady's finger, cauliflower, cabbage, onion and garlic.

Publications of Authority.

- Plant variety journal of India
- General and crop specific DUS test guidelines.
- Technical Bulletin
- Gene Bank Manual
- Agro biodiversity (Hotspots Book (Two volumes). A video CD entitled 'seed of sustenance' highlighting various provisions of the PPV & FR Act, 2001
- Annual Reports

Fees for Registration.

Application for registration of plant varieties should be accompanied with the fee of registration prescribed by the authority Fee for registration for different types of variety is as

S.No	Types of variety	Fees for registration
1.	Extant variety notified under section 5 of the seeds Act,1996	Rs.1000 /-

2.	New variety/Essentially derived variety (EDV)	Individual Rs.5000 /- Educational Rs.7000 /- Commercial Rs.10,000 /-
3.	Extant variety above which there is common knowledge (VCK)	Individual Rs.5000 /- Educational Rs.7000 /- Commercial Rs.10,000 /-

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PROMOTER REGION, ITS EVOLUTION AND ROLE IN GENE EXPRESSION

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Introduction

Promoter regions play a crucial role in gene expression by initiating the process of transcription, where the information in DNA is copied into RNA. Promoter regions are critical for the regulation of gene expression at the level of transcription initiation, playing a fundamental role in determining when and how genes are expressed in response to various cellular signals and environmental cues. Understanding promoter regions is crucial for genetic engineering and biotechnology applications. Researchers can manipulate promoters to control the expression of genes of interest in various organisms, such as enhancing the production of proteins for therapeutic purposes or improving crop resistance to environmental stresses.

Role of the promoter regions in gene expression:

Promoter regions are essential for gene expression as they serve as the initiation sites for transcription, a crucial step in the process of converting genetic information from DNA into RNA molecules and functional proteins. They are critical for ensuring that genes are expressed at the right time, in the right place and in the right amounts to support cellular functions and responses to environmental changes.

1. **Initiation of transcription**: Promoter regions provide binding sites for RNA polymerase and transcription factors. RNA polymerase is the enzyme responsible for synthesizing RNA from a DNA template. Transcription factors help recruit RNA polymerase to the promoter and initiate transcription.

2. **Regulation of transcription**: Promoters contain specific sequences of DNA that can interact with regulatory proteins called transcription factors. These transcription factors can either enhance or repress the initiation of transcription by binding to specific sites within the promoter region. The presence or absence of these transcription factors can dictate whether a gene is actively transcribed or remains silent.
3. **Determination of transcription start site**: Within the promoter region, there is a precise location called the transcription start site (TSS) where RNA polymerase begins synthesizing RNA. The sequence and structure of the promoter help determine this start site, influencing the exact boundaries and structure of the RNA transcript.
4. **Promoter strength**: Different promoters have varying strengths in terms of their ability to initiate transcription efficiently. Strong promoters are associated with high levels of transcription, whereas weak promoters result in lower levels of transcription. The strength of a promoter is influenced by the sequence elements it contains and how effectively transcription factors and RNA polymerase can bind to and initiate transcription from these elements.
5. **Response to regulatory signals**: Promoter regions integrate signals from the cellular environment and respond to regulatory cues. For instance, external signals such as hormones or environmental stressors can activate or inhibit transcription factors that bind to the promoter, thereby modulating the expression of the associated gene.
6. **Interaction with enhancers and silencers**: Promoters can interact with regulatory elements called enhancers and silencers, which are usually located upstream or downstream of the promoter. Enhancers can increase transcription by looping to the promoter and facilitating the binding of transcription factors. Silencers, on the other hand, can decrease transcription by blocking the binding of transcription factors or recruiting repressive proteins. This interaction helps fine-tune gene expression in response to complex regulatory networks.
7. **Evolutionary significance**: Changes in promoter regions can lead to evolutionary adaptations by altering gene expression patterns. Mutations or variations in promoter sequences can affect the binding affinity of transcription factors, thereby influencing the phenotype and adaptation of organisms to changing environments over evolutionary timescales.

Evolution of promotor region

The evolution of promoter regions is a complex process influenced by various factors, including natural selection, genetic drift and mutations. Here are some key aspects of the evolution of promoter regions:

1. **Conservation and divergence**: Promoter regions often exhibit both conservation and divergence across species. Certain core elements, such as the TATA box or GC-rich regions, may be conserved because they are essential for basic transcriptional machinery. However, other regulatory elements can evolve rapidly, allowing for species - specific gene expression patterns.
2. **Functional diversification**: Promoter regions can evolve to regulate gene expression in response to environmental changes, developmental stages, or tissue-specific requirements. This functional diversification occurs through the acquisition of new transcription factor binding sites or changes in the strength of existing regulatory elements.
3. **Duplication and divergence**: Gene duplication events can lead to the evolution of new genes with divergent promoter regions. This divergence allows duplicated genes to acquire new functions or regulatory patterns while maintaining some similarity to the original promoter structure.
4. **Adaptation to environmental changes**: Promoter evolution can be driven by environmental pressures, such as temperature fluctuations, availability of nutrients, or interactions with pathogens. Mutations in promoter regions that enhance or suppress gene expression in response to these pressures can confer adaptive advantages to organisms.
5. **Regulatory network changes**: Changes in promoter sequences can alter interactions with regulatory proteins, such as transcription factors or chromatin modifiers, leading to rewiring of gene regulatory networks. This rewiring can have profound effects on developmental processes, phenotypic traits, and evolutionary trajectories.
6. **Epigenetic modifications**: Promoter evolution is also influenced by epigenetic modifications, such as DNA methylation or histone modifications, which can regulate accessibility of the promoter region to transcriptional machinery. Evolutionary changes in these epigenetic marks can impact gene expression patterns across generations.

7. **Genomic context and chromatin structure**: Promoter evolution is influenced by the genomic context, including neighboring genes and chromatin structure. Changes in chromatin accessibility or interactions with boundary elements can affect the evolution of promoter regions and their regulatory functions.

Conclusion

Overall, promoter regions are fundamental elements of gene regulation and expression, playing a critical role in cellular function, organismal development and evolutionary processes. Their study continues to be central in advancing our understanding of genetics, development and disease mechanisms, as well as in the development of biotechnological applications. The evolution of promoter regions is driven by a combination of selective pressures, genetic mutations and regulatory changes that collectively shape gene expression patterns and contribute to the diversity of biological traits observed across species. Studying the evolution of promoter regions provides insights into the molecular mechanisms underlying adaptation, development, and evolutionary innovation in living organisms.

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REMOTE SENSING

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Introduction

Remote sensing is a powerful tool that has revolutionized the way we approach agriculture. By using satellite imagery, aerial photography, and other advanced technologies, farmers and researchers can gather invaluable data about crop health, soil conditions, and environmental factors that impact agricultural production. This information enables more informed decision-making, leading to increased yields, improved resource management, and more sustainable farming practices.

Overview of Fruit Production in India

India is a major producer and exporter of a wide variety of fruits, contributing significantly to the global fruit market. The country's diverse climate and fertile agricultural lands make it well-suited for the cultivation of a wide range of fruit crops, including mangoes, bananas, grapes, oranges, apples, and more. In recent years, the Indian government has placed a strong emphasis on the development of the fruit industry, implementing various initiatives and policies to boost productivity, improve quality, and increase exports.

According to the latest data, India is the world's second-largest producer of fruits, accounting for around 12% of the global fruit production. The country's total fruit production in 2021 was estimated to be around 102 million metric tons, with mangoes and bananas being the two most widely cultivated and exported fruit crops. The major fruit-producing states in India include Andhra Pradesh, Maharashtra, Uttar Pradesh, Gujarat, and Tamil Nadu, which together contribute to a significant portion of the country's overall fruit production.

Despite the country's impressive fruit production figures, the Indian fruit industry faces several challenges, including limited access to modern farming techniques, inadequate post-harvest infrastructure, and the prevalence of small-scale, fragmented farming operations. The government and industry stakeholders are actively working to address these issues through the introduction of innovative technologies, improved supply chain management, and targeted policy interventions.

Challenges in Traditional Fruit Farming

Despite its importance, traditional fruit farming in India faces numerous challenges that often limit productivity and profitability. One major issue is the reliance on manual labor-intensive methods, from pruning and harvesting to pest control and post-harvest handling. This makes fruit production highly dependent on the availability and skill of agricultural workers, which can be unreliable and costly, especially during peak seasons.

Another challenge is the vulnerability of fruit crops to adverse weather conditions, such as unseasonal rains, hailstorms, and droughts. These natural calamities can severely damage orchards and significantly reduce yields, leaving farmers with substantial financial losses. Additionally, the lack of access to modern irrigation techniques and efficient water management systems often results in suboptimal utilization of limited water resources, particularly in water-scarce regions.

Pests and diseases are also a significant concern for traditional fruit growers, as they can quickly spread and devastate entire plantations if left unchecked. The limited availability and high cost of effective pesticides and fungicides, along with the lack of integrated pest management strategies, further exacerbate this problem, leading to reduced crop quality and increased production costs.

Role of Remote Sensing in Precision Farming

Remote sensing technologies have emerged as a powerful tool for enabling precision farming practices. By integrating satellite and aerial imagery with advanced analytics, farmers can now make more informed decisions to optimize their crop production and resource utilization. These technologies allow for real-time monitoring of crop health, soil conditions, and environmental factors, providing valuable insights that were previously difficult to obtain through traditional methods.

1. **Precision Planting:** Remote sensing data can help identify optimal planting locations, adjust seed spacing, and tailor fertilizer applications to specific field conditions, leading to improved yields and reduced waste.
2. **Targeted Pest and Disease Management:** Multispectral and hyperspectral sensors can detect early signs of pest infestations or disease outbreaks, enabling targeted treatment and minimizing the use of pesticides.
3. **Efficient Irrigation Management:** Remote sensing-based soil moisture mapping and evapotranspiration monitoring can help farmers optimize irrigation schedules, conserving water and energy resources.
4. **Yield Forecasting and Monitoring:** Satellite-derived vegetation indices and crop models can provide accurate yield estimates, enabling better planning and decision-making for harvesting and storage.

By leveraging the power of remote sensing, farmers can transition towards a more data-driven, precision-based approach to agriculture, leading to increased productivity, improved resource efficiency, and reduced environmental impact.

Satellite-based Monitoring of Crop Health

One of the key applications of remote sensing in fruit production is the use of satellite imagery to monitor the health and condition of crops. Satellite-based sensors can capture detailed information about the spectral reflectance, vegetation indices, and other metrics that provide insights into the overall vigor and well-being of the fruit plants. By analyzing these satellite data, farmers and agronomists can identify areas of stress, disease, or nutrient deficiency within their orchards, allowing for targeted interventions and precise management decisions.

High-resolution satellite imagery, such as that provided by platforms like Sentinel-2 and Landsat, can deliver detailed information on factors like leaf chlorophyll content, plant water status, and even the early detection of pests or diseases. This information can be combined with weather data, soil moisture measurements, and other contextual factors to build a comprehensive picture of the crop's health and productivity. Sophisticated algorithms and machine learning models can then be used to automate the analysis and provide actionable insights to growers in near real-time.

Aerial Imagery for Yield Estimation

One of the most powerful applications of remote sensing technology in fruit production is the use of aerial imagery for yield estimation. By capturing high-resolution images of orchards and vineyards from drones or small aircraft, farmers can gain valuable insights into the health, growth, and potential yield of their crops. These aerial surveys provide a bird's-eye view of the entire farm, allowing for detailed analysis and measurement of individual trees or vines. Advanced image processing techniques, such as multispectral analysis and 3D modeling, can then be used to estimate fruit counts, canopy size, and other key metrics that are directly correlated with final yield.

This information is crucial for optimizing management practices, making informed decisions about harvesting and distribution, and ultimately maximizing the productivity and profitability of the fruit operation. *Aerial imagery also enables farmers to identify problem areas, such as disease outbreaks or water stress, and target their interventions more precisely.*

By integrating this data with other precision agriculture technologies, such as soil moisture sensors and weather monitoring, growers can create a holistic, data-driven approach to managing their fruit crops.

Hyperspectral Analysis for Disease Detection

Hyperspectral imaging has emerged as a powerful tool for early detection and diagnosis of plant diseases in fruit orchards. By capturing detailed spectral information across a wide range of the electromagnetic spectrum, hyperspectral sensors can identify unique spectral signatures associated with various diseases, nutrient deficiencies, and stress factors affecting the plants.

Using advanced machine learning algorithms, hyperspectral data can be analyzed to create precise maps of disease prevalence across an orchard. This information allows farmers to take targeted, timely action to treat affected areas, preventing the spread of disease and minimizing crop losses. The non-invasive, rapid, and high-resolution nature of hyperspectral imaging makes it an invaluable precision agriculture technique for proactive disease management in fruit production.

Soil Moisture Mapping for Irrigation Management

One of the key applications of remote sensing in fruit production is the ability to monitor and map soil moisture levels across a farm or orchard. By using satellite or aerial imagery, farmers can gain a comprehensive view of the soil moisture conditions in their fields, allowing them to optimize their irrigation practices and ensure that their crops are receiving the right amount of water. **Multispectral and hyperspectral sensors** can detect subtle variations in the

reflectance of soil, which can be correlated with soil moisture content. This data can then be used to create detailed soil moisture maps, highlighting areas that are either too dry or oversaturated.
These soil moisture maps can be integrated with **precision irrigation systems**, enabling farmers to precisely control the amount of water applied to different parts of their orchards. This not only helps to conserve water and reduce unnecessary irrigation, but also ensures that the fruit trees are receiving the optimal amount of moisture for healthy growth and maximum yield. By coupling remote sensing data with smart irrigation technologies, growers can significantly improve the efficiency and sustainability of their fruit production operations.

Integrating Remote Sensing with IoT for Smart Farming

The combination of remote sensing technology and the Internet of Things (IoT) is transforming traditional farming practices into "smart farming" approaches. By integrating data from satellite imagery, aerial drones, and ground-based sensors, farmers can gain unprecedented insights into their crops and optimize their operations accordingly.
IoT sensors placed throughout the fields can continuously monitor factors like soil moisture, temperature, and nutrient levels. This real-time data can then be paired with high-resolution satellite imagery to create detailed maps of crop health and growth patterns. Armed with this comprehensive data, farmers can make informed decisions on when to irrigate, fertilize, or apply targeted pesticides, leading to improved yields and reduced waste.

Furthermore, by connecting these smart farming systems to cloud-based analytics platforms, farmers can leverage machine learning algorithms to predict future trends and optimize their practices even further. This integrated approach empowers growers to be more proactive, efficient, and sustainable in their fruit production efforts.

Case Studies and Success Stories

The use of remote sensing technology has led to numerous success stories in India's fruit production industry. One notable example is the precision farming initiative implemented by the National Horticulture Mission in the state of Himachal Pradesh. By utilizing satellite imagery and drone-based data collection, farmers were able to monitor crop health, detect early signs of pests and diseases, and optimize irrigation schedules. As a result, apple yields increased by 20% on average, while water consumption was reduced by 30%.

Another success story comes from the state of Maharashtra, where remote sensing was applied to manage the cultivation of grapes. Hyperspectral analysis helped identify nutrient deficiencies and potential disease outbreaks, allowing growers to take proactive measures to protect their crops. This approach led to a 15% increase in grape quality and a 12% reduction in input costs.

In the state of Tamil Nadu, a pilot project integrating remote sensing with IoT sensors has revolutionized the mango farming industry. By continuously monitoring soil moisture, temperature, and other environmental factors, farmers were able to make more informed decisions regarding irrigation, fertilization, and pest management. This integrated system has led to a 25% increase in mango yields and a 40% reduction in water usage.

Conclusion and Future Prospects

As this examination of remote sensing applications in Indian fruit production has illustrated, the integration of satellite-based and aerial imagery with advanced analytical techniques holds immense promise for enhancing productivity, sustainability, and profitability in this vital agricultural sector. From monitoring crop health and detecting diseases to optimizing irrigation schedules and forecasting yields, remote sensing technologies empower farmers with unprecedented insights to make more informed, data-driven decisions.

Looking to the future, the continued advancements in sensor capabilities, data processing, and precision farming solutions will likely expand the reach and impact of remote sensing even further. Coupling these tools with emerging Internet of Things (IoT) technologies and machine learning models will enable truly smart, connected orchards that can rapidly adapt to changing conditions and maximize resource efficiency. With greater adoption of these innovative approaches, Indian fruit growers can look forward to a more prosperous, resilient, and environmentally-friendly agricultural landscape in the years to come.

1. **Enhanced Crop Monitoring** - Integrating high-resolution satellite imagery, drone-based data, and ground sensors to provide comprehensive, real-time insights into crop health, pest infestations, and environmental factors.
2. **Predictive Analytics** - Leveraging machine learning and big data analytics to forecast yields, optimize inputs, and anticipate market trends, empowering farmers to make more strategic, proactive choices.
3. **Precision Automation** - Automating irrigation, fertilization, and other agricultural processes based on remote sensing data, reducing waste and enhancing efficiency.

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BREEDING STRATEGIES IN RICE FOR THE PRESENT SCENARIO

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Abstract

Rice breeding strategies have evolved to address contemporary challenges such as climate change, resource constraints, and pest pressures. This article explores modern breeding approaches, including conventional crossbreeding, molecular breeding, genetic engineering, and participatory plant breeding. Conventional methods focus on yield, quality, and resistance, while molecular techniques like marker-assisted selection and CRISPR-Cas9 offer precision and efficiency. Addressing climate change requires breeding for heat tolerance, drought resistance, and flood resilience. Resource efficiency strategies enhance water and nutrient use, while nutritional enhancement aims to improve the rice grain's nutritional profile. Future directions emphasize integrating omics technologies, developing climate-resilient varieties, and promoting sustainable practices. Global collaboration remains crucial for advancing rice breeding and ensuring food security.

***Keyword*:** Climate Change, Rice, MAS, IPM, Conventional Breeding, Genomic Selection

Introduction

Rice (*Oryza sativa*) is a staple food for more than half of the global population, particularly in Asia, where it is a key dietary component. Given its critical role in food security and nutrition, rice breeding strategies have evolved significantly to address contemporary challenges such as climate change, population growth, and changing dietary patterns. This article examines current rice breeding strategies, their relevance to the present scenario, and future directions.

HISTORICAL BACKGROUND

1. Early Breeding Efforts

Rice breeding has a rich history, beginning with early farmers selecting and saving seeds from plants that exhibited desirable traits. Traditional breeding methods primarily involved selection for yield, grain quality, and resilience to pests and diseases. By the mid-20th century, the development of semi-dwarf varieties, such as the IR8 released by the International Rice Research Institute (IRRI) in 1966, marked a significant milestone. These high-yielding varieties played a crucial role in the Green Revolution, dramatically increasing rice production.

2. Modern Breeding Approaches

With advances in genetics and molecular biology, modern rice breeding has become more sophisticated. The incorporation of molecular markers, gene editing technologies, and genome sequencing has enhanced the precision and efficiency of breeding programs. Contemporary strategies focus not only on yield but also on addressing new challenges such as climate change, resource limitations, and pest and disease pressures.

MAJOR BREEDING STRATEGIES

1. Conventional Breeding

Conventional breeding involves the crossbreeding of different rice varieties to combine desirable traits. This method relies on natural variation and the selection of offspring that exhibit improved characteristics. Key objectives include:

a) **Yield Improvement**: Breeding programs aim to enhance grain yield by selecting varieties with better agronomic traits such as increased tillering, improved grain filling, and better plant architecture.

b) **Quality Enhancement**: Grain quality, including cooking and eating qualities, is a significant breeding objective. Traits such as grain size, shape, and aroma are critical for consumer preference.

c) **Disease and Pest Resistance:** Traditional breeding methods focus on developing varieties resistant to major rice diseases and pests, including blast, bacterial blight, and brown plant hopper.

2. Molecular Breeding

Molecular breeding utilizes molecular markers to track the inheritance of desirable traits. This approach offers several advantages:

a) **Marker-Assisted Selection (MAS)**: MAS allows breeders to select plants carrying specific genes associated with desirable traits, such as resistance to diseases or improved drought tolerance.

b) **Quantitative Trait Locus (QTL) Mapping**: Identifying QTLs associated with complex traits helps in understanding the genetic basis of traits and facilitates their incorporation into breeding programs.

c) **Genomic Selection (GS):** GS involves predicting the breeding value of individuals based on their genome-wide markers. This method accelerates the breeding process by selecting individuals with high potential for desired traits.

3. Genetic Engineering

Genetic engineering involves the direct manipulation of an organism's genome using biotechnological tools. Following are the some main applications in rice:

a) **Genetically Modified Organisms (GMOs):** GMOs are engineered to possess traits such as pest resistance, herbicide tolerance, and improved nutritional content. Examples include Bt rice, which expresses a gene from Bacillus thuringiensis for pest control.

b) **CRISPR-Cas9 Gene Editing**: CRISPR-Cas9 technology allows for precise modifications of the rice genome. This technique can be used to enhance traits such as drought tolerance, disease resistance, and nutrient use efficiency.

4. Participatory Plant Breeding

Participatory plant breeding (PPB) involves collaboration between breeders, farmers, and other stakeholders to develop varieties that meet local needs. This approach emphasizes:

Local Adaptation: By involving farmers in the breeding process, PPB ensures that the varieties developed are well-adapted to local conditions and farmer preferences.

Knowledge Exchange: Farmers contribute traditional knowledge and practical insights, which can improve the relevance and acceptance of new varieties.

ADDRESSING CURRENT CHALLENGES

1. **Climate Change**: Climate change poses a significant threat to rice production, affecting temperature, precipitation patterns, and the frequency of extreme weather events. Breeding strategies to address climate change include:

a) **Heat Tolerance**: Developing varieties that can withstand higher temperatures is crucial for maintaining yield under heat stress conditions. Traits such as better heat shock response and improved flowering synchronization are targeted.

b) **Drought Resistance**: Breeding for drought resistance involves selecting varieties with deeper root systems, better water use efficiency, and enhanced osmotic adjustment.

c) **Flood Tolerance**: Submergence-tolerant varieties, such as those with the SUB1 gene, have been developed to withstand prolonged flooding, which is critical for regions prone to seasonal inundation.

2. Resource Efficiency

Efficient use of resources such as water and nutrients is essential for sustainable rice production. Breeding strategies for resource efficiency include:

a) **Water-Use Efficiency**: Varieties with improved water-use efficiency can maintain yield under limited water availability. Traits such as reduced water loss through transpiration and better root architecture are targeted.

b) **Nutrient Use Efficiency**: Breeding for enhanced nutrient use efficiency helps in reducing the need for chemical fertilizers. Traits such as improved uptake and utilization of nitrogen and phosphorus are critical.

3. Pest and Disease Management

Pests and diseases continue to be major constraints to rice production. Breeding strategies for pest and disease management may be as follows:

a) **Host Resistance**: Developing varieties with resistance to major pests and diseases through both traditional breeding and genetic engineering approaches.

b) **Integrated Pest Management (IPM)**: Combining resistant varieties with other pest management strategies, such as biological control and cultural practices, to manage pest populations effectively.

4. Nutritional Enhancement

Nutritional enhancement focuses on improving the nutritional content of rice. Some important strategies may be as given below:

a) **Biofortification:** Enhancing the levels of essential nutrients such as vitamins and minerals in rice grains. Examples include golden rice, which is engineered to produce higher levels of provitamin A.

b) **Quality Traits**: Improving rice quality traits that contribute to better nutritional outcomes, such as increased amylose content or higher antioxidant levels.

FUTURE DIRECTIONS

Integration of Omics Technologies

The integration of genomics, transcriptomics, proteomics, and metabolomics (collectively known as omics technologies) offers new insights into rice biology and breeding. These technologies enable a comprehensive understanding of gene function, metabolic pathways, and physiological responses, which can be harnessed to develop new breeding strategies.

Climate-Resilient Breeding:

Future breeding programs will need to focus on developing climate-resilient varieties that can adapt to rapidly changing environmental conditions. This involves not only incorporating traits for heat, drought, and flood tolerance but also understanding the complex interactions between these traits and the environment.

Sustainable Breeding Practices

Sustainability in rice breeding involves reducing the environmental impact of rice production. Some Strategies may be as follows:

a) **Eco-Friendly Practices**: Incorporating practices such as reduced chemical inputs, conservation tillage, and organic farming into breeding programs.

b) **Biodiversity Conservation**: Preserving and utilizing genetic diversity within rice germplasm to ensure the long-term sustainability of breeding programs.

c) **Global Collaboration**: Global collaboration among research institutions, governments, and the private sector is essential for addressing global challenges in rice breeding. Collaborative efforts can facilitate the sharing of knowledge, resources, and technologies, leading to more effective and innovative breeding strategies.

Conclusion

Rice breeding strategies have evolved significantly in response to changing global challenges. From conventional breeding methods to advanced molecular techniques, each approach has contributed to improving rice productivity and quality. As we face new challenges such as climate change, resource limitations, and evolving pest and disease pressures, continued innovation and adaptation in rice breeding will be crucial. By integrating modern technologies, focusing on sustainability, and fostering global collaboration, we can ensure that rice breeding continues to meet the needs of the present and future generations.

This article explains in short, the importance of ongoing research and development in rice breeding to address current and emerging challenges. Through a multifaceted approach that combines traditional knowledge with cutting-edge science, we can work towards a more resilient and sustainable rice production system.

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CLIMATE RESILIENT RICE VARIETIES OF TAMILNADU

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Introduction

Rice is a crucial staple food crop in Tamil Nadu, capable of being cultivated year-round depending on the availability of irrigation. Based on rainfall patterns, rice is grown on approximately 20 lakh hectares across the state. However, climate change has introduced challenges such as drought, submergence, and salinity, which significantly impact rice yield. With the growing population, there is an increasing need to develop rice varieties that can withstand these stress conditions. To address this demand, TNAU has made extensive efforts to develop high-yielding varieties suitable for growth under adverse conditions.

Drought tolerant short-duration high yielding rice varieties

Of the 20 lakh hectares of rice-growing area in Tamil Nadu, 2 lakh hectares are cultivated under rainfed direct-seeded conditions, primarily in the districts of Ramanathapuram, Sivagangai, and Virudhunagar. In recent years, declining water resources inCuddalore, Thiruvarur, Nagapattinam, and Pudhukottai districts have led to an increase in direct-seeded rice during the North-east monsoon. Drought-tolerant landraces such as Norungan and Kuzhivedichan are commonly grown under these conditions. To support these efforts, TNAU has released short-duration, high-yielding rice varieties, including Anna (R)4, CO53 and TKM15.

Anna (R) 4

It is a selection from a cross betweenPantdhan 10 and IET 9911 which was released during the year 2009. It is a long slender white rice of duration100-105 days. It is drought tolerant, semi-dwarf, erect and non-lodging. It has high productivity of 3.7 t / ha (14.7 percent increased yield over the check variety PMK (R) 3). It is suitable for September – October sowing (North East Monsoon) in rainfed areas of Ramanathapuram and Sivagangai Districts. It has high head rice recovery of 62.1%

CO 53

It is a derivative of the cross PMK (R) 3 and Norungan. It is a drought tolerant early duration (115–120 days) variety. It is a high yielding medium tall variety with mean grain yield of 3718 kg/ha under dry condition and 3866 kg/ha under semi dry condition. It is moderately resistant to WBPH and moderately resistant to multiple diseases *viz.*, leaf blast, neck blast, sheath rot, brown spot and RTD. It is a white short bold rice with high milling percentage (69.6), head rice recovery (59.6%) and suitable for idly making. It is Suitable for drought prone districts of Tamil Nadu such as Sivaganga, Ramnad, and Virudhunagar

TKM 15

This drought-tolerant variety was developed by Rice Research Station, Thirurkuppam during the year 2022. It is derived from a cross between TKM 12 and IET 21620 with a duration of 118 days. It is suitable for raising during September-October in rainfed areas of Ramanathapuram, Sivagangai and Thiruvallur districts of Tamil Nadu. The average grain yield is 3995 kg/ha in rainfed, 4217 kg/ha in semi-irrigated conditions. It is medium slender white rice has high milling (68%) and head rice recovery (62.9%). It is tolerant to drought stress for 10-12 days and suitable for aerobic conditions. It is resistant to stem borer, leaf folder, gall midge and moderately resistant to Blast, Sheath rot, Sheath blight, brown spot and rice tungro disease.

Rice varieties suitable for saline and sodic soils

Tamil Nadu has around 1 lakh 32 thousand hectares of saline soil and 3 lakh 54 thousand 784 hectares of sodic soil. To address the challenges of these soil conditions, the Agricultural College in Trichy has developed high-yielding rice varieties. Recently, the varieties TRY3, TRY4, and TRY5 were released, specifically suited for these types of soils.

TRY 3

Anbil Dharmalingam Agricultural College and Research Institute, Trichy has developed the salinity tolerant rice variety TRY3 during the year 2010. It was derived from the cross ADT 43 x Jeeragasamba. It is a long duration rice variety of 135 – 140 days. It is suitable for growing in Samba/Late samba/Thaladi season. The average grain yield is 6050 kg/ha. It is a mediumbold white rice suitable for all tiffin preparation. It has a high milling rate of 71.3% and head rice recovery of 66.0%. It is moderately resistant to leaf folder, stem borer, blast, leaf spot and sheath rot.

TRY 4

It is a derivative of the cross ADT 39 x CO 45. It was released during the year 2021 as a mid-early duration variety with 127 days duration with high yield, high milling (68.1 %) and head rice recovery (57.2 %). It has an average yield of 5730 kg/ha when grown under saline conditions. It has intermediate amylose content hence suitable for cooking and idly making. It is resistant to major diseases *viz.,* blast and brown spot and has field resistance to major pests*viz.*, leaf folder, stem borer and gall midge. It is suitable for cultivation during late samba/thaladi in salt affected patches of Tamil Nadu.

TRY 5

It is a mutant of TRY 2 and short duration variety with 110 – 115 days. The average yield of the culture is 5100 kg/ha. It has milling of 64% and head rice recovery of 54%. The variety is suitable for Kuruvai / Late thaladi / Navarai seasons. It is a medium slender fine rice with cooking quality. It is suited to salt affected soils

Submergence tolerant high-yielding rice varieties

Out of the 20 lakh hectares of rice-growing area in Tamil Nadu, nearly 9 lakh hectares are cultivated during the samba season. Heavy rainfall during the North-east monsoon often leads to flooding, affecting around 2-3 lakh hectares of rice fields. The rapid rise in water levels due to heavy downpours and inadequate drainage facilities in the Kaveri delta regions contributes to this flooding. As a result, rice yield is significantly impacted in the tail-end delta regions such as Thiruvarur, Nagapattinam, and Cuddalore. In these flood-prone areas, CR 1009 is the most preferred rice variety grown by farmers.

CR1009 was introduced in Tamil Nadu during 1982 by TNAU. Later, it was released by the name “Savithri” by National Rice Research Institute, Cuttack during 1983. Due to its high yielding capacity, the variety was well known among the farmers of Tamilnadu.There are three types of flooding stress in rice: Submergence at vegetative or pre-flowering stage (submergence); Stagnant flooding of medium-deep (25–50 cm), deepwater (50–100 cm), or floating rice (>100 cm); Submergence at germination (anaerobic germination, AG). If the rice crop remains in submerged condition for more than one week, the yield potential of this variety will be greatly affected. The yield loss due to flood ranges from 50-100%. To combat the issue due to flood, Tamil Nadu Agricultural University conducted research and introgressed the submergence tolerance trait into CR1009 and released the submergence tolerant rice variety CR 1009 (*Sub*1) during the year 2014.

CR1009 (*Sub*1)

CR1009 (*Sub*1) was derived from a cross between CR1009 and FR13A. It has a duration of 150-155 days. It is a submergence tolerant rice variety suitable for sowing under Samba season. The average grain yield is 5759 kg/ha. It is tolerant to early-stage submergence for a period of 10 to 14 days. It is a short bold rice with high milling percentage and head rice recovery, suitable for idli and tiffin preparations. It is moderately resistant to brown spot, Blast, BPH and WBPH.

CO 43 *Sub*1

It is derived from the cross CO43 and FR13A. It has a duration of 130-135 days. It is suitable for growing in late samba and thaladi season. It has an average grain yield of 5800 kg/ha. It is tolerant to early-stage submergence for a period of 10 to 14 days. It is a medium slender white rice with intermediate amylose content suitable for both table purpose and tiffin preparations. It is moderately resistant to stem borer, GLH, blast, BLB and RTD.

The development of climate resilient rice varieties is essential for maintaining rice production in Tamil Nadu amid the challenges posed by climate change, such as drought, flooding, and salinity.The Tamil Nadu Agricultural University (TNAU) has made significant strides in breeding rice varieties that not only withstand these environmental stresses but also offer high yields, ensuring food security in the region. Varieties like Anna(R)4, CO53, and TKM15 provide robust options for drought prone areas, while TRY3, TRY4, and TRY5 cater to saline and sodic soils. Additionally, the introduction of submergence tolerant varieties such as CR1009 (Sub1) and CO 43 Sub1 addresses the issues posed by flooding in the delta regions. The continuous efforts in developing these resilient varieties underscore the importance of research and innovation in agriculture to meet the growing food demands of a changing world.

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ROLE OF ALGAE IN SPACE NUTRITION: A BIOTECHNOLOGICAL APPROACH TO LIFE SUPPORT SYSTEM

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Abstract

The prospect of extended human habitation beyond Earth demands innovative solutions for sustenance and environmental control. Algae, photosynthetic microorganisms, emerge as a promising candidate for revolutionizing space nutrition and life support systems. Their ability to convert minimal resources into substantial biomass, coupled with their nutritional value and potential for biofuel production, makes them ideal for closed-loop ecosystems. This paper explores the role of algae in space exploration, discussing their nutritional benefits, cultivation techniques, and challenges associated with their integration into life support systems.

Keywords: Algae, Space Exploration, Life Support Systems, Nutrition, Biotechnology, Cultivation, Photobioreactors, Sustainability

Introduction

Extended human habitation in space demands sustainable solutions for food and environmental control. Traditional food transport is impractical, making algae a key biotechnological candidate. Algae efficiently convert sunlight, water, and CO2 into essential nutrients and biomass, which can be used for food and biofuel. They also support closed-loop systems by recycling waste and generating oxygen. Optimizing cultivation and genetic engineering can further enhance their productivity, making algae a vital resource for long-term space missions.

Role of algae as a life support system

A) Source of food

Algae have become a promising food source for space exploration due to their nutritional value and ability to thrive in controlled environments. Since the 1960s, experiments have tested algae's viability in space, leading to the development of algae-based food products by the 1980s. As space missions grew longer in the 1990s, interest in algae as a sustainable food source increased. Today, various types of algae, such as Spirulina, Chlorella, and Nannochloropsis, are used in space for their high nutritional content, including omega-3 fatty acids.

Nutrient	Algae	Traditional Space Food
Protein	High content (50% of their dry weight)	may not provide a complete amino acid profile.
Vitamins	Rich in B vitamins, vitamin C, and others	Limited variety
Minerals	Contains iron, calcium, and magnesium	levels may vary and may not be as abundant as in algae.
Fiber	Provides dietary fiber promotes gut health, and can help regulate blood sugar levels.	Often low in fiber which can contribute to digestive issues.
Omega-3 Fatty Acids	Particularly rich in omega-3 fatty acids, especially docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA). These fatty acids are essential for brain health, heart health, and reducing inflammation.	Limited amounts of omega-3 fatty acids are typically found in packaged foods, especially those processed at high temperatures.
Antioxidants	Packed with antioxidants, including carotenoids and phycobiliproteins, which help protect cells from damage caused by free radicals.	Can be lower

Table: Nutritional Benefits of Algae Compared to Traditional Space Food

Leading space agencies, including NASA, ESA, and Roscosmos, have pioneered the exploration of algae as a food source for space missions. NASA has developed various algae-based food products, while ESA has focused on its nutritional benefits and cultivation in space. Roscosmos has contributed to understanding algae's growth in microgravity. Today, algae-infused snacks like energy bars and chips, as well as complete meals incorporating algae, are being used to meet the nutritional needs of astronauts during long-duration missions.

B) Source of life support

Long-term interplanetary missions require innovative life support solutions, as traditional methods of carrying supplies are unsustainable due to high costs. For example, launching the 6,800 liters of water needed annually for a crew of six would cost $150 million. Microalgae offer a promising alternative by absorbing CO2 and producing oxygen, creating a breathable environment while also serving as a food source and purifying water.

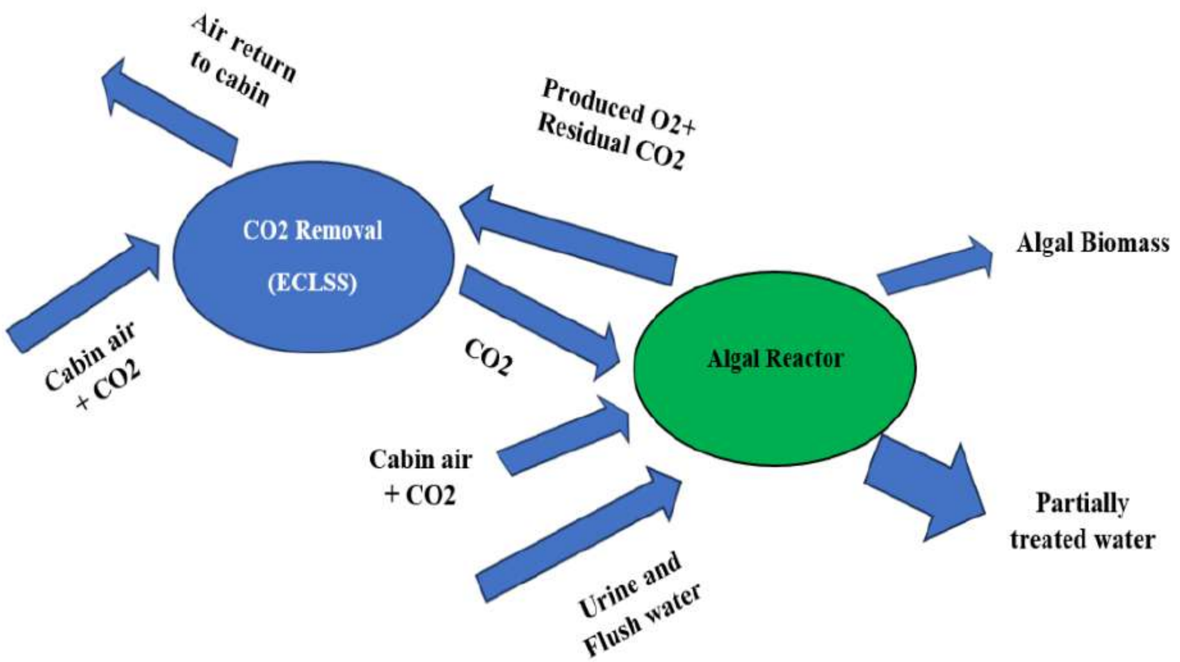

Figure: Integration of microalgal system into ECLSS (The Environmental Control and Life Support System onboard the International Space Station for air revitalization and water recovery)

Experiments like AQUARACK and the Eu: CROPIS mission have demonstrated the feasibility of integrating microalgae into life support systems. These systems can be combined with existing Environmental Control and Life Support Systems (ECLSS) by using CO2 from cabin air and nutrients from waste to enhance oxygen production and reduce waste. This integration not only supports a near-closed-loop system but also conserves valuable resources that would otherwise be lost.

Furthermore, microalgae could play a crucial role in future Mars missions, utilizing the planet's CO2-rich atmosphere to support human colonization. Overall, microalgal systems hold significant potential for sustaining life during long-duration space missions.

Biotechnological Advancements in Algae Cultivation in Space

Recent experiments on integrating photosynthetic microorganisms, especially microalgae, in space environment for life support has shown promise. Biotechnology has been playing a major role in helping design cultivation systems for algae in space to complement pre-existing life support systems. Thus, live algae cultures could be key to sustaining long-duration space missions in the near future.

A) Biotechnology and Algae

Biotechnology leverages living organisms and systems to develop valuable products, and in the case of algal biotechnology, it specifically involves the application of algae—both microalgae and macroalgae—for creating or modifying products or processes. Algal biotechnology is typically divided into two categories: the biotechnology of large, multicellular macro-algae (seaweeds) and the biotechnology of microscopic, mostly unicellular micro-algae. Currently, research is primarily focused on cultivating microalgae in space due to their potential in supporting long-duration missions.

B) Cultivation Systems

Since the 1940s, global efforts have focused on developing large-scale microalgae cultivation systems, with much attention given to open systems. The challenge in these systems is optimizing growth factors—light, nutrients, temperature, mixing, and pH—to achieve the best results. While light should be the limiting factor for maximum biomass, nutrients like macronutrients, trace elements, and vitamins are crucial for optimal growth. To boost biomass yield, an organic carbon source is often added, and the ideal temperature range is 15-30°C. Advanced computer systems are used to monitor and control these conditions.

However, conditions that maximize biomass may not be optimal for producing specific algal products like lipids or pigments. As a result, each system requires tailored optimization, often involving a two-step process: first maximizing biomass, then applying stress conditions, such as nutrient limitation, to stimulate the production of the desired product.

Cultivation systems are categorized into two main types: open outdoor systems and closed systems:

Open System: Commercial cultivation of microalgae typically occurs in open systems, where algae are exposed directly to the environment. The most basic form is large open ponds, which are cost-effective, durable, and simpler to maintain compared to large closed reactors. These ponds vary in dimensions, shape, construction materials, agitation methods, and inclination. The choice of materials—ranging from sand or clay to bricks, cement, or plastics like PVC—affects the pond's performance, cost, and longevity. Durable plastic membranes are commonly used for lining. Key factors like mixing, carbon dioxide availability, and contamination prevention are crucial for maintaining productivity.

There are three main types of open systems: (1) Inclined Systems: Use pumping and gravity for mixing, (2) Circular Ponds: Use a rotating arm for agitation, (3) Raceway Ponds: Designed as continuous loops with paddle wheels for circulation.

Closed System: In contrast, closed systems, or photobioreactors (PBRs), contain algae cultures within sealed, usually transparent containers. These systems are designed to supply light through the reactor's walls and provide nutrients to the algae, while releasing oxygen. PBRs require precise process control, maintaining optimal levels of substrate concentration, pH, redox potential, and temperature, alongside proper illumination.

Closed systems offer significant advantages over open systems. While open systems suffer from low cell densities, moderate growth rates, and inconsistent nutrient flow due to fluctuating environmental conditions, closed PBR systems achieve much higher productivity.

PBRs can be classified based on design and operation. In terms of design, they include: (1) flat or tubular; (2) horizontal, inclined, vertical, or spiral; and (3) manifold or serpentine. Operationally, they can be categorized as: (4) air or pump mixed, and (5) single-phase reactors (which contain media with gas exchange occurring in a separate gas exchanger) or two-phase reactors (where both gas and liquid are present, with continuous gas mass transfer within the reactor). Construction materials add further variation, such as (6) glass or plastic and (7) rigid or flexible PBRs.

C) Algal Biotechnology in Space

To minimize resupply needs for long-duration manned space missions, developing a bioregenerative life support system (BLSS) is crucial. This system must address the crew's food supply, air, water, and waste recycling. PBRs and liquid cultures of photosynthetic microbes are key components used in space to help achieve these goals.

D) Development of Space PBRs

Developing biological air revitalization systems for space involves assessing several critical factors before making a bioreactor operational. Initial tests include evaluating an organism's ability to survive space travel conditions, such as microgravity and ionizing radiation. Experiments focus on growth kinetics, metabolic pathways, and genetic stability under space conditions. Key parameters like O2 production, CO2 uptake, and nutrient utilization are modelled and tested in liquid cultures. Successful criteria lead to the development of photobioreactor (PBR) hardware, which must ensure sterility, biocompatibility, and effective mixing while incorporating controls for pH, temperature, and nutrients. Integrating the PBR with the Biological Life Support System (BLSS) follows. Space experiments on liquid culturing and PBRs have included algae and cyanobacteria, demonstrating survival and growth under space conditions, with the 2017 ISS experiment being the most advanced in measuring oxygen production and growth rates online.

E) PBRs for Air Revitalization and Biomass Production in Space Habitats

The use of photosynthetic organisms like plants, algae, and cyanobacteria to capture CO2 and H2O for producing biomass and oxygen has been explored since before the first human spaceflight, with significant progress in the latter half of the 20th century. The European Space Agency's MELiSSA project, initiated in 1988, integrates physicochemical technologies with biological processes through its five interconnected compartments, including two photobioreactors (PBRs). MELiSSA converts waste into nutrients and facilitates biological air revitalization, using light intensity and controlled conditions to optimize biomass production. Algae and cyanobacteria are particularly efficient, requiring less space and offering continuous harvesting with minimal processing, thus reducing waste and avoiding harmful microorganisms. This approach demonstrates the potential for sustainable life support systems in space exploration.

Organism	Vehicle	Hardware	Duration	Results
Nostoc sp. PCC7524 and	Long March 2	Dialysis bags that allow for	4.5 days	Fixation of the cells was successful, some of the *Nostoc*

a plastid mutant of *Euglena gracilis*		gas exchange		cells germinated in the microgravity conditions
Chlorella vulgaris LARG-1	Bion-9 (Cosmos-2044)	Three-component aquatic system	13 days	Microscopy revealed differences in organelle-organization between space and ground samples but there was so significant difference in growth
Nostoc sphaeroides Kütz	Shenzou-II	Closed chambers	6 days 15 h	A high growth rate was observed for the space samples exposed to microgravity
Anabaena siamensis FACHB 799	Chinese retrievable satellite	Small bioreactor	15 days	Growth in space was slower, but after return, the space cultures grew at a higher rate. After a few generations, both cultures grew at the same rate
Euglena gracilis with *Oreochromis mossambicus* (cichlid fish)	Foton M2	Cylindrical prototype with two connected bioreactors	15 days	The oxygen production of *E. gracilis* gradually decreased in the first 9 days and increased afterward. Seven of the 35 fish died
Chlorella pyrenoidosa FACHB 415 and *Bulinus australianus* (snail)	Chinese retrievable satellite and Shenzou-II	Culture chambers	Satellite: 15 days; spacecraft: 6 days 15 h	Satellite: The algae survived but became a little lower in number, the snails died (probably from CO_2 intoxication), spacecraft: the average *Chlorella* concentration decreased
Euglena gracilis with	Foton M3	Polycarbonate cylinder	12 days	The oxygen level in the tank decreased a little more than

Oreochromis mossambicus (cichlid fish)		with adjacent compartments		expected. 11 out of 26 fishes survived the flight
Euglena gracilis Z	Shenzou-8	Double culture chamber, separated by biofoil	17 days, fixation after 40 min (other samples failed)	First report on microgravity-induced changes at the transcriptional level of an unicellular eukaryotic organism
Limnospira indica PCC8005	ISS	Cylindrical PBR with flat membrane liquid and gaseous phase	5 weeks	Generally successful, but some technical difficulties. First dynamic growth of cyanobacteria in space and the gas and biomass model was shown to be applicable

Table: Space flight experiments with algae and cyanobacteria for PBR

Challenges and Future Directions in Space-Based Algal Cultivation

1. Challenges

Expensive and Risky Experiments: Space experiments are costly and require extensive preparation and astronaut involvement. Many photobioreactor (PBR) experiments have failed, such as a 30-day *Chlorella sorokiniana* study that ended due to a reactor leak, and the PBR@LSR project, which had to be terminated early due to technical issues.

Contingency Planning: Life support systems must be reliable, with backup mechanisms to prevent catastrophic failures. Any drop in oxygen production, for instance, must be addressed immediately through alternative systems or parallel PBRs.

Gas Balance: Balancing oxygen production by algae with the crew's CO2 output is complex, especially in microgravity, where gas exchange differs from Earth. Limited information is available on gas transport under microgravity, adding to the challenge.

Resource Utilization and Light Energy: A Bioregenerative Life Support System (BLSS) isn't fully self-sufficient, requiring external resources like carbonates and trace elements. While photoautotrophic organisms rely on light, experiments have so far used only artificial light sources due to the challenges of harnessing natural solar energy in space.

Upscaling: Most PBR research is at a small scale, insufficient to meet the oxygen needs of a full crew. Scaling up successful lab experiments is crucial for practical applications in space.

Effects of Space Conditions: Long-term microalgae cultivation in space requires consistent growth rates. Monitoring genetic stability, mutation rates, and the impact of cosmic radiation and low gravity on oxygen production and nutrient quality is vital.

2. Future Directions

Connecting Bioreactors for Closed Loops: Integrating bioreactors with other life support systems, such as waste recycling and crew support, is essential to address the challenges of incomplete loops in BLSS systems.

Improving Data Monitoring and Reporting: Space experiments often lack detailed data, such as light intensity, temperature, and pH levels, making it difficult to compare results. Implementing real-time monitoring and remote control of PBR experiments in space will improve reproducibility and reliability in future missions.

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SINGLE CELL PROTEIN- RECENT DEVELOPMENT

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Abstract

The growing global population, projected to reach 9.7 billion by 2050, has increased the demand for sustainable food systems. This paper explores Single Cell Protein (SCP) as a viable alternative to traditional food sources, with a focus on using food waste as a substrate. Food waste, driven by population growth and industrialization, poses significant environmental challenges. Recent advancements in SCP technology, particularly in the European Union and South Africa, highlight the potential of food waste valorization. While current pretreatment methods for lignocellulosic biomass are costly and energy-intensive, innovative solutions like ionic liquids offer promise in enhancing SCP yields and reducing environmental impact.

Introduction

The modernization of the world and the need for thriving societies have raised living standards, which in turn has heightened the demand for food safety and quality. With global population projections reaching 9.7 billion by 2050, there will be an inevitable increase in competition for land, water, and energy resources (https://www.un.org/development/desa/en/news/population/world-population-prospects-2019.html). Therefore, it is crucial to develop sustainable food systems that rely on renewable ingredients. Addressing challenges such as greenhouse gas emissions, the significant use of freshwater in agriculture (approximately 70%), and the emissions linked to livestock production (up to 18%) as well as ammonia utilization could help mitigate or at least alleviate these issues(FAO). Single cell protein can act as a substitute to traditional food sources. In these article we will look at the recent developments in Single cell protein.

Food waste as a substrate for Single Cell Protein

Food waste is one of the most abundant and accessible resources for achieving sustainable and cost-effective Single Cell Protein (SCP) technology. Factors such as rapid population growth, improved living standards, and high levels of industrialization contribute significantly to the ongoing increase in food waste (Dahiya *et al*.,2018). According to the United Nations Environment Program's Food Waste Index, approximately 1 billion tons of food waste are generated globally each year, with industrialized nations being major contributors. Historically, these countries have relied on traditional and unsustainable methods for food waste treatment, such as landfilling and incineration. However, stringent waste disposal regulations are now pushing them towards adopting eco-friendly approaches that align with the principles of a circular bioeconomy. The European Union, for instance, is leading research in this area (Fava *et al* .,2015).

Unfortunately, in developing countries like South Africa, food waste continues to pose a significant threat to both human health and ecological habitats due to inadequate waste management technologies (Mmereki *et al*.,2016). A study by the Council for Scientific and Industrial Research (CSIR) revealed that South Africa produces about 10.3 million tons of food waste annually, and this number is expected to rise. The alarming increase is concerning, especially considering that only 10% of waste, including food waste, is recycled in South Africa, while the remaining 90% is either landfilled or incinerated, leading to various environmental issues (Diemen *et al* .,2021). Recently, South Africa's Department of Environmental Affairs implemented strict environmental policies aiming to eliminate organic waste disposal by 2027(Wang *et al* ., 2023). This calls for immediate action from local industries and scientists to develop innovative biowaste valorization technologies, which could save the South African government millions of rands currently spent on waste management strategies.

PRETREATMENT OF STRAW RESOURCES

The pretreatment and hydrolysis of lignocellulosic biomass present significant challenges in the large-scale heterotrophic production of Single Cell Protein (SCP). To address these challenges, new technologies are being developed that aim to lower costs, reduce energy consumption, minimize environmental toxicity, and create value chains capable of producing food-grade SCP.

One promising approach involves the use of ionic liquids (ILs). ILs are salt-like materials composed of organic cations and inorganic anions, which are liquid at unusually low temperatures. In the context of SCP production, ILs break the glycosidic bonds between lignin and the cellulose and hemicellulose components, creating electrostatic repulsion between cellulose chains and making them more accessible after IL exposure (Rieland *et al*.,2020). Additionally, dissolved cellulose can be easily recovered from the IL solution by adding water or ethanol, and the IL can be reused, marking significant progress toward large-scale green cellulose recycling (Upcraft *et al* ., 2021).

A recent study explored the use of a choline-based, food-grade IL for producing mycoprotein from lignocellulose using *Fusarium venenatum* (Upcraft *et al* ., 2021). The life cycle assessment (LCA) of this process, assuming a production scale of 40,000 tons per year, showed improved sustainability for SCP intended for human consumption. However, further improvements in yield are necessary before this technology can be fully commercialized.

Conclusion

Single Cell Protein (SCP) presents a sustainable alternative to traditional food sources, addressing key challenges like greenhouse gas emissions, freshwater use, and food waste. Utilizing food waste as a substrate for SCP offers an eco-friendly solution, especially in regions with inadequate waste management, like South Africa. Although the pretreatment of lignocellulosic biomass remains costly and complex, advances in technologies such as ionic liquids are paving the way for more efficient SCP production. Continued innovation is essential to fully realize SCP's potential for improving food security and sustainability.

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SOIL ACIDITY- CAUSES, IMPACT AND MANAGEMENT

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Abstract

Soil acidity refers to the presence of excess hydrogen ions (H^+) in the soil, which lowers the soil pH. The pH scale, ranging from 0 to 14, measures the acidity or alkalinity of a solution, with a pH of 7 being neutral. Soils with a pH below 7 are considered acidic, and the degree of acidity increases as the pH decreases. Soil acidity is a critical factor affecting soil health and crop productivity, particularly in regions with high rainfall and intensive agricultural practices. Understanding soil acidity, its causes, effects, and management strategies is essential for maintaining soil fertility and ensuring sustainable agricultural production.

Keywords: Soil acidity, Soil fertility, Impact, Management

Introduction

Soil acidity is a critical aspect of soil chemistry that significantly influences plant growth and agricultural productivity. It refers to the concentration of hydrogen ions (H^+) in the soil, which determines the soil's pH level. Acidic soils are characterized by low pH and high levels of exchangeable hydrogen (H), aluminum (Al) and manganese (Mn) ions[1]. These soils typically have low cation exchange capacity (CEC) and are highly base unsaturated, leading to several adverse effects on plant growth. The accumulation of toxic levels of aluminum, manganese (Mn), and iron (Fe) is common, along with deficiencies in essential nutrients like calcium (Ca) and magnesium (Mg)[2]. In acidic soils, the availability of phosphorus (P) is often limited due to weak usability and a high capacity for phosphorus fixation. While most micronutrients are adequately available in these soils, molybdenum is typically deficient. In regions with high rainfall, intensive farming, or poor soil management practices, soils often become acidic, leading to a host of challenges for farmers and land managers. Acidic soils can hinder nutrient availability, increase the toxicity of certain elements like aluminum and manganese, and negatively impact microbial activity, all of which are vital for healthy plant development.

Classes of Soil Acidity

Soil acidity is typically classified into different categories based on where the acidity is located in the soil and how it affects the soil's properties. The three main classes of soil acidity are:

1. Active Acidity

Active acidity refers to the concentration of hydrogen ions (H^+) present in the soil solution. It is the acidity that directly influences the soil pH and is immediately available to affect plant roots and soil microorganisms. Active acidity affects nutrient availability, microbial activity, and the overall growth environment for plants.

2. Exchangeable Acidity

Exchangeable acidity refers to the hydrogen (H^+) and aluminum (Al^{3+}) ions that are adsorbed onto the soil's cation exchange sites. These ions are in a reversible state and can be exchanged with other cations in the soil solution, potentially becoming active acidity. Exchangeable acidity is important because it represents a reservoir of acidity that can be released into the soil solution, especially under conditions that lower the soil pH, such as heavy rainfall or the application of certain fertilizers.

3. Residual Acidity

Residual acidity refers to the hydrogen and aluminum ions that are bound to soil particles, particularly clay and organic matter, and are not easily exchanged or measured in the soil solution. This form of acidity is tightly held by the soil matrix and is not directly available to plants. Residual acidity represents a long-term source of acidity in the soil. Over time, it can contribute to the re-acidification of the soil after lime application, especially if the soil is subjected to leaching or further acidification processes.

Understanding these classes of soil acidity is crucial for effectively managing soil pH and ensuring optimal conditions for crop growth. Each class plays a distinct role in the soil's overall acidity, and addressing them requires different management strategies, such as lime application to neutralize active and exchangeable acidity, or soil amendments to deal with residual acidity.

Causes of Soil Acidity

Soil acidity can be caused by several natural and anthropogenic factors:

1. **Parent Material**: Soils derived from acidic rocks such as granite tend to be acidic. The weathering of these rocks over time releases acidic components into the soil.
2. **Leaching**: In regions with high rainfall, essential nutrients like calcium, magnesium, and potassium are leached away, leaving behind more acidic elements such as aluminum and iron.
3. **Organic Matter Decomposition**: The decomposition of organic matter produces H^+ ions which contribute to soil acidity[3]. While organic matter is beneficial for soil structure and fertility, excessive decomposition without proper management can lead to increased acidity.
4. **Use of Acidic Fertilizers**: Continuous use of fertilizers like ammonium sulphate or urea can acidify the soil over time. These fertilizers release ammonium, which is converted into nitrate by soil bacteria, releasing hydrogen ions in the process, thus lowering the pH.
5. **Crop Removal**: Harvesting crops removes basic cations (Ca^{2+}, Mg^{2+}, K^+) from the soil, leading to increased acidity if not replenished.
6. **Acid Rain**: Industrial emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_x) lead to acid rain, which can significantly lower soil pH.

Impact of Soil Acidity on Agriculture

Soil acidity has several detrimental effects on soil health and crop productivity.

1. **Nutrient Availability**: Acidic soils reduce the availability of essential nutrients such as phosphorus, calcium, and magnesium. Phosphorus, for example, becomes less soluble and thus less available to plants as soil pH decreases.
2. **Toxicity**: High soil acidity can increase the solubility of toxic elements like aluminum and manganese. Aluminum toxicity is particularly detrimental as it stunts root growth, reduces water and nutrient uptake, and impairs overall plant health.
3. **Soil Structure**: Acidic conditions can lead to poor soil structure, reducing water infiltration and increasing erosion risks.

4. **Microbial Activity**: Soil acidity affects the microbial population, particularly beneficial bacteria involved in nutrient cycling. Nitrogen-fixing bacteria, for instance, are less active in acidic soils, leading to reduced nitrogen availability.
5. **Plant Growth**: Crops grown in acidic soils often exhibit poor growth, yellowing of leaves, stunted roots, and reduced yields. Certain crops are more sensitive to acidity than others, which can limit the choice of crops that can be grown in such soils.

Management of Soil Acidity

Effective management of soil acidity is crucial for maintaining soil health and ensuring sustainable agricultural productivity. Several strategies can be employed to ameliorate soil acidity:

1. **Liming**: The most common and effective method for correcting soil acidity is the application of lime ($CaCO_3$). Applying the right amount of lime is crucial not only for achieving maximum economic returns but also for maintaining a proper nutrient balance essential for optimal crop production[4]. Lime raises soil pH by neutralizing hydrogen ions and reducing the solubility of aluminum. The amount of lime required depends on the soil's current pH, the desired pH, soil texture, and organic matter content. Regular soil testing is essential to determine the correct liming rate.
2. **Use of Alkaline Amendments**: In addition to lime, other alkaline materials such as dolomite (which provides magnesium as well as calcium), wood ash, and gypsum (calcium sulphate) can be used to amend acidic soils. Dolomite is particularly beneficial in soils deficient in magnesium.
3. **Organic Matter Management**: Incorporating organic matter, such as compost or green manure, can help buffer soil pH and improve soil structure. Organic matter can also enhance microbial activity, which aids in the gradual neutralization of soil acidity.
4. **Balanced Fertilization**: Avoiding excessive use of acid-forming fertilizers and opting for balanced fertilization strategies is crucial. Fertilizers like ammonium sulphate should be replaced with less acidifying alternatives such as ammonium nitrate or calcium nitrate. The use of lime-stabilized organic fertilizers can also help maintain a balanced pH.
5. **Crop Rotation and Selection**: Rotating crops with deep-rooted species that can access nutrients from deeper soil layers can help manage soil acidity. Additionally, growing

acid-tolerant crops like tea, potatoes, or rye can be a practical approach in areas where correcting soil pH is not feasible.

6. **Cover Cropping**: Planting cover crops like clover or legumes can improve soil structure, reduce erosion, and add organic matter to the soil. Some cover crops also have the ability to mobilize nutrients, making them more available to subsequent crops.

Conclusion

Soil acidity is a significant challenge in agriculture, particularly in regions with high rainfall and poor soil management practices. However, with proper management techniques, the negative effects of soil acidity can be mitigated, leading to improved soil health and crop productivity. Regular soil testing, appropriate liming and balanced fertilization are key strategies in managing soil acidity. By adopting these practices, farmers can ensure sustainable agricultural productivity and protect the long-term fertility of their soils.

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SOIL CARBON SEQUESTRATION: AN OVERVIEW

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Abstract

Soil carbon sequestration refers to the process of capturing and storing carbon dioxide (CO2) from the atmosphere in the soil through biological, chemical, and physical processes. As concerns about climate change intensify, soil carbon sequestration has gained recognition as a crucial tool in mitigating greenhouse gas emissions while simultaneously improving soil health and agricultural productivity. This practice not only supports climate action but also promotes more sustainable farming practices that benefit both the environment and agricultural economies. Recent developments in carbon sequestration reflect growing efforts to mitigate climate change through both technological and natural solutions. These advancements include improvements in agricultural practices, innovations in carbon capture technology, and the integration of policies and incentives to support large-scale implementation. Different soils have varying capacities to sequester carbon depending on their texture, mineral content, and moisture.

Keywords: Soil Carbon Sequestration, Climate Change, Environment, Challenges

Introduction:

Soil carbon sequestration involves capturing and storing carbon dioxide (CO_2) from the atmosphere in soil through natural processes like plant growth, photosynthesis, and the breakdown of organic material. This approach plays a crucial role in mitigating climate change by reducing atmospheric CO_2 levels, a major contributor to global warming. Plants absorb CO_2 during photosynthesis and transfer carbon to the soil through their roots and decomposing organic matter. This carbon becomes part of the soil organic matter (SOM), improving soil health, fertility, and its ability to retain water. Unlike short-term carbon storage methods, soil carbon sequestration offers a long-lasting solution, as carbon can remain stored in soils for decades to centuries, making it a sustainable option for addressing climate change while also boosting agricultural yields.

What is Soil Carbon Sequestration?

At its core, soil carbon sequestration involves increasing the carbon content of soils through natural processes. Plants absorb CO2 during photosynthesis, converting it into organic matter. When plants die or shed leaves, roots, and other biomass, the organic material breaks down and is incorporated into the soil, where it can be stored as Soil Organic Carbon (SOC). Over time, SOC accumulates, improving soil structure, fertility, and water-holding capacity.

The process is inclined by several factors, including soil type, climate, vegetation, and land management practices. Soils rich in organic matter have complex carbon-sequestration potential. However, soil disturbance from intensive tillage, monocropping, and overuse of chemical inputs can lead to carbon loss. Therefore, adopting sustainable land management practices is essential for exploiting the sequestration potential of agricultural soils.

Advantages of Carbon Sequestration in Soil

1. **Climate Change Mitigation**: One of the primary benefits of soil carbon sequestration is its potential to mitigate climate change by reducing atmospheric CO2 levels. Soils can act as a carbon sink, helping to offset carbon emissions from fossil fuel consumption, deforestation, and other human activities.
2. **Enhanced Soil Health and Productivity**: Increasing SOC improves soil health by enhancing its structure and increasing its capacity to retain water and nutrients. This can result in higher crop yields, reduced need for chemical fertilizers, and increased resilience to droughts and extreme weather events. Healthier soils also support biodiversity, fostering a diverse microbial community that further aids in nutrient cycling and plant growth.
3. **Sustainable Agriculture**: Soil carbon sequestration aligns with the goals of sustainable agriculture by promoting practices that are beneficial for both the environment and farmers. Techniques such as no-till farming, cover cropping, agroforestry, and rotational grazing not only increase soil carbon but also reduce soil erosion, enhance water infiltration, and improve overall farm resilience.

Essential Methods for Sequestering Carbon in Soils

1. **Conservation Tillage**: Reducing soil disturbance through no-till or reduced-till practices minimizes carbon loss from the soil. This allows carbon to accumulate over time, improving both carbon sequestration and soil health.
2. **Cover Cropping**: Planting cover crops during fallow periods prevents soil erosion and increases organic matter inputs. Cover crops such as legumes and grasses enhance soil carbon sequestration by contributing biomass to the soil.
3. **Agroforestry**: Integrating trees into agricultural landscapes helps capture more carbon both in the soil and in above-ground biomass. Trees' deep root systems also contribute to long-term carbon storage.
4. **Organic Modifications**: Adding organic matter to the soil, such as compost, manure, and biochar, increases carbon content and improves soil structure. These amendments also support soil microorganisms that aid in carbon cycling.
5. **Crop Rotation and Polyculture**: Diverse crop rotations and polyculture systems reduce soil degradation and improve nutrient cycling, promoting long-term carbon storage in the soil.

Constraints and Considerations

While soil carbon sequestration offers tremendous potential, it is not without challenges. One of the main difficulties lies in measuring and verifying the amount of carbon stored in soils. Carbon sequestration rates can vary significantly based on soil type, climate, and management practices. Additionally, the permanence of sequestered carbon is not guaranteed, as changes in land use or management can release stored carbon back into the atmosphere.

Farmers may face upfront costs in adopting carbon-sequestration practices, and there is often a lag before the benefits become visible. Incentives, subsidies, and carbon markets can help address these financial barriers by providing compensation to farmers for the carbon they sequester.

International Action and Policy: Their Roles

Government policies and international initiatives are key to scaling up soil carbon sequestration. Programs such as the "4 per 1000 Initiative," launched by France in 2015, aim to increase global soil carbon stocks by 0.4% annually. Such initiatives encourage collaboration between farmers, researchers, and policymakers to develop and promote best practices.

Carbon markets also offer potential for rewarding farmers who adopt practices that increase soil carbon. By providing a financial incentive for carbon storage, carbon markets could accelerate the adoption of sustainable farming techniques that sequester carbon and enhance soil health.

Advancements in Soil Carbon Sequestration

1. Direct Air Capture (DAC) Technology

Direct Air Capture (DAC), a form of carbon sequestration that mechanically pulls CO2 from the atmosphere, has seen significant investment and progress.

2. Enhanced Soil Carbon Sequestration Techniques

Biochar -a form of carbon-rich charcoal has gained attention for its ability to store carbon in soils for hundreds to thousands of years while improving soil health. Agroforestry and silvipasture (combining trees and livestock) are also being promoted as ways to sequester carbon on agricultural land. These practices not only sequester carbon but also provide biodiversity benefits and improved farm resilience.

3. Ocean-based Carbon Sequestration

Marine permaculture, which involves cultivating seaweed forests, shows potential for capturing large amounts of carbon while restoring marine ecosystems.

4. Carbon Sequestration in Agro-ecosystems

Innovative approaches in agroecosystems focus on increasing carbon storage in agricultural soils. Precision farming technologies that reduce soil disturbance, such as no-till farming, and the use of cover crops, have been fine-tuned to maximize carbon retention while improving crop yields. Partnerships between farmers, governments, and private companies have led to the development of carbon farming programs, which provide financial incentives for farmers to adopt carbon-sequestration practices.

5. Carbon Capture, Utilization, and Storage (CCUS) Projects

CCUS technologies that capture CO2 from industrial processes (such as steel or cement production) have continued to expand. Advances in carbon utilization have made it possible to turn captured CO2 into products like concrete, fuels, and plastics, effectively storing the carbon in long-lasting materials.

6. Emerging Carbon Markets and Incentives

Governments and businesses are increasingly incorporating carbon credits into their sustainability strategies, creating a growing demand for carbon-sequestration projects. The development of **carbon markets**, particularly voluntary carbon offset markets, allows organizations to compensate for their emissions by investing in sequestration initiatives.

7. Nature-Based Solutions

Reforestation and afforestation projects remain key components of nature-based carbon sequestration. Restoring degraded peat lands can prevent carbon emissions while enhancing biodiversity and water regulation.

Conclusion

Soil carbon sequestration holds immense promise as a natural, sustainable solution to combat climate change while improving soil health and agricultural productivity. By capturing atmospheric carbon dioxide and storing it in soils, we can simultaneously reduce greenhouse gas levels and enhance the resilience and fertility of agricultural land. However, realizing its full potential requires the widespread adoption of sustainable land management practices such as no-till farming, cover cropping, agroforestry, and improved grazing techniques. Despite its promise, soil carbon sequestration faces significant challenges, including the slow rate of carbon storage, the eventual saturation of soils, variability across different soil types, and the need for long-term policy support and financial incentives. Additionally, robust measurement and monitoring systems are essential to verify the effectiveness of these practices and ensure that stored carbon remains in the soil.

In conclusion, soil carbon sequestration is a critical component of global efforts to mitigate climate change. It offers co-benefits for agricultural systems, biodiversity, and water management. Addressing the scientific, economic, and policy challenges associated with this approach will be key to unlocking its full potential for a sustainable future.

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DYNAMIC FEEDBACK ANALYSIS OF AGROMET BULLETIN OF GRAMIN KRISHI MAUSAM SEVA (GKMS) IN DHALAI DISTRICT

Article ID: AG-V04-I09-29

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Introduction

Weather is one of the most vital factors affecting agricultural production. Different climatic abnormalities and extreme weather conditions like erratic rainfall, late onset of monsoon, abrupt changes in day and night temperature during crop season, and a sudden outbreak of pests and diseases are the big challenges for sustaining agricultural production. Agriculture plays a more vital part in the economic growth of the Country. For the improvement of agriculture, this sector requires proper planning and relevant information in a timely manner. Information regarding crop growth stages and weekly weather information at the time of crop season is most important for the proper management of crops. All the farm operations are related to weather information, which will decrease or increase the costs of inputs and various field operations costs. Farmers are not well aware of weather forecasting and their utilization on a daily based. The impact of climate change and associated weather hazards like drought, cyclones, thunderstorms, and hailstorms are key drivers which influence farmers' decision-making process. Further frequent occurrences of extreme events severely impacted agricultural production predominantly over north eastern India.

Initiatives:

To sustain the farmer's production and improve the farmer's economic conditions during 2019, the District Agro-Met unit was established in Krishi Vigyan Kendra (KVK) Dhalai. Dhalai which includes 8 blocks (Ambassa, Chhamanu, Dumburnagar, Durga Chowmahani, Ganganagar, Manu, Raishybari, Salema). District farmers will aware of next upcoming 5 days weather conditions twice in a week along with advisories regarding crops, animals, birds, fisheries, plantation crops and for soil conservation strategies also. In 2020-2021 this unit cover 2976 farmers and in total 5206 farmers are now aware about the weather forecasting. Farmers are receiving weather information and crop related information by mkishan portal, text messages and also by social media like whatsapp group, face book. During 2020-2021, 96 nos. of district bulletin and 768 nos. of bulletin for blocks were prepared by the unit.

Awareness programme on District Agromet Unit at Block Level and package of practices:

The farmers feedback survey was conducted during the month of November, 2020 to April, 2021 in Dhalai District of Tripura by District Agro-Met, KrishiVigyan Kendra Dhalai. The location of the area is 23.85^0 N and 91.91^0E and the average rainfall of the district is 2500mm.Two villages from two blocks were selected for collection of feedback. Total 50 nos. AAS of farmers were randomly selected from two villages, 25 nos. of farmers from each village. Srirampur village of Durgachowmahni block was selected for gummy stem diseases blight of water melon survey and Dabbari village of Salemais selected for early and late blight diseases of potato. Similarly this study was also done for the 50 nos. of Non-AAS farmers for comparative study for impact analysis between AAS farmers and Non-AAS farmes of this two villages. The weather based Agro Advisory bulletin were received from DSS-Portal, IMD, Agrimet Division and were disseminated through whatsapp group, text messages, mkishan portal and Meghdoot app.

Weather sensitive crop growth stages of water melon.

Sl. No.	Growth Stages	Important weather parameter	Effect of Weather parameter
1.	Vegetative growth	Cloud cover, foggy situation, Humidity, Rainfall	Favours gummy stem blight disease and reduce the population of termite
2.	Flowering stage	Cloud cover, foggy situation, Humidity, Rainfall	Favours gummy stem blight disease
3.	Fruiting stage	Cloud cover, foggy situation, Humidity, Rainfall	Favours gummy stem blight disease
4.	Maturity or Harvesting	Cloud cover, foggy situation, Humidity, Rainfall	No effect

Key Result:

Name- Biresh Debbarma
Fathers name- Brajendra Debbarma
Village- Srirampur
Block- Durga Chowmahani
Aadhar Number-
Contact Number-8837240078

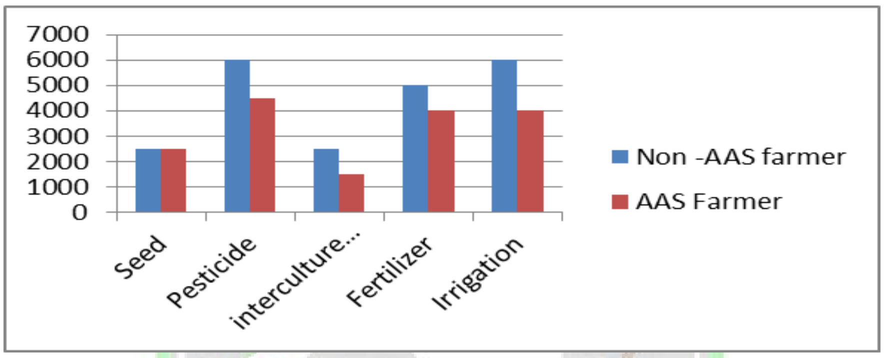

Fig.1-Comparative study of different inputs used in water melon field among the Non-AAS and AAS farmers

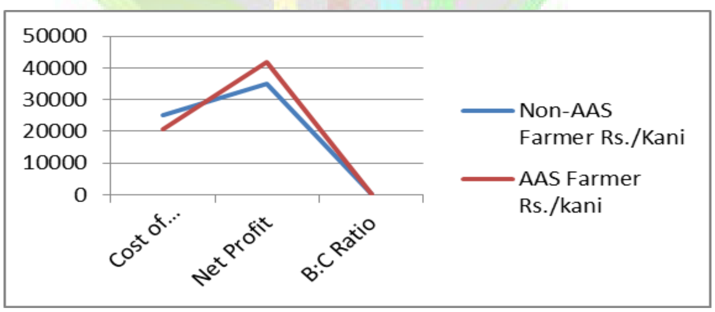

Fig.2- Comparative study of cost, return and B:C ratio of potato crop among the Non-AAS and AAS farmers.

Impact:

The watermelon crop was found very much sensitive to weather parameters at mainly vegetative stage. High humidity with high temperature plays a very much important role in vthe egetative stage because this kind of weather condition is very much favorable is also very much favorable for gummy stem blight disease of water melon.

The cost of various inputs incurred in the Watermelon crop (Fig.1) and (Fig 2) revealed that Non-AAS farmers' cost of cultivation was Rs. 22000/ and Rs.16500/- was AAS farmers. It was also revealed that more yield under AAS farmers and a high benefit-cost ratio compare to Non-AAS farmers. The benefit-cost ratio of Non- AAS farmers were 2.27 and AAS farmer was 3.51.

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SUCCESS STORY: IMPACT OF SUBSOILING ON MIXED CROPPING OF TUR AND SOYBEAN

Article ID: AG-VO4-I09-30

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Introduction

Mr. Dattu MarutiRao Mungade from Shimpala village in Nanded district faced significant challenges in his farming due to soil and water management issues. His soil was hard and compacted, which hindered root growth and water infiltration, leading to poor drainage and water stagnation. These conditions caused a decline in crop yield and health despite his best management practices. The presence of hardpan layers further restricted root penetration and nutrient absorption, while soil erosion indicated poor soil structure and stability. Inefficient water usage was evident as runoff and poor water retention exacerbated the problem. Frequent tillage over time had compacted the soil even more, resulting in nutrient deficiencies in crops. Symptoms of crop stress, such as stunted growth and poor root development, were apparent, and the introduction of new deep-rooted crops required improved soil conditions for optimal growth.

To address these problems, interventions of subsoiling were introduced to his field. KVK Sagroli provided guidance and assistance in implementing subsoiling and compared the results with traditional ploughing methods. The same amount of seeds, insect and pest control, and other inputs were provided to both plots.

KVK Interventions in the Farmer's Field

1. Subsoiling by tractor-operated subsoiler (cost for subsoiling operations Rs 1500/acre).
2. Ploughing by tractor-operated plough (cost for ploughing operations Rs 2000/acre).

Tur Crop in subsoiled Land

Tur Crop in without-subsoiled (ploughed) Land

The experiment aimed to compare the traditional farming method with an innovative subsoiling technique guided by KVK Sagroli.

Experimental Setup: Land Division: The two-acre field was divided into two equal parts.

- One Acre: Subsoiling technique was applied
- One Acre: Traditional farming method (ploughing) was used as the control

What is Subsoiling?

Subsoiling refers to the process of breaking up compacted layers formed beneath the surface of the soil. When the upper layers of the soil become compacted due to various factors, the soil structure deteriorates, and the soil becomes less porous. Subsoiling involves breaking through these compacted layers to improve soil aeration and drainage. The depth of subsoiling typically ranges from 2 to 2.5 feet, depending on the type of soil.

Observations of the experiment:

Sr. No.	Particular	Subsoiled Plot	Without Subsoiled plot
	Crop	Soyabean+ Tur	Soyabean+ Tur
1	Subsoiling Depth, cm	60	15
2	Fuel Consumption, l/h	5	4.5
3.	Subsoiling spacing, cm	120	30
4.	Field capacity, ha/h	0.3	0.15
5.	Soil moisture content	18	14
6.	Root growth ,cm	22	15
7.	Plant Growth	excellent	Normal
8.	Soyabean Yield, q/acre	12	10
9.	Tur Yield, q/acre	3	1.5
10	Income (Soyabean @5000/q and Tur @9000/q)	87000	63505
11.	(Subsoiling and without subsoiling cost/ acre)	1500	2000

Results:

Subsoiled Land:

- Subsoiling Depth, : 60 cm
- Plant Growth: Excellent
- Soybean production: 12 quintals (Rs. 5000/q)
- Tur production: 3 quintals (Rs. 9000/q)

Control (ploughed) Land:

- Ploughing Depth, : 15 cm
- Plant Growth: Normal
- Soybean production: 10 quintals (Rs. 5000/q)
- Tur production: 1.5 quintals (Rs. 9000/q)

Dr. Priyanka Khole, Scientist, SSM's KVK Sagroli visited to the Subsoiled field of farmer Mr. Dattu MarutiRao Mungade

Conclusion

The experiment demonstrated that the subsoiling operation significantly improved crop yields compared to traditional methods. Specifically, the subsoiled land yielded 2 quintals more soybeans and 1.5 quintals more tur than the control land. Additionally, subsoiling helped conserve soil and water, enhancing the sustainability of the farming practice. The expenses for doing subsoiling and ploughing operations are Rs 1500/acre and Rs 2000/acre, respectively.

This success story highlights the benefits of adopting innovative agricultural techniques, such as subsoiling, to save the initial cost, to improve productivity and resource conservation.

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THE NUTRITIONAL SIGNIFICANCE OF INSECTS IN THE HUMAN DIET

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Abstract

Insects have long been a part of human diets across various cultures worldwide, providing a valuable source of nutrition and sustenance. This abstract outlines the nutritional significance of insects in the human diet, highlighting their potential to address global food security challenges and promote sustainable food systems (Chakravorty J., 2014). Insects are rich in protein, healthy fats, vitamins, minerals, and fibre making them a nutritious alternative to conventional animal protein sources (FAO, 2009). They offer a complete amino acid profile and are particularly abundant in essential nutrients such as iron, calcium, and B vitamins. Additionally, insects are environmentally sustainable, requiring significantly less land, water, and feed compared to traditional livestock farming. Furthermore, incorporating insects into the human diet can contribute to addressing malnutrition and food insecurity, especially in regions where access to animal protein is limited. Their affordability, accessibility, and ease of cultivation make them an attractive option for combating nutritional deficiencies and promoting dietary diversity (Jongema Y., 2012). Moreover, the consumption of insects aligns with the principles of sustainable food production, offering a solution to the environmental challenges associated with conventional agriculture. Insects produce fewer greenhouse gas emissions, require minimal resources for rearing, and can thrive on organic waste, thus reducing food waste and environmental pollution (Van Huis A**,** 2013). Despite their nutritional and environmental benefits, the acceptance and

adoption of insect consumption in Western societies remain relatively low due to cultural taboos and perceptions. However, increasing awareness, education, and innovative culinary approaches can help overcome these barriers and promote the integration of insects into mainstream diets (Kumar, 2017). In conclusion, insects represent a promising and sustainable solution to global food security challenges, offering a nutritious and environmentally friendly alternative to conventional protein sources (Shantibala 2012). Embracing insect consumption can not only improve human health but also contribute to building more resilient and sustainable food systems for future generations.

Keywords: Insect, Sustainable environment, Nutrition, Greenhouse gas, Diet diversity.

Introduction:

What is Entomophagy ?

- Entomophagy is a Greek word, '*entomon*' means insect and '*phagein*' means to eat.
- Entomophagy is the practice of eating insects for food.
- FAO has registered some 1,900 edible insect species and estimates that there were, two billion insect consumers worldwide. (FAO 2013)
- Entomophagy is not only a historical practice but also a contemporary phenomenon gaining attention due to its potential as a sustainable and nutritious food source.
- Insect consumption can take various forms, including eating whole insects, incorporating insects into dishes as ingredients, or processing insects into powders, flours, or other food products.
- Insects are valued for their nutritional content, which often includes high levels of protein, healthy fats, vitamins, and minerals.
- Additionally, insects are often more environmentally sustainable to produce compared to traditional livestock, requiring fewer resources such as water, feed, and land.

History:

Eating insects has been going on in human culture for quite some time. Cave paintings have shown us that ancient civilizations ate insects. (30000 to 9000 BC)

- **Prehistoric Era**: Early humans likely consumed insects as a significant part of their diet due to their abundance and nutritional value.
- **Ancient Mesopotamia**: Locusts were among the insects consumed in this region, particularly during times of scarcity.

- **Ancient Egypt**: Hieroglyphs and archaeological evidence indicate that insects, including locusts, beetles, and caterpillars, were part of the ancient Egyptian diet, especially during times of famine.
- **Ancient Greece and Rome**: Insects were considered delicacies in these civilizations, with aristocrats enjoying beetle larvae and other insects as luxury foods.
- **Ancient China**: Insects such as silkworm pupae, cicadas, grasshoppers, and crickets were consumed in ancient China, both as food and in traditional medicine.
- **Mesoamerica (Aztecs and Mayans):** Insects like grasshoppers, ants, and agave worms were significant components of the Aztec and Mayan diets, often considered delicacies and used in various dishes.
- **South Asia (India):** Certain communities in India, particularly in tribal areas, have a history of consuming insects like red ants and their larvae.
- The **locust** *Schistocerca gregaria* for use both as human food and fertilizer in India and he has concluded that locusts were high in crude protein and fat. (Das 1945)
- The Greeks and Romans both ate insects. Records state that they ate locust and beetle larva. (Insect Cambridge World History of Food).
- As early as 1813, Forbes had mentioned that termites are eaten by local tribes in Mysore and the Karnataka region. (Forbes,1813)

Why eat insects ?

1. **Nutritional Value:** Many edible insect species are highly nutritious, serving as excellent sources of protein, healthy fats, vitamins, and minerals. For example, insects like crickets and mealworms are rich in protein, comparable to or even exceeding the protein content of traditional livestock such as beef or chicken. Insects also contain essential amino acids, omega-3 and omega-6 fatty acids, iron, calcium, and B vitamins.
2. **Environmental Sustainability:** Insects have a much smaller environmental footprint compared to traditional livestock. They require significantly less land, water, and feed to produce the same amount of protein. Insect farming produces fewer greenhouse gas emissions and generates less pollution compared to conventional livestock farming, making it a more sustainable option for protein production, particularly as global demand for food increases.

3. **Resource Efficiency:** Insect farming is highly efficient in terms of resource utilization. Insects can be reared on organic waste materials such as food scraps, agricultural by-products, or manure, converting these low-value materials into high-quality protein. This can help reduce food waste and alleviate pressure on finite resources like land and water.
4. **Biodiversity Conservation:** By promoting the consumption of a wider variety of insect species, entomophagy can contribute to the conservation of biodiversity. Many edible insect species are abundant in the wild and can be harvested sustainably without depleting natural populations. Encouraging the consumption of diverse insect species can also help raise awareness about the importance of conserving insect biodiversity.
5. **Cultural Significance:** In many cultures around the world, eating insects is a traditional practice with deep cultural significance. Insects have been part of human diets for thousands of years and are valued for their taste, nutritional value, and cultural symbolism. Embracing entomophagy can help preserve and celebrate cultural heritage while promoting sustainable food practices.
6. **Innovation and Food Security:** Insect farming presents opportunities for innovation in food production and technology. Insect-based foods can be processed into a wide range of products, including protein bars, snacks, pasta, and flour, offering diverse options for consumers. Incorporating insects into food systems can also enhance food security by providing a reliable and nutritious source of protein, especially in regions facing challenges such as food scarcity or climate change.

Environmental benefits:

1. **Feed conservation efficiency**
   - Bigger animals like beef required 10 kg of feed to gain 1 kg of animal weight
   - Pork required 5 kg of feed to gain one kg of their body weight.
   - For chicken to get one kg of their body weight required 2.5 kg feed.
   - Insect required 1.7 kg feed to get 1 kg of their body weight.
2. **Water use efficiency**
   - Bigger animal required 1500 litres of water to produce one kilo of protein.
   - Pork required 600 litres of water to produce one kilo of protein.
   - Chicken required 360 litres of water to produce one kilo of protein.

- For production of one kilo of protein insect required only one litres of water.

3. **Land use efficiency**
   - For the production of one kg of protein bigger animal required 200 m^2 arable land
   - Pork required the 50 m2 Arable land to produce 1 kg of protein.
   - To produce one kg of protein chicken required 45 m2 arable land.
   - Insect required 15 m2 arable land to produce one kg of protein.
4. **Production of greenhouse gas**
   - In insect 1 gm of greenhouse gas from the production of one kg of protein.
   - The second round goes to cricket emit only one gram of GHS per kg of protein.
   - Average three gram of greenhouse gas emits from production of one kg of protein.

Medicinal value:

1. **Honeybees (*Apis spp.):***

- Honey: Known for its antimicrobial, wound-healing, and antioxidant properties. It has been used in traditional medicine to treat wounds, sore throats, and coughs.
- Propolis: A resinous substance collected by bees, propolis has antimicrobial, anti-inflammatory, and antioxidant properties. It has been used to treat various infections, including oral health issues and skin conditions.

2. **Silkworms (*Bombyx mori*):**

- Silk: Silk has been investigated for its potential wound-healing properties due to its biocompatibility and ability to promote cell proliferation and tissue regeneration.
- Silkworm pupae: In traditional Chinese medicine, silkworm pupae have been used for their purported hepatoprotective, anti-inflammatory, and antioxidant effects.

3. **Cochineal Insects (*Dactylopius coccus*):**

- Carmine pigment: While primarily used as a natural dye, carmine derived from cochineal insects has been used historically in traditional medicine for its purported medicinal properties, including fever reduction and anti-inflammatory effects.

4. **Black Soldier Fly Larvae (*Hermetia illucens*):**

- Larvae and frass: Black soldier fly larvae and their waste products (frass) have been studied for their potential as sources of antimicrobial compounds and immune-boosting agents. They may have applications in wound healing and infection control.

5. **Maggots (various species):**

- Maggot therapy: Certain species of maggots, such as Lucilia sericata, are used in maggot therapy for wound healing. Maggots selectively feed on necrotic tissue (debridement) and produce antimicrobial substances that help prevent infection and promote wound healing.

6. **Ants (various species):**

- Formic acid: Certain species of ants produce formic acid, which has antimicrobial and anti-inflammatory properties. In traditional medicine, ant extracts or formulations containing formic acid have been used to treat conditions such as arthritis and rheumatism.

7. **Termites (various species):**

- Termite mounds: Clay from termite mounds has been used in traditional medicine for its purported healing properties. It has been applied topically to wounds, skin infections, and inflammatory conditions.

8. **Crickets (Gryllidae):**

- Chitin: Crickets and other insects contain chitin, a polysaccharide that has been studied for its potential immunomodulatory and wound-healing properties. Chitin-based materials may have applications in tissue engineering and regenerative medicine.

Future-oriented features:

- **Innovative Product Development:** As consumer acceptance of insect-based foods grows, we can expect to see an influx of innovative insect-based products hitting the market. This could include items such as insect-based protein bars, snacks, pasta, flour, and beverages, catering to a diverse range of dietary preferences and culinary tastes.
- **Sustainable Food Solutions:** Insect farming offers a sustainable solution to the growing challenges of food security and environmental sustainability. Insects can be raised efficiently using minimal resources such as land, water, and feed, making them an environmentally friendly alternative to traditional livestock. As concerns about the environmental impact of food production continue to rise, insect consumption is likely to gain traction as a sustainable food choice.

- **Functional Foods and Nutraceuticals:** Insects are not only a rich source of protein but also contain various bioactive compounds with potential health benefits. In the future, we may see the development of insect-based functional foods and nutraceuticals targeted at specific health concerns. These products could leverage the nutritional and medicinal properties of insects to promote health and well-being.
- **Integration into Mainstream Cuisine:** As awareness of entomophagy grows and culinary boundaries continue to blur, insect-based dishes are likely to become more mainstream. Chefs and food entrepreneurs may experiment with incorporating insects into traditional and contemporary cuisines, offering consumers unique and exciting dining experiences.
- **Technological Advances in Farming:** Advancements in insect farming technology, such as automated systems, controlled environments, and precision nutrition, could increase efficiency and scalability in insect production. This could lead to higher yields, lower production costs, and greater consistency in quality, making insect farming more economically viable and accessible.
- **Policy and Regulatory Support:** Governments and regulatory agencies may implement policies and regulations to support the growth of the insect farming industry. This could include measures such as research funding, tax incentives, food safety standards, and labeling requirements for insect-based products, fostering a conducive environment for industry development and consumer acceptance.
- **Cultural Acceptance and Education:** Continued efforts to raise awareness about the nutritional, environmental, and cultural benefits of insect consumption could contribute to greater acceptance and normalization of entomophagy. Educational initiatives, culinary events, and media coverage may help dispel myths and misconceptions surrounding insect-based foods, encouraging more people to embrace them as a part of their diets.

Conclusion

- **Nutrient-Rich:** Insects are packed with essential nutrients, including high-quality protein, healthy fats, vitamins, and minerals, offering a well-rounded nutritional profile.
- **Sustainability:** Insect farming requires fewer resources such as land, water, and feed compared to traditional livestock, making it a more environmentally sustainable protein

- **Bioavailability:** Nutrients in insects are highly bioavailable, ensuring efficient absorption and utilization by the human body.
- **Diverse Nutrients:** Insects provide a wide range of nutrients, including essential amino acids, omega-3 and omega-6 fatty acids, iron, calcium, zinc, and B vitamins, supporting overall health and well-being.
- **Environmental Benefits:** Insect consumption helps mitigate environmental impact by reducing greenhouse gas emissions, minimizing land use, and conserving water resources.
- **Cultural Relevance:** Entomophagy has deep cultural roots in many societies and offers an opportunity to celebrate and preserve cultural heritage through food.
- **Innovation:** Insect-based products offer opportunities for culinary innovation, product development, and market expansion, catering to diverse consumer preferences.
- **Food Security:** Insects present a sustainable solution to food security challenges, offering a reliable and nutritious source of protein for a growing global population.
- **Shifting Perceptions:** Increased awareness, education, and culinary creativity are gradually shifting attitudes toward insect consumption, paving the way for wider acceptance and integration into mainstream diets.

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VEGETATIVE AND AGRONOMIC MEASURES FOR SOIL & WATER CONSERVATION

Article ID: AG-V04-I09-32

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Abstract

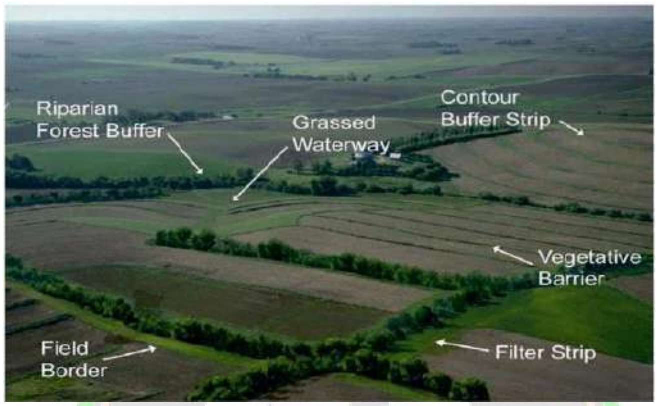
A range of vegetative and agronomic practices are included in sustainable soil and water conservation strategies. Riparian forest buffers and vegetative filter strips are crucial for catching runoff and filtering pollutants. Conservation cover and contour buffer strips help stabilize soil and control water flow, reducing erosion. Alley cropping and grassed waterways are examples of techniques that contribute to soil health and effective water management. Contour cropping and strip cropping improve soil structure and reduce runoff. Mulching keeps moisture in the soil and prevents erosion. Conservation or contour furrow, ridge furrow, and broad bed furrow systems optimize water distribution and improve soil fertility. By putting these varied measures into practice, we can ensure that agriculture is conducted in a balanced manner ensuring productivity while protecting natural resources.

Keywords: Vegetative filter strips, Riparian forest buffers, alley cropping, grassed waterways, Contour cropping, BBF systems, Soil and Water Conservation.

Introduction

Soil and water conservation are integral to sustainable land management and environmental protection. In agricultural practices, effective strategies are essential to mitigate erosion, manage runoff, and maintain soil health. Implementing vegetative measures such as strategically placed buffer strips and forested areas along water bodies helps in intercepting and filtering runoff, thus reducing pollution and erosion. Complementary agronomic practices involve techniques that enhance soil structure and water retention. These include the use of cover crops, tailored cropping patterns, and methods to optimize water distribution across the land. By integrating these approaches, it is possible to create a resilient agricultural system that not only improves productivity but also preserves critical natural resources. Understanding and applying these practices are vital steps toward achieving long-term sustainability and mitigating environmental impacts associated with conventional farming methods.

Vegetative Measures for Soil & Water Conservation:



I. Vegetative filter strips:

The densely planted vegetation (usually grass, up to 45 cm in height) that is placed across the slope to filter out sediment and other pollutants from runoff that originates straight from the agricultural area is known as a vegetative filter strip. The VFS as sheet flow lessens the likelihood of gullies and rills forming. Before the contaminated runoff reaches any surface waters, a filter strip is meant to filter and catch nutrients, sediment, and pathogens in surface runoff from grazing areas (manure, farmland, etc.). The primary purpose of a filter strip is to help prevent pathogens such as fecal coliform bacteria found in cattle dung from entering streams, ditches, and seasonal drainages. **Eg:** haylands and pastures.

II. Vegetative barriers:

To lessen the amount of silt produced, delay and distribute flow, and aid in slope benching, tall, upright, stiff-stemmed native perennial grasses are planted in narrow strips (about 1.2 m wide) along contours. Eco-friendly, more affordable, and beneficial to farmers are the perceptions around vegetative barriers. Growing evidence points to their potential as an earthen bund replacement or complement.

III. Grassed waterways:

A channel covered in vegetation that directs runoff toward a stable outlet at a non-erosive speed is known as a grassed stream. By adding filter strips to capture sediment outside of the stream and filter runoff, grassy waterways can be improved. While the vegetation in the filter strips should be tall and stiff to prevent submergence and filter particles from runoff, the vegetation in the channel should be laid down to transmit water.

Agronomical Measures for Soil & Water Conservation:

I. Contour Cropping:

A conservation farming technique called contour cropping is applied to slopes to reduce soil erosion caused by water. Crops are planted as contour cropped, which means they are planted across the slope as opposed to up and down. Using contour cropping lowers runoff water velocity and increases infiltration, protecting the important topsoil. Contour cropping works better on long, smooth slopes since the flow velocity is higher in these conditions and the slope length is shortened to lower the flow velocity. The best slopes for contour farming are those between two and ten percent.

II. Strip Cropping:

The process of growing a strip of crops with poor potential for controlling erosion, like cereals and root crops (intertilled crops), alternates with strips of crops with good potential for controlling erosion, like close-growing crops like fodder crops and grasses. This technique is known as strip cropping. Crop rotation preserves soil moisture and yields food and fodder by using a mix of closely spaced, intertilled crops on contours. In the long run, close-growing crops lessen soil erosion by acting as flow barriers and lowering the runoff velocity produced by the strips of intertilled crops.

III. Mulching:

Mulches are used to manage weeds, limit rain splash, lower evaporation, lower soil temperature in hot areas, and modulate temperature to a level that promotes microbial activity. It assists in reducing the energy of raindrops, preventing splashing and soil structure dissipation, blocking runoff flow to lessen its velocity, and preventing sheet and rill erosion. They also aid in preserving a conductive soil structure at the land's upper surface and enhancing the infiltration capacity.

IV. Conservation/contour furrow:

To save precipitation and lessen soil and nutrient losses from the agricultural fields, a conservation furrow can be opened 45 days after sowing using

bullock-drawn tools in between crop rows. On sloping fields, contour-furrow irrigation can improve crops, save irrigation water, and lessen erosion. Water is distributed more evenly over the field, providing optimal growing conditions for each and every plant. Better yields and higher-quality products are the results of this.

V. Ridge-furrow system:

One of the creative water-saving solutions that aims to significantly improve the efficiency of precipitation usage in rainfed farming systems of arid and semi-arid regions is the ridge-furrow system, which alternates between ridges and furrows. When the monsoon season begins in June, a bullock-drawn plow is used to create ridges and furrows across the slope. The furrow is 20 cm high and 45 cm wide. Both medium and heavy rainfall regions saw improved performance from the ridge and furrow technique. This system functions as both a moisture-saving mechanism and a drainage system in areas with heavy rainfall.

VI. Broad bed and furrow system:

The broad bed and furrow strategy calls for preparing a 90–120 cm broad bed, a 45 cm furrow, and crop sowing at a 30 cm row spacing. In areas with moderate rainfall, the broad bed and furrow (BBF) method greatly enhanced crop yields; for example, it increased soybean yields in the Vertisols of Maharashtra and Madhya Pradesh by up to 83% in comparison with farmer practices. BBF functions as storage with moisture availability during periods of scarcity and drains runoff through furrows during heavy rainfall occurrences.

Conclusion

In conclusion, the effective implementation of vegetative and agronomic measures is crucial for sustainable soil and water conservation. Vegetative practices, such as cover cropping and reforestation, play a vital role in stabilizing soil, enhancing fertility, and promoting biodiversity. Complementarily, agronomic techniques like contour ploughing and conservation tillage are essential for optimizing land use and reducing water runoff. Together, these strategies offer a comprehensive approach to mitigating soil erosion and improving water retention. By adopting a holistic approach that integrates both vegetative and agronomic methods, we not only address immediate environmental challenges but also build long-term ecological resilience. This integrated strategy ensures the preservation of our natural resources, contributing to a healthier ecosystem and a more sustainable future for coming generations.

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INVOLVEMENT OF RURAL YOUTH IN AGRICULTURE

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Introduction

Involving rural youth in agriculture is vital for the future of farming, rural development and global food security. Their active participation ensures that agriculture remains dynamic, innovative and sustainable. Here's a detailed look at the various aspects of rural youth involvement in agriculture.

Current status of Rural Youth in Agriculture

- **Traditional Farming:** Many rural youth are already involved in traditional farming, often working on family farms. They contribute to daily agricultural activities such as planting, harvesting, and livestock rearing. However, the extent of their involvement often depends on family circumstances and the availability of opportunities.
- **Emerging Agribusinesses:** Some rural youth are moving beyond traditional farming to establish their own agribusinesses. These might include ventures such as organic farming, horticulture, poultry farming, agro-processing and agritourism. These businesses offer opportunities for rural youth to innovate and add value to agricultural products.
- **Technological Engagement:** With the rise of digital technologies, rural youth are increasingly using smartphones, apps, and social media to access agricultural information, connect with markets, and share best practices. This technological engagement helps modernize agriculture and makes it more appealing to young people.

Barriers behind Rural Youth Involvement in Agriculture

- **Perception Issues:** Agriculture is often perceived as a low-status, labor-intensive career with limited financial returns. This negative perception discourages many young people from pursuing a career in farming.
- **Lack of Access to Resources:** Limited access to land, finance, inputs, and technology are significant barriers for rural youth. Without these resources, it's difficult for them to start or expand agricultural activities.
- **Insufficient Training and Education:** Many rural youth lack access to formal agricultural education and training programs, which hinders their ability to adopt modern farming techniques or pursue innovative agricultural practices.
- **Urban Migration:** The allure of better opportunities in urban areas leads to rural-urban migration, resulting in a reduction of youth population in rural areas. This migration weakens the agricultural labor force and diminishes the vitality of rural communities.

Benefits of Involving Rural Youth in Agriculture:

- **Innovation and Modernization:** Youth bring fresh ideas and are more likely to adopt new technologies, leading to increased efficiency, productivity, and innovation in agriculture.
- **Sustainability:** Engaging rural youth in agriculture ensures the continuation of farming practices across generations. Their involvement is crucial for maintaining sustainable agricultural practices and conserving natural resources.
- **Economic Development:** Youth-driven agribusinesses can stimulate rural economies by creating jobs, generating income, and reducing poverty. This economic activity can revitalize rural communities and contribute to national economic growth.
- **Food Security:** Increased youth participation in agriculture can boost food production, helping to meet the growing demand for food both locally and globally.

Strategies to Enhance Rural Youth Involvement in Agriculture:

- **Educational Programs:** Expanding agricultural education and vocational training can equip rural youth with the skills they need to succeed in agriculture.
- **Access to Land and Finance:** Governments and organizations can support youth involvement by providing access to land through land reforms, leasing schemes, or

cooperative models. Additionally, offering low-interest loans, grants, and microfinance tailored to young farmers can help them overcome financial barriers.

- **Promotion of Agripreneurship:** Encouraging entrepreneurship in agriculture, or "agripreneurship," can attract rural youth by showcasing the profitability and potential of agricultural ventures. Governments and NGOs can promote success stories and provide start-up support to young entrepreneurs.
- **Use of Technology and Innovation:** Facilitating access to modern technologies, such as precision agriculture, drones, and mobile apps, can make farming more attractive to youth. Digital platforms that connect farmers with markets, suppliers, and training resources can also empower young farmers.
- **Public Awareness Campaigns:** Changing the perception of agriculture through public awareness campaigns that highlight the importance, innovation, and opportunities within the sector can help attract more youth to agriculture.

Conclusion

The involvement of rural youth in agriculture is essential for the sector's future. By addressing the challenges they face and implementing targeted strategies, rural youth can be empowered to drive innovation, enhance food security, and contribute to the economic development of their communities. Their participation is not only crucial for sustaining agricultural practices but also for transforming agriculture into a modern, dynamic, and profitable sector that can attract future generations.

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SUCCESS STORY ON NUTRITION GARDEN BACKYARD GARDEN : A MANAGEABLE, MODEL FOR FOOD SECURITY AND DIVERSITY

Article ID: AG-VO4-I09-34

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Introduction

- **Name-**Vasava Urmila ben Dalpatbhai
- **Age-**39 years
- **Education-**9th
- **land holding-**1.5 Acre
- **size of family-**Medium
- **Address -** Vill: Gajargota, Taluka: Dediapada, District: Narmada

- **Size of nutrition garden (sqm)- 200**
- **Crops grown in nutrition garden:**
- **Kharif :** Bitter gourd ,Bottle gourd, Brinjal, Chili, Ladies' fingers, Ridge gourd, Indian bean, spinach, amarnanthus, etc.

  Rabi: Beetroot, brinjal, broccoli, cabbage, capsicum. Carrot , cauliflowers ,drumstick, Tomato etc.
- **Growing condition -** Natural farming

Success point

According to Smt. Urmila ben, kitchen garden has been impactful for her family and their village as well as other villages of district. There is seen increase in the Micro monthly savings which has led to financial stability. Her family gets proper nutritional balanced diet that consists of green vegetables like root crop, cauliflower, cabbage, leafy vegetables, Okra, Bitter guard, brinjal, carrot ,spinach, ,cucumber, Indian bean , Bottle guard, Drumstick, chili, coriander, radish etc. She also planted fruit plants such as Banana, Mango, Guava, lemon, and custard apple, Papaya, etc. she started to do Millet crop like Finger millet and little millet too. Urmila ben proudly claimed that the vegetables and fruits grown in the garden were being utilized in recipes within their home. Additionally, she said the quantity was more than sufficient for the foods to be distributed equally for the whole family. Now she is happy to enhance the nutritional affordability for his family and earn an addition income from sale of surplus produce. The intervention has also been successful in reducing reliance on the market.

Production and consumption of nutrition garden crops:

S.No.	Name of crops	Varieties	Area grown (sqm)	Production (kg)	Consumption (kg)	Sell of produce (kg)	Income from sell of produce (Kg)
A.	**Vegetable**						
1	Brinjal	Surati gulabi		55	10	45	2700
2	Bitter gourd	VIVR-28	200	45	10	35	2100
3	Bottle gourd	Sarita		55	5	50	2000
4	Ladies' fingers	Purna Rakshak		80	20	60	2400
5	Ridge gourd,	Hybrid		30	15	15	600
6	Indian bean	GNIB-21		60	20	40	1250
7	Spinach	-		50 (no.)	10	40	600
8	Drumstick	PKM-1		45	10	35	1250
9	Cauliflower	-		65	15	50	1650
10	Cabbage	-		45	15	30	1350
11	Tomato	hybrid		52	15	37	2220
12	Lemon	’’		25	10	15	750
13	Amrnathus	deshi		50	20	30	300
B	**Fruit crop**						
1.	Custard apple	deshi		90	20	70	4200
2.	Papaya	’’		15	5	10	300
3	Banana	’’		20	10	10	400

		

Feedback:

Now she became a motivator for many of farm women in her village. She adopted the technology and produce year-round fruits and vegetables. She was also found to actively guide other farmers in adoption of new technologies. With his intervention they have started to grow different vegetable crops in a season in the village and as a result they are realizing better price in the market. The key to his success seems to his eagerness to learn and understand very soon, hard work & positive attitude. She started to sale surplus vegetables in the weekly market.

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ROLE OF CROPPING SYSTEMS IN IMPROVING CARBON SEQUESTRATION

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Abstract

Carbon sequestration is a crucial process for reducing global warming due to climate change. Natural systems, such as cropping systems, play a significant role in increasing soil carbon stores and lowering atmospheric CO_2 concentrations. Carbon sequestration involves plant photosynthesis, biomass formation, root exudates, soil microbial activity, and soil aggregates. Techniques for carbon sequestration include conservation tillage, cover crops, crop rotation, agroforestry, and biochar application. Advantages of cropping include climate change mitigation, improved soil health, and enhanced crop productivity. However, limitations include implementation and adoption, measurement and verification, and long-term sustainability. To fully utilize cropping systems, more research, innovation, and farmer assistance are needed. Techniques like agroforestry, crop rotation, conservation tillage, cover crops, biochar application, and crop rotation can help farmers increase soil carbon stores and make agriculture more sustainable.

Introduction

Carbon sequestration, or the process of absorbing and storing atmospheric carbon dioxide (CO_2), has become a vital process for reducing global warming in the face of intensifying climate change. Although carbon capture and storage (CCS) and other technology solutions have received a lot of attention, natural systems provide a potent and frequently more sustainable method of sequestering carbon. Among these, cropping systems—various crop configurations and farming techniques—are essential for increasing soil carbon stores and lowering atmospheric CO_2 concentrations. This paper investigates the ways in which cropping systems aid in the sequestration of carbon, looks at different cropping approaches, and talks about the advantages and disadvantages of incorporating these methods into contemporary agriculture.

Carbon Sequestration: The process by which atmospheric CO2 is transformed into organic carbon molecules in the soil is the main method of carbon sequestration in agricultural soils (Lal, 2004).

Mechanisms of Carbon Sequestration:

- **Plant Photosynthesis and Biomass Formation**: Through photosynthesis, plants take in CO2 from the environment and transform it into organic matter, which includes stems, roots, leaves, and seeds. When plants die or lose their leaves, the organic matter that remains in the soil breaks down and becomes part of the soil organic matter (SOM), which increases soil carbon reserves.
- **Root Exudates and Soil Microbial Activity:** Exudates are organic chemicals released into the soil by plant roots. Exudates like this provide soil microbes nourishment, which helps stable soil organic matter build. Humus, a stable form of organic carbon that remains in the soil for extended periods, is produced by the breakdown of organic material by soil microbes.
- **Soil Aggregation**: Aggregates, or groups of soil particles, are formed by the physical structure of the soil and can help sequester carbon. Plant leftovers and microbiological byproducts are examples of organic debris that aids in the binding of soil particles into aggregates. These aggregates increase the stability of organic carbon in the soil by preventing microbes from breaking it down (Brady and Weil., 2008).

Strategies for Carbon Sequestration and Cropping Systems

- **Conservation Tillage**: Conventional tillage techniques agitate the soil, which may cause carbon that has been stored to be released into the atmosphere. Reduced tillage and no-till farming are examples of conservation tillage techniques that limit soil disturbance and support the maintenance or growth of soil organic carbon levels. With conservation tillage, crop leftovers remain on the surface and less disturbance of the soil occurs, which promotes organic matter buildup and enhanced storage of carbon (Powlson *et al*., 2014).
- **Utilizing cover crops**: Plants produced in between the major agricultural seasons can greatly increase the sequestration of carbon dioxide. Through their roots and decomposing biomass, cover crops enhance soil structure, prevent soil erosion, and

supply more organic matter to the soil. Additionally, legume cover crops have the ability to fix atmospheric nitrogen, improving soil health and production even more (Marsden, 2010).

- **Crop Rotation**: By growing several crops in succession on the same plot of land, a variety of crop rotations can be used to enhance soil health and sequester carbon. Crop rotation improves soil structure, lessens the impact of pests and diseases, and broadens the variety of organic matter inputs into the soil. This variety may help to raise and stabilize the amounts of organic carbon in the soil.
- **Agroforestry:** The practice of incorporating trees and shrubs into farming systems, or agroforestry, has several advantages for sequestering carbon dioxide. In addition to storing carbon in their biomass and roots, trees also add organic matter to the soil through their leaf litter. Moreover, agroforestry systems strengthen farming ecosystems, lessen soil erosion, and enhance soil structure (Jose, 2009).
- **Application of Biochar**: To improve carbon sequestration in soils, biochar, a stable form of carbon produced from organic materials by pyrolysis, can be added. Biochar boosts soil organic carbon stores, retains more water in the soil, and improves soil fertility. It is a useful instrument for long-term carbon sequestration due to its stability in the soil (Lehmann & Joseph, 2015).

Advantages

- **Climate Change Mitigation**: Cropping techniques help to lower atmospheric CO2 levels and mitigate climate change by sequestering carbon. This organic carbon sink can assist in offsetting other forms of greenhouse gas emissions.
- **Improved Soil Health**: By boosting microbial activity, improving soil structure, and adding more organic matter, many techniques that increase carbon sequestration also improve soil health. More productive and resistant to erosion and drought are healthier soils.
- **Enhanced Crop Productivity**: Higher crop yields and enhanced agricultural productivity can result from improved soil organic matter and soil structure. Soils become more productive and fertile as a result of techniques like cover crops and conservation tillage (Lal, 2002).

Limitations

- **Implementation and Adoption:** A number of issues, including lack of funds, ignorance, and reluctance to change, may hinder the uptake of carbon sequestration techniques. To properly apply these methods, farmers may require technical assistance, education, and incentives.
- **Measurement and Verification**: It takes a lot of resources and expertise to measure and verify soil carbon sequestration accurately. To evaluate the efficacy of various strategies and make sure that carbon sequestration targets are fulfilled, trustworthy techniques and instruments are required.
- **Long-Term Sustainability**: Although a lot of methods improve sequestration of carbon, their efficiency might change over time and in different environments. To guarantee the long-term advantages of these procedures and to handle any potential trade-offs, long-term study and monitoring are required.

Conclusion

Cropping systems are essential for enhancing carbon sequestration and reducing global warming. Agroforestry, crop rotation, conservation tillage, cover crops, biochar application, and crop rotation are a few techniques that farmers may use to increase soil carbon stores and make agriculture more sustainable. The advantages—which range from reducing climate change to enhancing soil health and productivity—underline the need of incorporating carbon sequestration techniques into contemporary agriculture, notwithstanding the difficulties involved in putting these methods into practice and quantifying their effectiveness. To fully use cropping systems in tackling the global climate catastrophe, more research, innovation, and farmer assistance are required.

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BEHAVIOURAL DRIVERS OF ENERGY EFFICIENCY: REDUCING FOSSIL FUEL USE AND PROTECTING THE OZONE LAYER

Article ID: AG-VO4-I09-36

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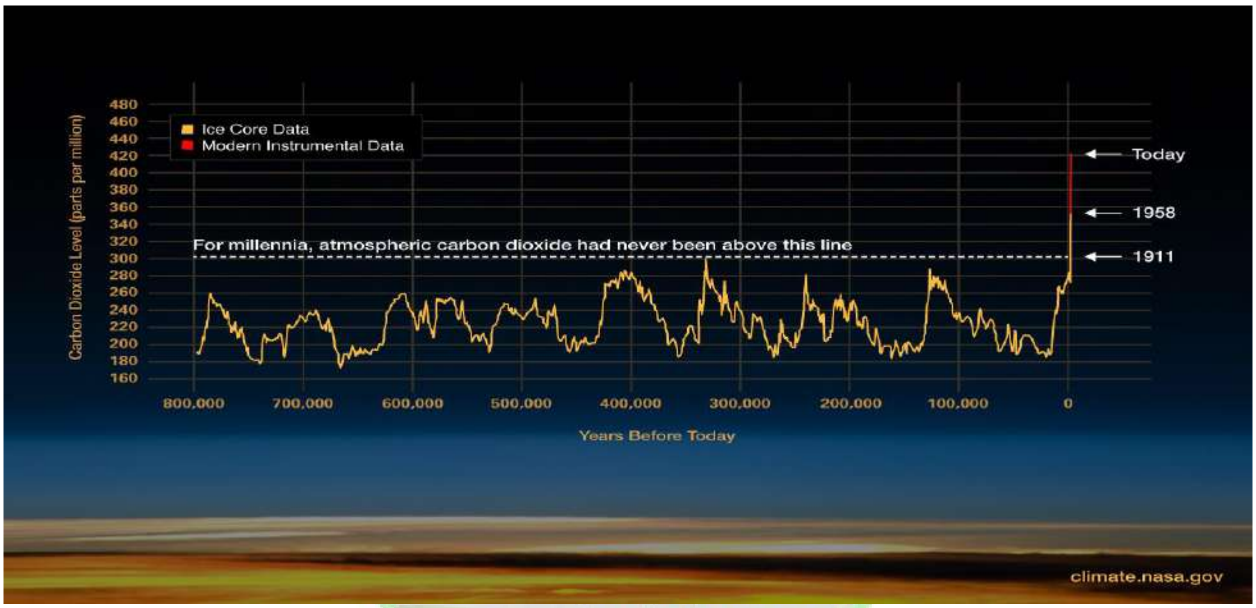
Abstract

As the planet faces challenges of climate change and ozone layer depletion, enhancing energy efficiency emerges as a vital solution. The behavioural analysis delves into the key factors that drive individuals and organizations to adopt energy-saving practices, and how these actions contribute to lowering fossil fuel use and preserving the ozone layer. It explores how financial benefits, new technologies, and educational outreach inspire more energy efficient choices. The saving on energy costs, access to innovative solutions, and a deeper understanding of environmental impacts encourage a shift towards sustainable energy use. By understanding these behavioral motivations, the analysis sheds light on how we can effectively promote energy efficiency. It highlights the importance of understanding what drives people to make energy conscious decisions, offering insights into developing strategies that support both fossil fuel reduction and ozone layer protection.

Keywords: energy efficiency, fossil fuels, behaviour, ozone layer, sustainability, climate change

Introduction

The climate of Earth has undergone significant transformations throughout its history. Over the past 800,000 years, there have been eight distinct cycles of glacial and interglacial periods, with the conclusion of the last glacial period approximately 11,700 years ago signaling the onset of the contemporary climate era and the rise of human civilization. These historical climate fluctuations are primarily linked to minor variations in Earth's orbit, which influence the amount of solar radiation received by the planet. However, the current trend of warming is markedly different, as it is predominantly driven by human activities since the mid-19th century and is occurring at an unprecedented rate compared to recent millennia. It is evident that human actions have led to the release of greenhouse gases that have increased the retention of solar energy within the Earth's system. This additional energy has resulted in the warming of the atmosphere, oceans, and land, leading to widespread and rapid alterations in the atmosphere, oceans, cryosphere, and biosphere.



Source: Luthi, D., et al.. 2008; Etheridge, D.M., et al. 2010; Vostok ice core data/J.R. Petit et al.; NOAA Mauna Loa CO2 record.

Climate change and ozone layer depletion are two interconnected environmental issues that significantly threaten the planet's ecosystems and human health. The primary driver of climate change is the combustion of fossil fuels, which constitutes nearly 80% of global energy usage. This process releases substantial amounts of greenhouse gases (GHGs), particularly carbon dioxide (CO_2), into the atmosphere. These gases trap heat, resulting in increased global temperatures, which lead to consequences such as melting ice caps, rising sea levels, extreme weather patterns, and altered agricultural practices. These changes pose risks to food security and biodiversity, as highlighted by the Intergovernmental Panel on Climate Change (IPCC) in 2018.

Ozone layer depletion is intricately linked to fossil fuel consumption through the release of pollutants like nitrous oxide (N_2O) and chlorofluorocarbons (CFCs). These substances ascend into the stratosphere, where they decompose ozone molecules, thereby diminishing the protective layer that safeguards the Earth from harmful ultraviolet (UV) radiation. The consequences of a depleted ozone layer include a rise in skin cancer and cataracts, along with adverse effects on agricultural yields and marine ecosystems. The combined challenges of climate change and ozone layer depletion underscore the urgent need for action.

Tackling these intricate challenges necessitates a comprehensive strategy, with energy efficiency playing a vital role as a solution. Enhancing energy efficiency means utilizing less energy to achieve the same outcomes, which leads to a decrease in overall energy usage. For instance, implementing energy-efficient lighting, appliances, and heating systems can significantly lower energy consumption in both residential and commercial settings without sacrificing comfort or productivity. By decreasing energy demand, these practices reduce dependence on fossil fuels, thereby lowering greenhouse gas emissions and minimizing the release of substances that deplete the ozone layer.

Energy Efficiency as a Strategic Solution:

Global initiatives like the Paris Agreement and the Montreal Protocol have established ambitious goals to reduce carbon emissions and phase out ozone-depleting substances. Energy efficiency is a fundamental aspect of these international efforts. The International Energy Agency (IEA) states that enhancing energy efficiency could account for over 40% of the CO2 emissions reductions necessary to meet global climate targets by 2040. Furthermore, energy-efficient technologies can help minimize the reliance on air conditioning and refrigeration, which have historically depended on substances like CFCs and HFCs, both potent greenhouse gases and ozone-depleting agents.

Despite the availability of the technological advancements required for significant energy efficiency improvements, their uptake is largely influenced by the behaviors of individuals, organizations, and governments. Research indicates that merely having access to energy-efficient technologies is insufficient to drive meaningful change; behavioral factors play a crucial role in whether individuals opt for energy-efficient solutions.

The Role of Behavioral Drivers:

Behavioral science provides valuable insights into how individuals and organizations make decisions related to energy consumption. Although many energy efficiency programs emphasize technological advancements, human behavior often determines the ultimate success of these efforts. Key behavioral drivers, which shape energy consumption patterns, include factors such as financial incentives, access to technology, social norms, environmental awareness, and psychological influences like habits and perceptions of control (Frederiks et al., 2015).

One of the most influential drivers is the financial motivation to reduce energy costs. Research indicates that both households and businesses are more inclined to adopt energy-efficient technologies when they can clearly observe long-term cost savings (Allcott & Rogers, 2014). Government initiatives that offer subsidies, rebates, or tax incentives for energy-efficient upgrades have been shown to effectively increase adoption rates. Additionally, easy access to affordable and dependable energy-efficient technologies—such as smart meters, energy-efficient appliances, and renewable energy systems—also promotes their widespread use. However, without sufficient knowledge and awareness of these technologies and their benefits, individuals may be reluctant to adopt them (IEA, 2020).

Educational initiatives and awareness campaigns play a crucial role in influencing behavior. Programs that highlight the environmental and financial advantages of energy efficiency have been shown to significantly impact consumer choices. For instance, when people understand the link between energy consumption and climate change, they are more likely to engage in energy-saving behaviors, such as cutting electricity use during peak hours, using public transportation, and purchasing energy-efficient appliances (Abrahamse et al., 2005). Moreover, behavioral strategies like "nudging", a small interventions that steer individuals toward more sustainable choices without limiting their freedom are increasingly incorporated into energy policy. For example, energy efficiency labels on appliances can "nudge" consumers to select more efficient products by making the environmental consequences of their choices clearer (Frederiks et al., 2015).

Purpose and Objectives

In light of the pressing necessity to diminish fossil fuel usage and safeguard the ozone layer, this study investigates the influence of behavioral factors on the promotion of energy efficiency. By integrating findings from behavioral science, environmental policy, and energy research, the study aspires to provide a thorough understanding of the primary elements that foster energy-efficient practices.

This conceptual examination emphasizes the identification of the most significant drivers, including financial incentives, access to innovative technologies, and educational initiatives, while analyzing their roles in mitigating fossil fuel consumption and preserving the ozone layer. Consequently, the research aims to address pertinent questions, such as: What are the principal behavioral determinants that affect energy efficiency, and in what ways can an understanding of these factors aid in the reduction of fossil fuel consumption and the protection of the ozone layer. Through the exploration of these inquiries, the study intends to present actionable recommendations for policymakers, corporations, and environmental organizations to formulate more effective strategies that encourage sustainable energy use and environmental conservation.

Theoretical Foundations

The theoretical foundations offer a comprehensive understanding of the behavioral drivers of energy efficiency. These frameworks emphasize the complexity of human decision-making and highlight the role of financial, social, and psychological factors in shaping energy behaviors. By integrating insights from these theories, policymakers and organizations can develop more effective strategies to encourage energy efficiency, reduce fossil fuel use, and protect the ozone layer.

1. Energy Efficiency and Behavioral Economics

Energy efficiency extends beyond mere technological advancements; it fundamentally involves shaping human behavior to promote more sustainable practices. Insights from behavioral economics illuminate the ways in which psychological, social, and emotional elements influence energy consumption decisions. Conventional economic theories typically state that individuals behave rationally, consistently aiming to optimize their utility. In contrast, behavioral economics acknowledges that decision-making is frequently swayed by cognitive biases and prevailing social norms (Frederiks et al., 2015).

For example, behavioral nudges, a subtle prompt that encourage energy-efficient actions without limiting options have demonstrated significant effectiveness. A prominent illustration of this is the implementation of energy-saving devices, such as thermostats, which are preset to an energy-efficient default mode. Research indicates that individuals are more inclined to maintain these settings when they are established in advance (Allcott & Rogers, 2014). This finding emphasizes the critical role of behavioral influences in promoting energy-efficient behaviors.

2. Theory of Planned Behavior (TPB)

The Theory of Planned Behavior (Ajzen, 1991) plays a crucial role in comprehending energy efficiency by linking behavior to three essential elements: attitudes, subjective norms, and perceived behavioral control. Attitudes encompass an individual's favorable or unfavorable assessments of energy efficiency, while subjective norms pertain to the perceived societal pressures to adopt such behaviors. Perceived behavioral control indicates the perceived ease or difficulty associated with implementing energy-saving measures.

Research indicates that the Theory of Planned Behavior accounts for a substantial portion of the variance in pro-environmental behaviors (Abrahamse & Steg, 2009). For instance, a favorable attitude towards energy-efficient technologies, coupled with social endorsement and the belief in one's ability to utilize these technologies, enhances the likelihood of their adoption.

3. Diffusion of Innovations Theory

The Diffusion of Innovations Theory, as articulated by Rogers in 2003, offers a valuable perspective for analyzing energy efficiency. This theory outlines the process by which new technologies disseminate throughout society, highlighting the distinct roles played by innovators, early adopters, the early majority, the late majority, and laggards. Energy-efficient technologies typically adhere to this diffusion model, where initial users experiment with and advocate for these innovations, thereby inspiring wider adoption.

A tangible example of this theory in action can be seen in the uptake of smart meters and solar panels. Early adopters, often driven by a commitment to environmental sustainability or financial benefits, showcase the advantages of these technologies, which fosters greater acceptance and eventually leads to their mainstream integration (IRENA, 2021). Grasping this diffusion process is crucial for facilitating significant changes in energy consumption patterns.

4. Value-Belief-Norm (VBN) Theory

The Value-Belief-Norm Theory, as articulated by Stern in 2000, suggests that environmental actions are rooted in fundamental values, beliefs, and personal norms. This theory indicates that individuals who possess a strong commitment to environmental protection are more inclined to implement energy-saving practices due to a sense of moral obligation. Such individuals are motivated to align their actions with their values, regardless of the absence of immediate personal gains. For example, those who prioritize altruistic or biospheric values, demonstrating concern for the welfare of others and the planet are more likely to adopt energy-efficient behaviors (Dietz et al., 2009). Their motivations stem not from financial rewards but from the conviction that reducing energy use and reliance on fossil fuels is essential for environmental preservation and addressing climate change.

5. Environmental Psychology and Energy Efficiency

Environmental psychology explores the ways in which individuals perceive and engage with their surroundings, which in turn affects their energy usage. Research in this domain indicates that highlighting the environmental advantages and presenting energy efficiency as a shared obligation can significantly boost motivation (Gifford, 2011). Observing peers taking proactive steps, such as neighbors installing solar panels or switching to electric vehicles, often encourages others to adopt similar behaviors due to social influence. Furthermore, recent studies have demonstrated that offering feedback on energy usage through smart meters or mobile applications can promote more mindful energy consumption. Access to real-time data allows individuals to modify their habits, leading to quantifiable decreases in energy use (Karlin et al., 2015).

Key Drivers of Energy Efficiency

Energy efficiency is influenced by a variety of behavioral, economic, and technological factors. Identifying and leveraging these key drivers is essential for promoting a reduction in fossil fuel use and protecting the ozone layer.

1. Financial Incentives and Cost Savings:

A key motivator for embracing energy-efficient practices is the opportunity for financial savings. The immediate decrease in utility expenses, along with the long-term advantages of energy-efficient technologies, encourages both individuals and businesses to invest in energy efficiency when they recognize tangible economic benefits. Research indicates that financial incentives, such as rebates for energy-efficient appliances and subsidies for renewable energy projects, play a crucial role in enhancing adoption rates (Gillingham & Palmer, 2014). Government initiatives that provide tax incentives or rebates for energy-efficient home upgrades have also been effective in promoting energy-conscious choices. For instance, a report from the U.S. Energy Information Administration (EIA, 2021) revealed that households that transitioned to energy-efficient appliances experienced an average annual electricity cost reduction of 10–30%. These savings act as a significant catalyst for further investments in energy efficiency.

2. Technological Advancements:

Technological advancements are essential in enhancing energy efficiency. The rise of smart home technologies, renewable energy options, and energy-saving appliances is becoming more prevalent. For instance, the adoption of energy-efficient LED lighting, intelligent thermostats, and solar energy systems has surged, driven by technological progress and lower costs (Moezzi & Janda, 2014). Additionally, innovations such as smart grids facilitate more effective energy distribution, minimizing waste and maximizing energy utilization. The increasing availability of these technologies empowers both individuals and businesses to decrease their reliance on fossil fuels and enhance overall energy efficiency.

3. Social Norms and Peer Influence

Research in behavioral science underscores the significant role of social norms in promoting energy efficiency. People tend to embrace energy-saving behaviors when they see their peers engaging in similar practices. This social influence can be effectively utilized through community initiatives and campaigns that present energy-efficient behaviors as both admirable and responsible. A study conducted by Schultz et al. (2007) revealed that households made aware of their neighbors' energy-saving efforts were more inclined to decrease their own energy usage. This type of peer influence, commonly known as "descriptive norms," is crucial in fostering collective efforts toward energy efficiency.

4. Environmental Awareness and Education

Awareness and education regarding environmental issues are crucial factors in promoting energy efficiency. Individuals are more inclined to adopt energy-saving practices when they comprehend the effects of fossil fuel usage on the environment and the deterioration of the ozone layer. Initiatives that highlight the relationship between energy consumption, climate change, and ozone layer preservation can inspire more sustainable practices. Educational programs, whether implemented in educational institutions, corporate environments, or community organizations, have proven effective in raising awareness about the significance of energy efficiency. Research indicates that ongoing education can help convert temporary behavioral changes into lasting energy-saving habits (McKenzie-Mohr, 2011).

Strategies for Enhancing Energy Efficiency

To maximize energy efficiency, there are several strategies that individuals, organizations, and governments can adopt. These strategies are supported by the key drivers discussed above and aim to foster widespread behavioral change.

1. Government Policy and Regulation:

Governments are essential in promoting energy-efficient practices by implementing various policy tools. Regulations, including building codes, appliance standards, and fuel efficiency mandates, establish minimum energy efficiency standards for both residential and industrial sectors (Sorrell et al., 2020). Policies that enforce energy-saving measures can result in substantial decreases in fossil fuel consumption. For instance, the Energy Efficiency Directive of the European Union compels member countries to attain energy savings through initiatives like energy audits and enhanced building insulation, resulting in observable advancements in energy consumption across different sectors.

2. Behavioral Interventions and Incentives

Behavioral strategies, such as nudges and incentives, have become increasingly recognized as effective tools for enhancing energy efficiency. Implementing straightforward modifications, such as setting energy-efficient defaults on appliances or offering opt-out options for renewable energy, can foster more sustainable practices (Allcott & Mullainathan, 2010). Additionally, financial incentives like tax rebates, subsidies, and rewards for decreased energy usage serve to further encourage positive energy-related behaviors.

3. Public-Private Partnerships

Collaboration between public institutions and private organizations is essential for speeding up the adoption of energy-efficient technologies. Public-private partnerships (PPPs) can harness the strengths of both sectors, governmental backing and private sector innovation to create synergies. Through joint efforts, these partnerships can significantly enhance the development and widespread deployment of energy-efficient solutions (IEA, 2021).

Energy Efficiency and Environmental Impacts

Energy efficiency is vital for mitigating environmental degradation as it reduces fossil fuel use and decreases greenhouse gas emissions. It serves as a key approach to tackling critical environmental issues such as climate change, air pollution, and the depletion of the ozone layer.

1. Reducing Fossil Fuel Use

Energy efficiency reduces dependence on fossil fuels, which are major contributors to environmental pollution. Burning fossil fuels like coal, oil, and natural gas releases significant amounts of carbon dioxide (CO_2), a greenhouse gas that accelerates global warming. The International Energy Agency (IEA, 2020) reports that enhancing energy efficiency could lower global energy demand by over 10% by 2040, thus reducing fossil fuel consumption.

Impact on Climate Change: By decreasing energy use, energy efficiency directly cuts CO_2 emissions, helping to mitigate global warming. The Intergovernmental Panel on Climate Change

(IPCC, 2018) emphasizes that improving energy efficiency across buildings, transportation, and industrial sectors is essential for keeping the global temperature rise to 1.5°C above pre-industrial levels.

2. Mitigating Air Pollution

The burning of fossil fuels also emits harmful pollutants like sulfur dioxide (SO_2), nitrogen oxides (NOx), and particulate matter (PM), which exacerbate air pollution and contribute to respiratory illnesses. By cutting energy consumption, energy efficiency measures reduce the release of these pollutants, leading to cleaner air and better public health.

Example: In the United States, advancements in energy efficiency within the power sector—such as the adoption of energy-efficient appliances and LED lighting—have been associated with a 7% decrease in air pollution-related deaths between 2008 and 2017 (American Council for an Energy-Efficient Economy [ACEEE], 2018).

3. Preserving the Ozone Layer:

Although chlorofluorocarbons (CFCs) and other ozone-depleting substances are the primary causes of ozone layer depletion, energy efficiency also contributes to its protection. Historically, CFCs were used in energy-intensive industrial processes such as refrigeration, air conditioning, and aerosol production. These substances were subsequently banned under the Montreal Protocol due to their harmful effects on the ozone layer.

By promoting energy efficiency, the demand for such energy-intensive processes is reduced, which in turn diminishes the reliance on ozone-depleting substances. Furthermore, the shift towards energy-efficient alternatives, such as hydrofluorocarbons (HFCs), has helped mitigate the environmental impact of refrigerants.

Recent Developments: The Kigali Amendment to the Montreal Protocol, adopted in 2016, targets the phase-down of HFCs, which are potent greenhouse gases. As part of this global initiative, energy-efficient cooling technologies are being encouraged to both protect the ozone layer and combat climate change simultaneously (UN Environment Programme, 2018).

Energy efficiency is intrinsically connected to resource efficiency, as it diminishes the necessity for the extraction and consumption of natural resources. By optimizing energy use, industries can decrease their material and energy requirements, thereby minimizing the overall environmental impact of their production activities. This is especially pertinent in sectors such as manufacturing and agriculture, where energy-intensive methods can result in considerable environmental consequences, including deforestation, depletion of water resources, and soil erosion.

Circular Economy Perspective: Within the framework of a circular economy, energy efficiency plays a vital role in promoting the sustainable utilization of resources by reducing waste and fostering the reuse and recycling of materials. For instance, the implementation of energy-efficient technologies in manufacturing can lower the energy needed for production, resulting in reduced waste and a diminished environmental footprint (Geissdoerfer et al., 2017).

5. Protecting Ecosystems and Biodiversity

Energy efficiency has notable environmental benefits, particularly in protecting ecosystems and biodiversity. The extraction and burning of fossil fuels often result in habitat destruction, water pollution, and soil erosion, all of which pose threats to wildlife and disrupt ecosystems. By curbing energy demand, energy efficiency reduces the need for environmentally harmful activities like mining and deforestation.

Biodiversity Impact: In regions where natural habitats are jeopardized by energy production, implementing energy efficiency measures can help preserve these ecosystems. For example, enhancing energy efficiency in transportation and infrastructure can decrease the necessity for new energy projects that might otherwise invade sensitive wildlife habitats (WWF, 2019).

Policy Model for Driving Behavioral Change in Energy Efficiency and Ozone Layer Protection

1. Behavioral Drivers for Policy Change

Understanding and utilizing important behavioral drivers is essential to promoting energy efficiency and preserving the ozone layer. In order to affect behavior, the policy should address the following:

Financial Incentives: Offering financial advantages in the form of tax breaks, rebates, or subsidies can encourage businesses and individuals to adopt energy-efficient technologies. Customers are encouraged to switch to energy-efficient appliances, cars, and building materials by programs that lower upfront costs or provide savings over time.

Education and Awareness: It's critical to increase public knowledge of the financial and environmental advantages of adopting energy-efficient practices. Citizens can be made aware of how their actions contribute to energy conservation and ozone layer protection through educational campaigns, workplace initiatives, and community-based outreach.

Social Norms and Peer Influence: Social influence has a big impact on how much energy people use. Behavioral nudges that emphasize energy-saving practices as the standard can motivate more people to adopt them. Rewards or public acknowledgment for energy-saving actions (e.g. "energy-efficient neighborhoods") can be effective inducers.

2. SDG 7.3 and Policy Integration

Sustainable Development Goal 7.3 aims to double the global rate of energy efficiency improvement by 2030. To achieve this objective, policies should focus on the following strategies:

Establishing Efficiency Standards and Regulations: Enforce rigorous energy efficiency standards for appliances, vehicles, and buildings. These standards must be regularly updated to align with technological advancements and global best practices.

Promoting Research and Development Investment: Foster innovation by backing research into new energy-efficient technologies. This includes funding for both public and private sector R&D initiatives aimed at identifying more effective methods to minimize energy consumption.

Encouraging Global Cooperation: Collaborate with international agreements such as the Paris Agreement and the Montreal Protocol to ensure that energy efficiency initiatives are integrated with global climate and environmental objectives. Countries can exchange best practices and learn from successful examples of energy efficiency policies.

Aligning with SDGs:

SDG 7 (Affordable and Clean Energy): Aims to guarantee that everyone has access to energy that is affordable, dependable, sustainable, and modern. Sub-target 7.3 emphasizes the importance of enhancing energy efficiency, which is essential for reducing emissions and addressing climate change.

SDG 13 (Climate Action): Seeks to implement urgent measures to address climate change and its effects, with energy efficiency being vital for minimizing carbon footprints and greenhouse gas emissions.

SDG 12 (Responsible Consumption and Production): Promotes sustainable patterns of consumption and production, which involve decreasing energy demand through improved efficiency and changes in behavior at both household and industrial levels.

3. Monitoring and Evaluation

Effective policies require monitoring mechanisms to assess progress. Governments can implement tracking systems to evaluate the uptake of energy-efficient technologies and the behavioral impact of incentives. Such data can be used to refine and improve policy frameworks over time.

Examples of Successful Behavioral-Based Energy Policies

A number of nations have effectively executed energy policies based on behavioral principles, showcasing their efficacy in promoting energy efficiency and curbing emissions. One such nation is Germany, whose energy policy incorporates behavioral principles in its strategy for promoting energy efficiency and the uptake of renewable energy sources. The policy promotes sustainable energy use through the use of financial incentives, educational initiatives, and regulatory measures (Kruyt et al. (2009)).

Japan's Cool Business Campaign: To cut down on air conditioning use during the summer, Japan's Cool Business campaign encourages staff members to dress more casually. To reduce energy consumption, the campaign combines nudging with public education, illustrating the effect of behavioral interventions on energy savings (Sato, 2009).

The state of California has instituted various energy efficiency initiatives that incorporate behavioral insights. These initiatives include the utilization of feedback mechanisms and incentives to encourage energy-saving behaviors among businesses and residents (California Public Utilities Commission, 2020).

Conclusion

There is a significant relation between behavioral drivers and energy efficiency, focusing on financial incentives, technological advancements, and educational initiatives. Financial incentives, such as tax credits and rebates, effectively lower the cost barrier for adopting energy-efficient technologies, making sustainable choices more accessible. Technological advancements, including innovative energy-efficient products and systems, provide practical solutions for reducing energy consumption. Educational programs play a crucial role in raising awareness and fostering a deeper understanding of the benefits of energy efficiency. These drivers are interconnected, as financial incentives can support technological adoption, and education can enhance the effectiveness of both. Together, they contribute to reducing fossil fuel use and protecting the ozone layer by promoting sustainable energy practices.

Future Research Directions

Future research should delve deeper into how different cultural contexts influence energy-saving behaviors. Understanding cross-cultural differences can help tailor policies and interventions to diverse populations, enhancing their effectiveness. Additionally, exploring the role of emerging technologies, such as smart grids and advanced energy management systems, can provide insights into new opportunities for promoting energy efficiency. Research on the integration of these technologies with behavioral insights can offer innovative solutions for addressing energy challenges and advancing sustainability goals.

To achieve global sustainability, a multi-faceted approach is essential, combining behavioral science, policy, and technology. Behavioral insights can drive effective policy design and implementation, while technological advancements provide the tools necessary for reducing energy consumption. Policymakers, researchers, and technologists must collaborate to create comprehensive strategies that address the complex interplay of these factors. By integrating behavioral science with policy and technology, we can foster a more sustainable future and effectively combat the challenges of fossil fuel dependence and ozone layer depletion.

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MOLECULAR GENETICS OF INSECT BEHAVIOUR

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Introduction

Insect behaviour covers a very wide range of activities, including locomotion, grooming, feeding, communication, reproduction, dispersal, flight, learning, migration, host or prey selection, diapause and various responses to environmental hazards such as temperature, humidity, parasites, and toxins. One definition of behaviour is any action that an individual carries out in response to a stimulus or its environment, especially an action that can be observed and described. Behaviour genetics began to develop as a field of study in the 1960s but was limited to demonstrating that a behavioural trait was heritable, determining whether its mode of inheritance was dominant or recessive, sex-linked or autosomal, and resolving whether the variation was due to single or multiple genes. The genetic basis of insect behaviour has been analyzed most extensively using *Drosophila melanogaster* and a few other species, such as honey bees, grasshoppers, *Nasonia* parasitoids, and crickets.

Molecular genetic techniques provide powerful methods to analyze insect behaviour, including olfaction, learning, circadian rhythms, and mating behaviour. Having the complete sequence of the genome of *D. melanogaster* simplifies the isolation of specific genes that are involved in the behaviour. P-element mediated transformation makes it possible to insert genes from one species of *Drosophila* into the genome of another, and their effect(s) on behaviour can be determined. Transgenic *D. melanogaster* carrying markers such as green fluorescent protein (GFP) allow scientists to determine when and where specific genes are active.

Traditional Genetic Analyses of Behaviour

Mutations in a single gene or a few major genes alter a behaviour and the mode of inheritance can be assessed by traditional methods. The traditional behaviour-genetic analysis uses two main experimental approaches: crossing and selection. A third, limited to *D. melanogaster*, involves analysis of fate maps in genetic mosaics to locate the anatomical site of abnormalities that affect behaviour. Many genes may influence an insect's behaviour, although a specific behaviour sometimes can be altered by the mutation of a single gene. When many genes are involved, analyses of behaviour traditionally have required the use of quantitative genetic methods and sophisticated statistical analysis.

Crossing Experiments

A crossing experiment involves mating individuals that differ in a particular behaviour and then examining the behaviour of their F1 and backcross progeny. (A backcross is a cross of F1 individuals to a parental line, usually the homozygous recessive one) Ideally, the environment is controlled so all individuals experience the same conditions. It is easiest to interpret the experiment results if the crossed individuals differ only concerning a single behavioural attribute. The phenotype of the F1 and backcross progeny indicates whether a single gene or multiple genes determine the behaviour, and whether there is dominance, sex linkage, or maternal influences. If many genes influence the trait, it is difficult to determine the number of loci, their relationship to each other, or their location on specific chromosomes because most insect species lack sufficient genetic markers. New molecular and statistical methods using quantitative trait loci (QTLs) may provide greater power to study and locate multiple and interacting loci. One aspect of honey bee behaviour provides an example of a trait that appears to be determined by a few genes. Other behaviours, including house-entering behaviour in the mosquito *Aedes aegypti*, foraging in *D. melanogaster*, and host choice in the parasitoid *Nasonia* also appear to be determined by one or a few genes.

Susceptibility to American Foulbrood in *Apis mellifera*

Susceptibility to foulbrood disease, caused by *Bacillus* larvae, originally was analyzed by crossing two inbred *A. mellifera* strains with differing levels of resistance. The differences in resistance were attributed to differences in "hygienic behaviour" in worker (sterile female) bees and represent one of the first demonstrations that behaviour is genetically determined. Resistant workers (=hygienic) consistently remove dead larvae and pupae from the brood nest at a high rate, thus slowing the spread of the bacteria through the colony by reducing contamination. Crosses between "hygienic" queens and susceptible "nonhygienic" haploid males yield F1 worker progeny that are non-hygienic, indicating that the "genes" conferring resistance are recessive. Progeny produced by backcrosses to the homozygous-recessive hygienic strain yielded approximately 25% hygienic workers, which is consistent with the hypothesis that hygienic behaviour is determined by two recessive loci. Under a two-locus model, hygienic worker queens are homozygous for two genes, *uu* and *rr*. The hygienic workers (*uu*, *rr*) both uncap the cells (*uu*) containing dead broods and remove them (*rr*). However, *uu*, *r+r* individuals will uncap the cells, but not remove dead brood. The *u+u*, *rr* individuals do not uncap brood but will remove them if the cells are uncapped for them. Individuals that are *u+u*, *r+r* are unhygienic, and will neither uncap nor remove brood.

Moritz (1988) proposed a three-locus model for hygienic behaviour in bees. The expression of hygienic behaviour depends on colony strength and the composition of worker types within the colony. Electro-antennogram analyses of the olfactory and behavioural responses of hygienic and non-hygienic bees to diseased brood indicated that hygienic bees have a higher sensitivity to low concentrations of the odor of diseased bee pupae. Such differences are due to a lower stimulus threshold and are not a direct result of age or experience of the bee. Thus, nonhygienic bees may be unable to detect diseased broods. Understanding hygienic behaviour in *A. mellifera* has resulted in practical recommendations to beekeepers for selecting colonies resistant to chalkbrood (a fungal disease) and the pest bee mite *Varroa*.

House-Entering Behaviour in *Aedes aegypti*

House-entering behaviour by the mosquito *A. aegypti* from East Africa was analyzed by crossing different populations with different behaviours. One population of *Ae. aegypti* commonly entered houses (domesticated or D), whereas others rarely did so (either peridomestic, P, or feral, F). House-entering behaviour is important in determining whether a population transmits yellow fever to humans. Marked mosquitoes were captured inside houses and in the village area. Of the mosquitoes entering houses, 45% were from the D population, 13.9 % from hybrids between the domestic and peridomestic population (DP and PD), 9.8% from the P population, and 5.7% were hybrids (DF and FD).

Foraging in *Drosophila*

Drosophila melanogaster larvae feed on yeast growing on decaying fruit. Naturally occurring populations contain individuals that vary in the distance the larvae travel while foraging for food, a difference attributed to a single foraging gene. Natural populations comprise approximately 70% “rovers” (who forage long distances) and 30% “sitters” (short-distance foragers), with the rover phenotype dominant to sitter, indicating a single-gene mode of inheritance. The *foraging* gene encodes a cyclic guanosine monophosphate (cGMP)–dependent protein kinase, and rovers have higher kinase activity levels than sitters.

Selection Experiments

Selection experiments provide another traditional method to determine the degree to which a given behaviour is determined genetically. In a selection experiment, individuals with a specific behavioural attribute are allowed to reproduce and this process is repeated over succeeding generations. Eventually, the behaviour of the selected population is altered if the genetic variation for the attribute is present in the initial colony and the selection procedures were appropriate. The response of the population to selection can be analyzed to estimate the heritability of the trait.

Migratory Behaviour in *Oncopeltus fasciatus*

The migratory behaviour of *Oncopeltus fasciatus* is under genetic control. Strains of *O. fasciatus* were selected for wing length and propensity to fly. Bidirectional selection on wing length (selection for increased and decreased wing length) was performed for 13 generations, and the flight behaviour of individuals was monitored. Individuals also were selected for flight time, and those whose flight times totalled 30 minutes were considered “fliers,” whereas those with a shorter flight time were labelled “nonfliers.” Response to selection on wing length was rapid, and flight tests of the long- and short-winged insects indicated there was a positive correlation between wing length and flight duration. Selection after two generations for flight or non-flight likewise resulted in divergent responses, indicating a large genetic component to flight behaviour.

Some Polygenically Determined Behaviours

Behaviour often is a continuous variable, controlled by multiple genes with small additive effects. The task of teasing apart the respective roles of genes and environment requires statistical analysis. *Drosophila* behaviours determined by multiple genes include locomotor activity, chemotaxis, duration of copulation, geotaxis, host-plant preference, mating speed, phototaxis, preening, and the level of sexual isolation within and between species. Multiple genes influence host-plant adaptation and host preference in insects, and learning also may affect host preference. The host-plant choice usually is a hierarchy of several components. For example, attraction to a site from a distance and oviposition-site preference (egg laying at the site) are genetically distinct in *Drosophila tripunctata*.

The genetic basis of host-plant specialization in the fruit flies *Drosophila sechellia* and *D. simulans* is determined by a minimum of three or four loci that affect egg production, survival, and host preference. *Drosophila sechellia* breeds in a single plant, *Morinda citrifolia*, which is toxic to other Drosophila species. Its sympatric relative, *D. simulans*, breeds on a variety of plants. The two species can be crossed, and the F1 hybrid embryos produced by *D. simulans* females are susceptible to *Morinda* fruit because susceptibility is maternally inherited and fully dominant. Females of *D. sechellia* are stimulated by *Morinda* to produce eggs, but this plant inhibits oviposition in *D. simulans*. In hybrid progeny, the inhibition observed in *D. simulans* is dominant. F1 hybrids and backcross progeny exhibit intermediate, approximately additive, behaviour. These differences result in the isolation of the two species in nature, although their ranges overlap geographically. Thus, their ecological niches are determined by tolerance to toxic products in the ripe *Morinda* fruit, with *D. sechellia* exhibiting a strong preference for *Morinda*, an ability to detect fragrant volatiles from *Morinda* over a long distance, and stimulation of egg production by *Morinda*. By contrast, *Morinda* inhibits egg production in *D. simulans*.

Other specific behavioural attributes inherited in a complex manner include the number of attempts to mate by males (*Musca domestica*), high and low ability to learn to extend the proboscis to a stimulus applied to the forelegs (*Phormia regina*), call the rhythm of males and female response to call songs (hybrid crickets), ability to avoid pesticides (*Anopheles albimanus*), high and low collection of alfalfa pollen and stinging behaviour by bees (*Apis mellifera*).

Learning in *Drosophila*

Learning can be defined as a change in behaviour with experience, but this definition would not exclude responses such as growth and maturation, or other processes that are triggered by events such as mating or feeding. Another definition is a reversible change in behaviour with experience, but this excludes phenomena in which the modification caused by some experience is fixed and resistant to further change. Papaj and Prokopy (1989) suggested the following properties are characteristic of learning in insects as

1. An individual's behaviour changes in a repeatable way as a consequence of experience.
2. Behaviour changes gradually with continued experience, often following a "learning curve" to an asymptote.
3. The change in behaviour accompanying experience declines in the absence of continued experience of the same type or as a consequence of a novel experience or trauma.

Drosophila melanogaster can be sensitized and habituated, learn associations with positive or negative reinforcement, and be classically conditioned. *Drosophila melanogaster* can learn to run away from specific odors that they previously experienced with an electric shock and hungry flies can learn to run toward odors previously associated with a sugar reward. Flies can learn visual, tactile, spatial, and proprioceptive cues. Analyses of memory mutants in *Drosophila*, including *dunce, rutabaga, amnesiac, radish, zucchini, cabbage, tetanic, turnip, linotte* and *latheo*, indicate that memory consists of distinct phases: short-term, intermediate, long-term, and anaesthesia- resistant memory. The learned avoidance lasted only a few hours, but the odor-avoidance test was used to screen mutagenized flies for strains that had normal olfaction and aversion to shock, but an abnormally low ability to associate odors with shocks. The mutant flies obtained were poor learners, but each had different phenotypes. Flies with the mutant gene amnesiac had a nearly normal learning ability, but forgot rapidly. Flies with mutated dunce genes had a shortened memory for several different conditioned behaviours due to a defective gene for cAMP-specific phosphodiesterase, an enzyme that regulates levels of cyclic AMP (cAMP).

Conclusions

Great advances have been made in understanding the behaviour of insects using many new molecular tools, especially those based on whole-genome sequencing. The ability to sequence the genomes of multiple inbred lines of *D. melanogaster*, for example, has provided exceptional opportunities to dissect the genetic bases of behaviour. Statistical methods have advanced, and methods to evaluate groups of insects by recording their behaviour and analyzing the data with computer programs provide new opportunities, as well, to obtain high-throughput data.

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NEED AND SIGNIFICANCE OF PROTEIN IN DAILY DIET

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Introduction

Every human cell has protein. An amino acid chain is the basic unit of a protein. Our bodies need protein in our diets to help with cell growth and repair. Protein is also required for every individual's growth and development. Protein is a vital part of every well-balanced diet. The human body uses amino acids for bone and muscle repair, hormone synthesis, and enzyme synthesis. They are useful as an energy source. Protein is used by the body to create and repair tissues. It boosts immune system function, maintains fluid balance, pH stability, and metabolic activities. It also transports and stores nutrients and has the ability to produce energy.

Here are some of the main roles that proteins play:

Protein is essential for the development and maintenance of body tissues. Enzymes are proteins that facilitate critical chemical reactions within the human body. The different lengths of amino acid chains combine to make proteins and peptides, which are different types of hormones that let cells, organs, and tissues communicate with one another. Fibrous proteins are a type of proteins that provide various bodily parts their structure, elasticity, and strength. To keep the pH levels of bodily fluids, including blood, at the proper levels, the human body uses proteins as a buffer mechanism. Blood proteins are involved in maintaining the fluid balance between your blood and the soft tissues in your immediate environment. Proteins create antibodies to protect the body.

Antibodies are formed by proteins to shield your body against foreign invaders like viruses and bacteria that cause illness. Certain proteins move nutrients around the body, while others hold them in reserve. Protein can be an important source of energy, but only during fasting either excessive exercise or insufficient caloric intake.

During digestion, the protein in food is divided into pieces known as amino acids. Fooptimal health, the human body requires a variety of amino acids in sufficient quantities. Animal products like meats, milk, fish, and eggs contain amino acids. Additionally, they can be found in plant sources like quinoa, wheat germ, beans, legumes, nut butters, and soy. To obtain all the protein you require in your diet, you do not have to consume animal products.

Three categories exist for amino acids:

- Essential
  Non-Essential
- Conditional

Food is the only source of essential amino acids because the body is unable to synthesise them. They're not necessary to eat with every meal. What matters more is the balance throughout the entire day.

The body synthesises nonessential amino acids from essential amino acids or during the regular breakdown of proteins.

Conditional amino acids are required in times of stress and illness.

Recommendations

Based on your total energy requirements, your diet's required protein intake will vary. Protein should make up 10% to 35% of a healthy adult's daily caloric requirements. A gram of protein has four calories in it. Thus 90 grams of protein, or 360 calories, could be consumed by a person following an 1800 calorie diet. This would account for 20% of the daily calorie intake.

The majority of foods high in protein contain 7 grammes of protein per ounce (30 grammes).

One ounce (30 grammes) is equivalent to:

- One large egg
- One ounce (30 grammes) of meat, fish, or poultry
  A half-cup (60 millilitres) of tofu and
- a half-cup (65 grammes) of cooked lentils or beans

Protein can also be found in low-fat dairy products.

Protein content is higher in whole grains than in refined goods.

Depending on their age, children and teens may require different amounts. A few nutritious sources of animal protein are skin-free turkey, chicken, or bison (also known as buffalo meat). Trim any visible fat from lean beef or pork cuts like tenderloin, top sirloin, or round.

Shellfish or fish

Additional protein-rich foods include split peas, lentils, kidney beans, black beans, pinto beans, and garbanzo beans.

Almonds, hazelnuts, mixed nuts, peanuts, peanut butter, sunflower seeds, or walnuts are examples of nuts and seeds. (Be careful with portion sizes because nuts contain a lot of fat. Gaining weight can result from consuming more calories than you need.)

 Products made from soy protein, such as tempeh and tofu

Reduced-fat dairy items

Increasing your daily intake of protein naturally

Here are some ideas to help you increase the amount of protein in your diet:

- Try a sandwich with peanut butter. Use natural peanut butter (or any other nut paste) that hasn't had any sugar, salt, or other fillers added.
- High in protein, low-fat cottage or ricotta cheese can be used in pasta dishes, casseroles, mashed potatoes, and scrambled eggs. Alternatively, spread it on your morning toast.
- Nuts and seeds taste great in salads, paired with veggies, or added to curries. Consider adding toasted pine nuts or flaked almonds to your green salad.
- Soups, casseroles, and pasta sauces all taste fantastic with beans. Consider tossing a can of drained cannellini beans.
- Consider adding drained cannellini beans to your preferred casserole or vegetable soup recipe.
- You can easily get extra protein at lunch time with hummus spread on your sandwich or as a snack on a plate of freshly cut vegetable sticks.
- Greek yoghurt is a high-protein food that you can eat all day long. Sprinkle some over your preferred cereal for breakfast, place a spoonful over a bowl of pumpkin soup, or serve it with fresh fruit for dessert.
- Eggs are a simple, adaptable food that go well with many different dishes or can be eaten on their own.

Protein requirements for different age groups

For an average sedentary adult, the recommended dietary allowance to prevent deficiency is 0.8 grammes per kilogramme of body weight.

Age group	**Category of work**	**Protein(gm)**
Men	Sedentary	72
	Moderate	90
Women	Sedentary	57
	Moderate	72
Pregnant women		72
Lactating mothers	0-6 months	77
	6-12 months	78
Children	1-3 yrs	38
	4-6 yrs	46
	7-9 yrs	59
Boys	10-12	76
Girls	10-12	70
Boys	13-15	95
Girls	13-15	81
Boys	16-18	107
Girls	16-18	85
Elderly >60 yrs	Man	62
	Woman	56

Source:ICMR-NIN, Dietary guidelines for Indians-2024

Protein deficiency

Inadequate intake of protein in the diet is known as protein deficiency. Protein shortage symptoms include:

• Loss of muscle mass

• Oedema, or fluid buildup, mostly in the ankles and feet

• Delayed growth, particularly in children; anaemia, which is the blood's inability to supply enough oxygen to the cells, is typically brought on by nutritional deficiencies resulting from a lack of iron.

Diets heavy in protein can be harmful

Extremely high protein intakes of 200–400 g per day are encouraged by certain fad diets. The kidneys and liver may be strained by an extremely high-protein diet. Additionally, it may result in an excessive loss of the calcium mineral, raising your risk of osteoporosis.

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UNDERSTANDING THE CONCEPT OF NUTRITIONAL HEALTH

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Introduction

Nutritional health is a multifaceted concept that transcends the simple act of eating. It involves the strategic intake and balance of various nutrients to promote optimal bodily functions and well-being. This detailed exploration of nutritional health will cover its components, significance, and practical applications, highlighting how a well-rounded diet is fundamental to maintaining health and preventing disease.

Defining Nutritional Health

Nutritional health is achieved when the body receives the appropriate amounts of essential nutrients needed for optimal functioning. These nutrients include macronutrients (proteins, fats, and carbohydrates) and micronutrients (vitamins and minerals). Each plays a unique role in maintaining health, supporting bodily functions, and preventing nutrient deficiencies that could lead to health issues.

The Importance of Nutritional Health

1. **Prevention of Chronic Diseases**: Adequate nutrition helps prevent chronic conditions such as cardiovascular diseases, diabetes, and obesity. For instance, a diet rich in fruits, vegetables, and whole grains can reduce the risk of heart disease and certain cancers.
2. **Optimal Growth and Development**: Proper nutrition is vital for the growth and development of children and adolescents. Essential nutrients like calcium, vitamin D, and protein are crucial for developing strong bones, muscles, and cognitive functions.

3. **Immune System Support**: A well-balanced diet supports a robust immune system, enabling the body to fend off infections and diseases. Nutrients such as vitamin C, vitamin E, and zinc play significant roles in maintaining immune health.
4. **Mental Health and Cognitive Function**: Nutritional health is closely linked to mental well-being. Deficiencies in certain nutrients, like omega-3 fatty acids and B vitamins, have been associated with mood disorders and cognitive decline.

The Role of Macronutrients

1. Proteins

- Proteins are fundamental for growth, repair, and maintenance of body tissues. They are composed of amino acids, some of which are essential and must be obtained through the diet. Proteins support immune function, hormone production, and enzyme activity. High-quality protein sources include lean meats, poultry, fish, eggs, dairy products, legumes, and nuts.
- Functions: Proteins are crucial for muscle development and repair. They also play a role in producing enzymes and hormones essential for various metabolic processes.
- Recommended Intake: The Dietary Guidelines suggest that protein should make up 10-35% of total daily calories. For an average adult, this translates to approximately 46 grams per day for women and 56 grams per day for men, though individual needs may vary.

2. Fats

- Fats are a concentrated source of energy and are essential for absorbing fat-soluble vitamins (A, D, E, K). They also support cell membrane integrity and hormone production. Fats are categorized into saturated, unsaturated, and trans fats, each impacting health differently.
- Healthy Fats: Unsaturated fats, found in olive oil, avocados, and nuts, are beneficial for heart health and cholesterol levels. Omega-3 fatty acids, found in fish such as salmon and flaxseeds, support brain function and reduce inflammation.
- Limitations: Saturated fats, found in red meat and dairy products, and trans fats, present in many processed foods, should be limited as they are associated with increased risk of cardiovascular disease.

- Recommended Intake: Fats should constitute about 20-35% of total daily calories, focusing on healthy fats while minimizing saturated and trans fats.

3. Carbohydrates

- Carbohydrates are the body's primary energy source. They are categorized into simple and complex carbohydrates. Simple carbohydrates are sugars that provide quick energy but can lead to rapid blood sugar spikes. Complex carbohydrates, such as those found in whole grains, fruits, and vegetables, offer sustained energy and are rich in fiber, which aids digestion.
- Functions: Carbohydrates are broken down into glucose, which fuels bodily functions and physical activity. Fiber, a type of carbohydrate found in plant foods, promotes digestive health and can help regulate blood sugar levels.
- Recommended Intake: Carbohydrates should make up 45-65% of total daily calories. Emphasis should be on consuming complex carbohydrates over refined sugars and processed foods.

Micronutrients and Their Importance

1. Vitamins

- Vitamins are organic compounds essential for various biochemical processes. They are classified into water-soluble (B-complex and C) and fat-soluble (A, D, E, K) vitamins.
- Vitamin A: Crucial for vision, immune function, and skin health. Sources include liver, carrots, and sweet potatoes.
- Vitamin C: Important for immune support and collagen synthesis. Found in citrus fruits, strawberries, and bell peppers.
- Vitamin D: Supports bone health by enhancing calcium absorption. Sources include sunlight exposure and fortified dairy products.
- B Vitamins: Play roles in energy metabolism and red blood cell formation. Found in whole grains, meats, and leafy greens.

2. Minerals

- Minerals are inorganic elements necessary for maintaining various physiological functions.

- Calcium: Essential for bone and teeth health. Found in dairy products, leafy greens, and fortified plant-based milks.
- Iron: Vital for oxygen transport in the blood. Sources include red meat, legumes, and fortified cereals.
- Potassium: Helps regulate fluid balance and muscle function. Found in bananas, potatoes, and beans.
- Hydration: The Overlooked Component
- Water is a crucial yet often overlooked aspect of nutritional health. Proper hydration is essential for digestion, nutrient transport, and temperature regulation.
- Functions: Water aids in the absorption of nutrients, removal of waste products, and maintains electrolyte balance.
- Recommended Intake: While individual needs vary, a general guideline is to drink about 8 cups (2 liters) of water daily. Adjustments should be made based on factors such as activity level, climate, and overall health.

Strategies for Achieving Nutritional Health

1. Diverse and Balanced Diet

A diverse diet ensures the intake of a wide range of nutrients. Incorporate a variety of fruits, vegetables, whole grains, proteins, and healthy fats. Aim for colorful plates, as different colors often signify different nutrient profiles.

2. Mindful Eating and Portion Control

Be mindful of portion sizes to prevent overeating. Utilizing smaller plates and paying attention to hunger and fullness cues can help maintain a healthy weight.

3. Regular Meals and Snacks

Eating at regular intervals helps sustain energy levels and prevent excessive hunger. Balanced meals and snacks can prevent overeating later in the day.

4. Limiting Processed Foods

Processed foods often contain high levels of sugar, salt, and unhealthy fats. Minimizing their intake can prevent nutrient imbalances and health issues.

5. Consulting Health Professionals

For personalized nutrition advice, consider consulting a registered dietitian or nutritionist. They can provide tailored recommendations based on individual health needs and goals.

Conclusion

Nutritional health is an integral part of overall well-being, impacting everything from physical health to mental and emotional states. By understanding the roles of macronutrients, micronutrients, and hydration, individuals can make informed dietary choices that promote optimal health and prevent disease. Implementing practical strategies such as eating a balanced diet, controlling portions, and staying hydrated can lead to sustained health benefits and a higher quality of life. Investing in nutritional health is not just about making temporary changes but adopting long-term habits that support lifelong well-being.

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A NEW ERA OF PEST CONTROL: REMOTE SENSING

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Abstract

Agriculture is a cornerstone of India's economy, contributing significantly to GDP. However, insect pests, diseases, and weeds pose a substantial threat to crop yields. Forecasting pest outbreaks is vital for implementing effective Integrated Pest Management (IPM) strategies. Traditional methods, such as farmer observations and weather data, have limitations. Remote sensing technology, which measures changes in electromagnetic radiation emitted by crops, offers a more objective and accurate way to assess biotic stress. By analyzing these data, pest-warning expert systems can provide farmers with location-specific advice, helping to mitigate crop losses and enhance agricultural productivity.

Keywords: Remote sensing, Agriculture system, Insect-pest, Pest forecasting

Introduction

Agriculture plays a dominant role in the growth of the Indian economy contributing nearly 28 per cent towards Gross Domestic Product. Insect pests (14%), diseases and weeds inflict enormous losses to potential agricultural production. If the prevalence of the pest population is recognized in advance, effective remedial action can be taken to reduce yield losses resulting from the pest population. This gave rise to the idea of "forecasting," which is a crucial part of the IPM strategy.

Forecasting methods are based on models that utilize data on weather parameters, farmer's eye estimates, agrometeorological conditions, remote sense crop reflectance observations, etc. either separately or in an integrated manner. The graphic recognition of plant reactions to biotic stresses with acceptable levels of precision and speediness is hard. These responses disturb the quantity and excellence of electromagnetic radiation imitated from crop covers. Hence, remote sensing is the technique involving instruments that measure and record the changes in electromagnetic radiation and provide a better means of objectively quantifying biotic stresses in comparison to visual assessment methods.

Based on this, it is determined that several pest-warning expert systems possess the potential to efficiently and effectively provide farmers with location-specific technology and advice. Available information on the insect damage level, weed infestation, and plant diseases can explore a clear vision for decision-making of management programs. Remote sensing technology provides data assistance in decision support systems for various pest management programs depending on monitoring, mapping, and predicting outbreak patterns. The accurate and efficient monitoring of insect populations is the key point to improving pest control. Also, the rapidity and thoroughness of forecasting and reducing management costs have increased by using computer-based systems. The important component of the IPM strategy is the forecast for pests and the RS achieved it. Detecting crop stresses like nutrient deficiency, pest infestation, and disease development and monitoring drought by remote sensing techniques are useful.

Applications of remote sensing in pest management

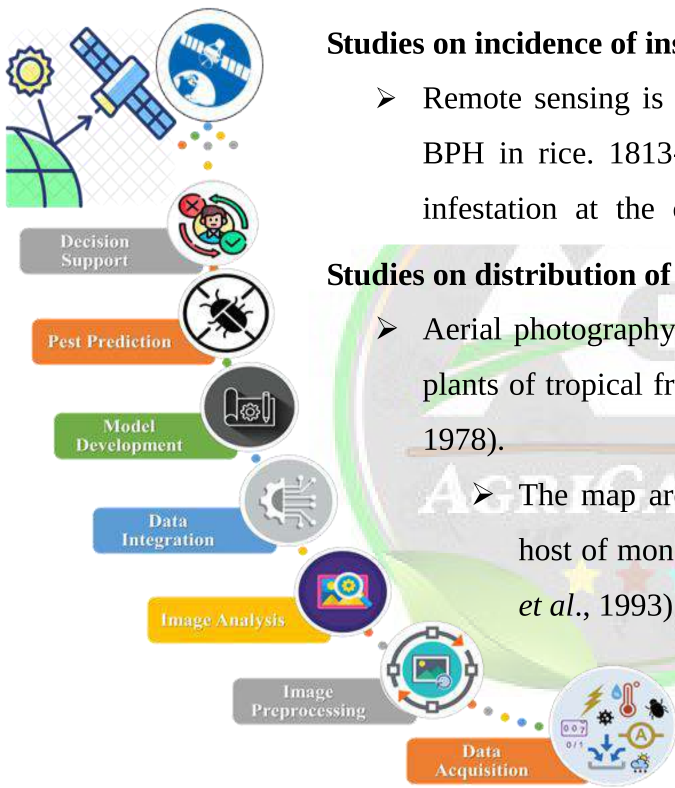
- Photography and videography from aircraft & the ground
- Satellite-borne multispectral scanning (MSS)
- Thermal imaging
- Ground based & airborne radar methods (Riley, 1989)

The pest damage can be predicted with	Spectral indices based on leaf pigments
	Optical & video imaging in near infrared & microwave regions
	Multi-Spectral Remote Sensing (MRS)
	Area identification with help of portable GPS equipment

Based on reviews we correctly noted, a significant obstacle in the effective application of remote sensing for pest prediction lies in the lack of unified models that accurately describe how insects scatter light. This inconsistency in modeling leads to challenges in:

- **Data Interpretation:** Different models may yield varying interpretations of the same spectral data, making it difficult to draw reliable conclusions about pest presence or severity.
- **Accuracy:** The accuracy of pest predictions can be compromised if the underlying models do not accurately capture the complex interactions between light and insects.
- **Generalizability:** Models that are too specific to particular insect species or environmental conditions may limit their applicability to a wider range of scenarios.

Here are some of studies regarding Pest forecasting using RS



Studies on incidence of insects through RS

- ➢ Remote sensing is possible to detect the stress caused by the BPH in rice. 1813-1836 nm may be most sensitive to BPH infestation at the canopy measurement level. (Zhou *et al*.,

Studies on distribution of insects through RS

- ➢ Aerial photography was used to study the distribution of host plants of tropical fruit flies in Hawaii and Mexico (Hart *et al*., 1978).
  - ➢ The map areas of milkweed (*Asclepias* spp.), a major host of monarch butterfly (*Danaus plexippus*) (Malcom *et al*., 1993).

Potential Solutions

To address these challenges, researchers and practitioners should focus on developing:

1. **Comprehensive light scattering models:**
   - **Hybrid approaches:** Combine physical optics and numerical methods to create more accurate models that account for the intricate geometric and optical properties of insects.

- **Machine learning integration:** Incorporate machine learning techniques to learn from large datasets of spectral data and insect images, refining the models' predictive capabilities.

2. **Standardized data collection protocols:**
   - **Consistent measurements:** Ensure that spectral data is collected under standardized conditions to minimize variability and improve comparability across studies.
   - **Metadata management:** Maintain detailed metadata about data collection parameters, insect species, and environmental conditions to facilitate data analysis and model development.
3. **Multi-sensor approaches:**
   - **Complementary data:** Combine data from different sensors (*e.g.*, hyperspectral, thermal, LiDAR) to capture a more comprehensive view of the ecosystem and improve pest detection accuracy.
4. **Real-time data analysis:**
   - **Cloud-based platforms:** Utilize cloud-based platforms to enable real-time processing and analysis of remote sensing data, facilitating timely pest management decisions.

Future directions

As technology continues to advance, future research should explore:

- **Drone-based remote sensing:** Employ drones for more flexible and efficient data collection, especially in remote or inaccessible areas.
- **Hyper-spectral imaging:** Utilize hyperspectral imaging to capture detailed spectral information across a wide range of wavelengths, potentially improving pest discrimination.
- **AI-driven pest identification:** Develop AI algorithms capable of automatically identifying and classifying pests based on their spectral signatures and morphological features.

By addressing the limitations of current light scattering models and adopting innovative approaches, remote sensing can become a more reliable and effective tool for predicting and managing pest infestations.

Conclusion

Remote sensing technology offers a valuable tool for pest management, providing data on pest incidence, occurrence, and potential damage. By monitoring vegetation and earth surface conditions over large areas, it supports IPM strategies. While remote sensing has shown great promise, ongoing research and development are necessary to enhance system design and operation, reducing costs and improving image quality. This will ensure that remote sensing continues to be a valuable asset for farmers in managing pest outbreaks effectively.

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PROCESS OF CELLULOSE-BASED PRODUCTS AND THEIR APPLICATION

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Abstract

Cellulose, a plant-based, renewable polymer, is integral to various industries due to its adaptability and environmental benefits. Its uses extend across textiles, packaging, and paper, where it provides durability and comfort and offers sustainable alternatives to conventional plastics. Recent advancements, such as cellulose nanomaterials and innovative packaging technologies, demonstrate its potential to improve performance and minimize environmental impact. However, challenges such as technical and economic issues in large-scale production, material constraints, and the need for ongoing research persist. The outlook for cellulose-based products is positive, fueled by continued research and technological advancements, with promising applications in high-strength materials, coatings, and medical devices. As demand for eco-friendly products grows, the market for cellulose-based solutions is anticipated to expand. Realizing the full potential of these products will require collaboration among researchers, industry leaders, and policymakers, along with investments in cutting-edge technologies and sustainable practices. Adopting cellulose-based solutions can help reduce plastic waste, conserve resources, and promote a circular economy, paving the way for a more sustainable future.

Key words: Cellulose, Processing, Biodegradable alternatives ,Textile, Fibers

Introduction

Cellulose is a complex carbohydrate and stands as the most abundant organic polymer on Earth, playing a crucial role as the primary structural element in plant cell walls. It is composed of linear chains of β-D-glucose units connected by β-1,4-glycosidic bonds, which provide it with significant mechanical strength and rigidity. These chains align to create crystalline regions, reinforced through extensive hydrogen bonding, rendering cellulose insoluble in water and highly resistant to chemical degradation. This crystalline structure is key to cellulose's exceptional chemical stability, making it unreactive with most common solvents and necessitating specific treatments for its processing. Beyond its strength and stability, cellulose is hydrophilic, owing to the presence of hydroxyl groups (-OH), which enable it to absorb water and swell an essential property in applications such as papermaking and textiles. Moreover, cellulose is biodegradable and non-toxic, breaking down naturally under microbial activity, which underscores its status as an environmentally friendly material sourced from renewable resources. The primary sources of cellulose are plant-based, with wood being the most prominent. Wood, containing approximately 40-50% cellulose, is widely used in industries like papermaking, with both softwoods, such as pine, and hardwoods, such as oak, being common sources. Cotton, nearly pure cellulose, is an excellent source of high-quality cellulose, particularly in the textile industry. Other plant fibers, like those from hemp and flax, are also rich in cellulose and are prized for their strength and durability, making them suitable for producing textiles, ropes, and specialty papers. Additionally, cellulose can be sourced from agricultural residues, including straw, corn stalks, and sugarcane bagasse, which are frequently utilized in the production of biofuels, paper, and bioplastics

Cellulose can also be derived from non-plant sources. Bacterial cellulose, produced by certain bacteria such as *Acetobacter xylinum*, is highly pure and exhibits unique mechanical properties. This form of cellulose is especially useful in specialized applications, including biomedical materials and high-performance membranes. Some algae, particularly certain species of green algae, also generate cellulose as part of their cell walls. Algal cellulose is gaining interest for its potential in sustainable production methods and novel material applications. In summary, the versatility, abundance, and variety of natural sources of cellulose highlight its significance across numerous industries and its potential to foster sustainable and innovative solutions.

EXTRACTION AND PROCESSING OF CELLULOSE:

Methods of cellulose extraction from raw materials

Extracting cellulose from raw materials involves isolating it from lignocellulosic biomass, which typically consists of components like lignin, hemicellulose, and other impurities. The extraction process generally starts with the pretreatment of the raw material to break down its complex structure, making the cellulose more accessible. Common extraction methods include:

1**. Chemical Extraction:**

Alkaline Treatment: This method involves treating the raw material with alkaline substances, such as sodium hydroxide (NaOH), to remove lignin and hemicellulose. The alkaline solution breaks down non-cellulosic components, leaving relatively pure cellulose behind. This technique is commonly used in pulp production for papermaking. **Acid Hydrolysis:** Strong acids like sulfuric acid (H_2SO_4) or hydrochloric acid (HCl) are used in this process to hydrolyze hemicellulose and degrade lignin, effectively isolating cellulose. Although effective, acid treatment can lead to cellulose degradation if not carefully controlled. Organosolv Process: This method employs organic solvents, often mixed with water, to dissolve lignin and hemicellulose. The cellulose remains undissolved and can be easily separated. The organosol process is environmentally favorable, as it allows for the recovery and reuse of solvents.

2. **Mechanical Extraction:**

Steam Explosion: In this technique, the raw material is exposed to high-pressure steam, which is then rapidly released, causing the material to explode. This mechanical action disrupts the lignocellulosic structure, making it easier to separate cellulose fibers. Grinding and Refining: Mechanical grinding and refining processes physically break down the raw material to release cellulose fibers. These methods are often combined with chemical treatments to enhance extraction efficiency.

Chemical and Mechanical Processing Techniques

After extraction, cellulose often undergoes further chemical and mechanical processing to refine and modify it for various applications:

1. Chemical Processing:

Bleaching: Following extraction, the cellulose may contain residual lignin and other impurities that give it a brown color. Bleaching processes using chlorine, hydrogen peroxide, or ozone are employed to remove these impurities and produce white, high-purity cellulose.

Esterification and Etherification: These chemical reactions modify cellulose by introducing ester or ether groups, improving its solubility, chemical reactivity, and compatibility with other materials. For instance, cellulose acetate, produced through esterification, is used in films, textiles, and plastics.

Nanocellulose Production: Cellulose can be chemically treated to produce nanocellulose, which has exceptional mechanical properties and a high surface area. This material is used in advanced applications like composites, coatings, and biomedical devices.

2. Mechanical Processing:

Pulping: Mechanical pulping involves physically breaking down the raw material into pulp, which is then refined to separate cellulose fibers. This process is crucial in the papermaking industry.

Beating and Refining: The cellulose pulp is subjected to mechanical beating or refining to enhance fiber quality. This step improves the bonding properties of cellulose fibers, making them suitable for producing strong and durable paper and cardboard.

TYPES OF CELLULOSE-BASED PRODUCTS:

Cellulose Fibers in Textiles:

Cellulose fibers, sourced from natural materials like cotton, wood, and other plants, are integral to textile manufacturing. Cotton, composed almost entirely of cellulose, is prized for its softness, breathability, and comfort, making it a popular choice for clothing and home textiles. In addition to cotton, other cellulose fibers like flax (used in linen) and hemp are appreciated for their strength and durability. Furthermore, regenerated cellulose fibers such as viscose, rayon, and lyocell are created by dissolving cellulose and reconstituting it into fibers. These regenerated fibers provide the comfort of natural fibers while offering enhanced properties, such as improved moisture absorption and better dyeing capabilities. Growing environmental awareness has led to more sustainable processes for producing these fibers, including the use of closed-loop systems in lyocell production, which significantly reduces chemical waste.

Cellulose-Based Plastics and Biodegradable Alternatives:

Rising environmental concerns regarding traditional plastics have spurred the development of cellulose-based plastics as biodegradable alternatives. Cellulose acetate, one of the most prevalent types of cellulose-based plastic, is commonly used in products like eyeglass frames, film, and cigarette filters. These plastics are created by chemically modifying cellulose to enhance flexibility and durability. A key benefit of cellulose-based plastics is their biodegradability, which helps mitigate the environmental impact of plastic waste. Researchers are also exploring other cellulose-based materials, such as nanocellulose and cellulose composites, for applications in packaging, automotive parts, and even electronics. These materials not only offer potential replacements for petroleum-based plastics but also improve product performance through greater strength, reduced weight, and sustainability.

Cellulose in Paper Production and Its Variants:

The production of paper is one of the oldest and most widespread uses of cellulose. The process typically involves breaking down wood or other plant materials into pulp, which is then refined and formed into sheets. The fibrous structure of cellulose makes it ideal for paper production, providing the necessary strength and flexibility. Beyond standard paper, cellulose is crucial in the manufacturing of cardboard, which requires a more robust and thicker material, as well as specialty papers designed for specific uses such as currency, filter papers, and technical papers used in various industries. Recent innovations in the paper industry include the development of recycled paper and paper products made from alternative cellulose sources, such as agricultural waste, reducing dependence on wood and lowering environmental impact.

INNOVATIVE APPLICATIONS OF CELLULOSE:

Cellulose Nanomaterials and Their Potential Uses:

Cellulose nanomaterials, including cellulose nanocrystals (CNCs) and cellulose nanofibers (CNFs), are gaining attention for their remarkable properties and diverse applications. These materials, derived from natural cellulose, are noted for their high mechanical strength, low density, and large surface area. CNCs, which have a rod-like structure, are used to reinforce polymers, enhancing their strength without significantly increasing weight, making them ideal for lightweight composites used in the automotive and aerospace sectors. CNFs have a network-like structure that is useful for making films and coatings with excellent barrier properties, which could potentially replace traditional synthetic materials in packaging and coatings. Furthermore, the biocompatibility and biodegradability of cellulose nanomaterials are leading to their exploration in biomedical fields, such as tissue engineering scaffolds and drug delivery systems, where they can support tissue regeneration and provide controlled release of medications.

Cellulose in Biomedical Applications:

Cellulose is increasingly employed in biomedical fields due to its compatibility with biological systems, safety, and adaptability for various uses. In wound care, cellulose-based materials create a moist environment that aids in healing while protecting the wound from infection. Advanced wound dressings using cellulose nanofibers or bacterial cellulose offer properties like high absorbency, breathability, and the capacity to deliver antimicrobial agents directly to the wound. In drug delivery, cellulose derivatives such as methylcellulose and hydroxypropyl cellulose are utilized to produce hydrogels and films that control drug release over time. These materials can be engineered to respond to specific conditions like pH or temperature, ensuring targeted drug delivery. The natural abundance and sustainability of cellulose also make it a promising choice for cost-effective and eco-friendly biomedical products.

Use of Cellulose in Sustainable Packaging Solutions:

With the increasing need for eco-friendly packaging, cellulose is emerging as a key player in creating sustainable alternatives to conventional plastics. Cellulose-based packaging is both biodegradable and compostable, sourced from renewable materials, making it a more sustainable option. It can be formed into various types of packaging, such as films, coatings, and molded products, which are strong, lightweight, and protective for goods during transportation and storage. Cellulose-based materials are particularly valuable for their ability to create barrier coatings that resist moisture and oxygen, which is crucial for preserving food and extending shelf life. Recent advancements have led to the development of packaging materials enhanced with nanocellulose, which offers superior mechanical strength and barrier properties, potentially replacing petroleum-based plastics. Additionally, combining cellulose with other bio-based materials can produce fully biodegradable packaging solutions that align with the growing demand for environmentally friendly products.

ENVIRONMENTAL BENEFITS OF CELLULOSE-BASED PRODUCTS

Biodegradability and Compostability of Cellulose Products

Cellulose products are highly regarded for their ability to biodegrade and compost, which makes them a sustainable alternative to conventional plastics. As a natural polymer, cellulose breaks down into its basic components through microbial action in the environment. Unlike petroleum-based plastics, which can remain in the environment for centuries, cellulose-based items decompose relatively quickly and return to the soil as organic matter that enriches it. Products like cellulose-based packaging and disposable items can be composted in industrial facilities, where factors such as temperature and moisture speed up their decomposition. This process significantly reduces landfill waste and lowers environmental pollution, emphasizing cellulose’s role as an eco-friendly choice.

Reduction of Plastic Waste Through Cellulose-Based Alternatives

Cellulose-based materials offer a viable solution to the escalating issue of plastic waste. Traditional plastics, derived from fossil fuels, contribute to significant environmental pollution and fill up landfills. By using cellulose-based alternatives, the dependence on non-renewable resources is decreased, and the environmental impact of waste is minimized. Cellulose-derived products, such as biodegradable films and containers, decompose more rapidly and thoroughly compared to traditional plastics. This not only helps mitigate pollution but also fosters more sustainable consumption habits. Additionally, advances in cellulose-based materials, including those enhanced with nanocellulose, provide effective alternatives with comparable or superior performance to plastics while being environmentally friendly.

Conclusion

Cellulose, a plant-derived natural polymer, is crucial across various sectors due to its abundance, renewability, and versatility. In textiles, cellulose fibers such as cotton and regenerated types like rayon and lyocell are valued for their comfort, durability, and eco-friendliness. The packaging industry benefits from cellulose-based materials, which provide biodegradable and compostable alternatives to conventional plastics. Additionally, cellulose remains fundamental in the paper industry, supporting the production of everything from everyday paper to specialized products like cardboard. Innovative developments in cellulose-based products, including cellulose nanomaterials and advanced packaging solutions, underscore the material's potential to boost performance and minimize environmental impact. However, challenges persist, including technical and economic obstacles in large-scale production, material property limitations, and the ongoing need for research and development. Embracing cellulose solutions can help reduce plastic waste, conserve resources, and support a circular economy. Continued exploration and innovation in cellulose materials will be key to achieving these objectives and fostering a more sustainable future.

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BIOSPHERE RESERVES IN INDIA

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Introduction

Ever-increasing human population requires increasing manipulation of the natural world to make food production efficient enough to feed so many people. The relationship between humans and nature has changed dramatically over the last 10,000 years. The biosphere reserves (BRs) of India are the repository of biodiversity as well as the abode of many traditional societies. BRs are unique kind of PAs comprising of terrestrial and coastal ecosystems that differ from a national park, wilderness area, national forest or wildlife refuge. When compared with national parks and other kinds of protected natural areas, it is found that while the other kinds of PAs are primarily concerned with conservation, and only secondarily with research and sustainable development, the BR takes into account the entire landscape and its elements both living and non-living under the ambit of conservation. BRs are designated to deal with important questions of reconciling the conservation of biodiversity, the quest for economic and social development and maintenance of associated cultural values. Some important aspects of BRs delineate conservation of landscapes, ecosystems, species and genetic variations; 88 Journal of the Anthropological Survey of India 68(1) economic development, which is culturally, socially and ecologically sustainable and extension of logistic support for research, monitoring, education and exchange of information related to local, national and global issues.

CRADLE OF CONCEPT OF BIOSPHERE RESERVE:

The concern for the protection and promotion of conservation led to the formulation and adoption of many measures. The initial approach to promote conservation has followed the 'hands off' philosophy by setting aside areas (now known as protected areas) at the cost of people who have depended on the rich biodiversity of the same for centuries. The concept of protected areas (PAs) for the conservation of wild species of fauna and flora has changed drastically since the establishment of the Yellowstone National Park in the United States of America in 1872. It was the world's first national park. Here and in other areas, wildlife was protected against people.

Central to this concept was the approach of non-interference, and public access to enjoy nature. It has been subsequently realised that in most parts of the world (particularly in the developing countries), PAs are neither completely insular nor isolated pieces of habitat. Subsequently, it was recognised that the ideal approach for conservation is to preserve the health of the overall ecosystem, including diversity of species. It can be best accomplished by integrating it into the fabric of social, environmental and economic canvas. Under this ecosystem approach, man and environment are integrated together for a better future for all the living being. These considerations led to the origin of the concept of biosphere reserve (BR). The initiation of BRs goes back to the 'Biosphere Conference' organised by the UNESCO in 1968. This was the first inter-governmental conference examining as how to reconcile the conservation and use of natural resources, thereby foreshadowing the present-day notion of sustainable development.

OBJECTIVES OF BIOSPHERE RESERVES:

- To conserve the diversity and integrity of plants and animals within the natural ecosystem.
- To safeguard the genetic diversity of species on which their continuing evolution depends
- To provide areas for multi-faceted research and monitoring
- To provide facilities for research and training
- To ensure the sustainable use of natural resources through most appropriate technology for improvement of economy and living standard of local people.

BIOSPHERE RESERVES IN INDIA:

These are large area of terrestrial and coastal ecosystem pro- moting solution to reconcile the conservation of biodiversity with its sustainable use. These area are under National and or international declaration, which has defined ecogeography and harmonious interaction among its components. These have inter- national recognization, declared by the National government and remain under the Sovereign jurisdiction of the states where they are located. These act as living laboratories for testing out and demonstrating integrated management of land, water and biodiversity. Collectively these biosphere reserves form the world Network of Biosphere Reserves (WNBR). There are about 500 biosphere reserves in over 100 countries. In India there are 18 biosphere reserves of which the following nine were listed under the World Network of Biosphere Reserves by the UNESCO Man and the Biosphere (MAB) programme.

Presently, there are 18 BRs in India. These are:

1. Nilgiri Biosphere Reserve

2. Gulf of Mannar Biosphere Reserve

3. Nanda Devi Biosphere Reserve

4. Sundarbans Biosphere Reserve

5. Simlipal Biosphere Reserve

6. Pachmarhi Biosphere Reserve

7. Nokrek Biosphere Reserve

8. Great Nicobar Biosphere Reserve

10. Dibru-Saikhowa Biosphere Reserve

11. Dehang-Dibang Biosphere Reserve

12. Khangchendzonga Biosphere Reserve

13. Agasthyamalai Biosphere Reserve

14. Achanakmar-Amarkantak Biosphere Reserve

15. Kachchh Biosphere Reserve

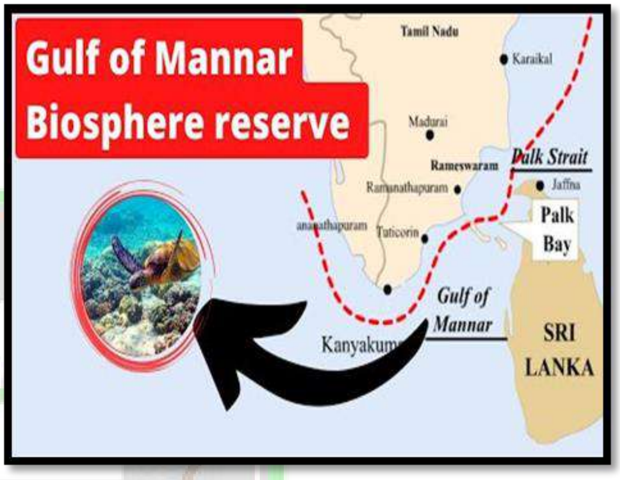
16. Cold Desert Biosphere Reserve

1.The Nilgiri Biosphere Reserve:

- The first biosphere reserve in India established in the year 1986.
- The total area of the Nilgiri Biosphere Reserve is 5,520 sq. kms & it is located in the Western Ghats
- Wide ranges of ecosystems and species diversity are found in this region.
- The Nilgiri Biosphere Reserve falls under the biogeographic region of the Malabar rain forest.

State	Area (Sq. Kms)
Tamilnadu	2537.6
Kerala	1455.4
Karnataka	1527.4

2. Gulf of Mannar Biosphere Reserve:



- It is located between India & Srilanka & it takes its name from Talaimannar in Srilanka.
- The Indian part of the Gulf covers about 10,500 sq.kms.
- It is unique for its rich biodiversity consisting of algae,sea weed,sea grass,mangroves,corals,pearl banks & other biological organisms.
- A national park was constituted by the state government to cover this area under the wildlife Act of 1972.

3. Nanda Devi Biosphere Reserve (NDBR):

- It is spread across three districts of Uttarakhand viz. Chamoli, Pithoragarh and Bageshwar.
- With an area of over 6407.03 km^2, NDBR is divided into two distinct zones, namely, the core zone and the outer buffer zone.
- There are two core zones, namely Nanda Devi National Park (NDNP) and Valley of Flower National Park (VoFNP).

4. Sundarban Biosphere Reserve:

- It is the largest prograding delta in the world
- Having an area of about 25,500sq.kms of which 9630 sq.kms lies in West Bengal state of India & the rest in the Bangladesh.
- Unique mangrove forests covers more than 4264 sq.kms of the Sunderbans of India.
- It includes a tiger reserve,a national park & three wildlife sanctuaries.

5. Similipal Biosphere Reserve:

- Having an area of about 556,900 ha & is located in northeast India.

- The Similipal Biosphere Reserve lies within two biogeographical regions:the Mahanadian east coastal region and the Chhotanagpur biotic province of the Deccan peninsular zone.
- The biosphere reserve has the largest zone of Sal in all of India.
- Altogether, 1,265 villages are located within the biosphere reserve.

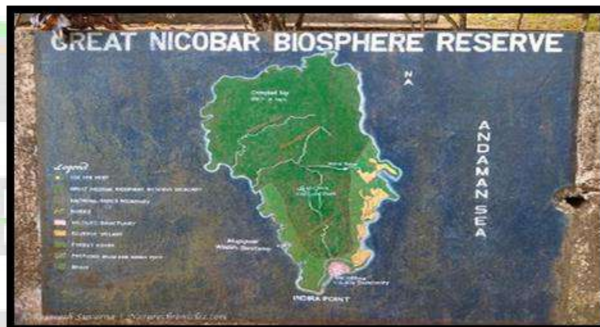
6. Pachmarhi Biosphere Reserve:

- The Pachmarhi Biosphere Reserve is a non-use conservation area and biosphere reserve in the Satpura Range of Madhya Pradesh state in Central India.
- Having an area of about 498,172 ha.
- The Pachmarhi Biosphere Reserve is characterized by high population growth, with Gond tribes accounting for 50% to 90% of the tribal population.

7.Nokrek Biosphere Reserve:

- Nokrek National Park is well known among locals and tourists in the Garo Hills as one of the bio-diverse hotspots.
- The highest peak in the Garo Hills range is Nokrek.
- It is located 1412 meters above sea level.
- The Nokrek National Park is an ideal place to go birdwatching.

8.Great Nicobar Biosphere Reserve:



- The Great Nicobar Biosphere Reserve encompasses a large part (some 85%) of the island of Great Nicobar.
- Nicobar Islands in the Indian Union Territory of Andaman and Nicobar Islands.
- The Nicobars lie in the Bay of Bengal, eastern Indian Ocean, 190 km (120 mi) to the north of the Indonesian island of Sumatra.
- The reserve has a total core area of approximately 885 km^2, surrounded by a 12 km-wide "forest buffer zone".

9. Manas Biosphere Reserve:

- Manas National Park (ˈmʌnəs) is a national park, Project Tiger reserve, and an elephant reserve in Assam, India.
- Located in the Himalayan foothills, it borders the Royal Manas National Park in Bhutan.
- The park is 950 square kilometres in the area and is situated at an altitude of 61–110 metres (200–361 ft) above mean sea level.

10. Dibru-Saikhowa Biosphere Reserve:

- Dibru-Saikhowa National Park is a national park located in Dibrugarh and Tinsukia districts, Assam, India.
- It was designated a Biosphere Reserve in July 1997 with an area of 765 km^2,including a core area of 340 km^2 (130 sq mi) and a buffer zone of 425 km^2 (164 sq mi).
- It is a heaven for many endangered species and rich in fish diversity.

11. Dehang-Dibang Biosphere Reserve:

- Dihang-Dibang or Dehang-Debang is a biosphere reserve constituted in 1998,located in Arunachal Pradesh.
- The reserve spreads over three districts: Dibang Valley, Upper Siang, and West Siang. It covers high mountains of Eastern Himalaya and Mishmi Hills.
- The elevation in the reserve ranges up to more than 5,000 metres (16,000 ft) above sea level.

12. Khangchendzonga Biosphere Reserve:

- It is a national park and a biosphere reserve located in Sikkim, India.
- It was inscribed to the UNESCO World Heritage Sites list in July 2016, becoming the first "Mixed Heritage" site of India.
- The park is named after the mountain Kangchenjunga, which is the third-highest peak in the world at 8,586 m (28,169 ft) tall.
- The total area of the park is 849.5 km^2

13. Agasthyamalai Biosphere Reserve:

- The Agasthyamala Biosphere Reserve is a biosphere reserve in India established in 2001, located in the southernmost end of the Western Ghats and includes 3,500.36 km^2 of which 1828 km^2 is in Kerala and 1672.36 km^2 is in Tamil Nadu.

- Agasthyamalai Biosphere Reserve became part of the UNESCO World Network of Biosphere Reserves in 2016.

14. Achanakmar-Amarkantak Biosphere Reserve:

- The Achanakmar-Amarkantak Biosphere Reserve is a biosphere reserve in India that extends across the states of Madhya Pradesh and Chhattisgarh.

- It covers a total area of 383,551 hectares.

15.Kachchh Biosphere Reserve:

- It is located in Gujarat State.

- Kachchh Biosphere Reserve (KBR) is mainly composed of two major ecosystems called Great Rann of Kachchh (GRK) and Little Rann of Kachchh (LRK).
- It covers an area of about 12,454 km^2

16. Cold Desert Biosphere Reserve:

- Cold Desert Biosphere Reserve is a biosphere reserve located in the Western Himalayas, within Himachal Pradesh in North India. It was established as a biosphere reserve in August 2009.

- Cold Desert has an area of 7,770 square kilometres (1,920,000 acres).

17. Seshachalam Biosphere Reserve:

- In 2010, it was designated as a Biosphere Reserve.
- It has large reserves of red sandalwood which is used in medicines, soaps, spiritual rituals, etc.

18. Panna Biosphere Reserve:

- The Panna Biosphere Reserve was designated in 2020 by UNESCO.
- The biosphere reserve includes protected areas and minimally-disturbed areas, including over 300 villages.
- The reserve has a total area of 299,898 ha, with 79,253 ha of core area, 98,720 ha of buffer zone, and 121,925 ha of transition zone. The reserve includes forests, woodlands, wetlands, farms, and wastelands.
- Residents of the reserve practice agriculture, horticulture, and forestry, and gather kattha, gum, resins, and medicinal plants from the forests.
- It was declared in 1994 as the twenty second Tiger reserve of India and the fifth in Madhya Pradesh.

Conclusion

Biosphere reserves are the **natural sites** that help in testing and demonstrating sustainable management of land, natural resources, and biodiversity.We can conclude that the biosphere reserve safeguards the organisms (plant and animal species) within the specific area. It develops strategies for the **sustainable use** of land and natural resources and the mutual benefit of humankind and nature.

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INNOVATIVE FOOD PRESERVATION WITH CHITOSAN: A BIODEGRADABLE PACKAGING SOLUTION

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Abstract

Chitosan, derived from chitin, is a versatile biopolymer found in crustaceans, insects and fungi. Through deacetylation of chitin, chitosan is obtained, showcasing functional versatility due to its amino groups. Recent research focuses on its application in biodegradable antimicrobial food packaging to address environmental concerns associated with non-biodegradable plastics. Various enhancement strategies, such as plasticizers, cross-linkers, and fillers like nanoparticles and cellulose, have been employed to improve chitosan's properties. The review emphasizes the formulation of an antioxidant film for sustainable food packaging using chitosan. The film, produced through a cost-effective method, exhibits antioxidant and antimicrobial qualities, meeting essential food packaging standards. With its eco-friendly nature and ability to extend shelf life by reducing oxidative stress, chitosan-based films offer a promising solution for environmentally conscious food packaging. This review contributes to the development of innovative, sustainable packaging materials aligned with the growing demand for eco-friendly practices in the food industry.

Keywords: Antioxidant film, Chitosan, Sustainability, Antimicrobial properties, Shelf-life extension.

Introduction

Packaging involves the fusion of artistic, scientific, and technological elements to securely deliver goods to end consumers at cost-effective prices. The preservation of fresh or processed food is significantly influenced by the food packaging process, which plays a crucial role in ensuring that food prepared in one location remains accessible to consumers in different, even after an extended period from the initial harvest or manufacturing. The continuous demand for improvement and innovation prompted research in the field of food packaging, resulting in the development of sophisticated packaging materials utilized in the present day (Ojagh *et al.*, 2010).

Since the introduction of plastics in food packaging, the generation of municipal solid waste (MSW) has become a significant environmental concern. As a response to this issue, research has been initiated on Biopolymers, which not only possess biodegradable properties but also exhibit desirable characteristics such as antimicrobial and antioxidative properties. These attributes can prove advantageous in prolonging the shelf life of food products (Priyadarshi and Negi 2019).

Source of Chitosan

The primary and cost-effective method for obtaining chitosan involves the deacetylation of chitin. Alternatively, chitosan can be directly extracted from certain fungi, as noted by White, Farina, and Fulton (1979). Chitin functions as the structural material for various organisms in both the animal and fungal kingdoms. Table 1 provides information on some typical sources of chitin along with their chitin content.

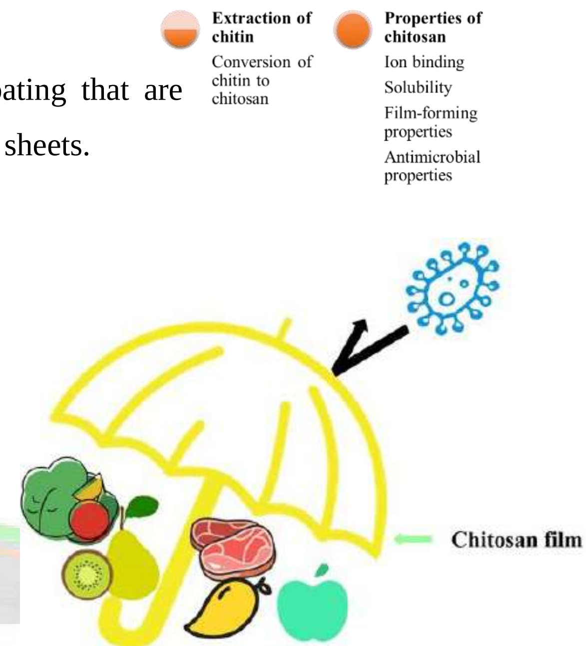
Table: 1. Various sources for chitin extraction with percentage content in each by dry mass

Sr. No.	organism	Chitin content (%)	References
1.	Crustaceans (Nephro)	69.8	Arbia, Adour & Amrane 2013
	Homarus (lobster)	60.0-75.0	Arbia, Adour & Amrane 2013
2.	Insects (*Pieris*)	64.0	Kaur & Dhillon 2015
	Diptera	54.8	Kaur & Dhillon 2015
3.	Fungi (*Aspergillus niger*)	42.0	Synowieeki & Al-Khateeb 2003
	Penicillium chrysogenum	19.5 - 42.0	Synowieeki & Al-Khateeb 2003

Chitosan production and processing:

Chitosan-based films:

Chitosan is used in food packaging as coating that are applied directly to food ingredients or as packaging sheets.



Preparation of chitosan solution

For the preparation of chitosan and EOs-based active films, the casting approach is widely used. This procedure begins with dissolving the chitosan in target solvents or acid solutions at a pH that is appropriate (Fig. 1). The film-forming solution is then supplemented with Essential oils (EOs), chitosan, and a preferred plasticizer following final dissolution. To get the proper homogeneity, the chitosan and EOs-based solution is then agitated for 15–20 minutes. The solution is then dried at an appropriate temperature and stored on desirable glass, Petri, or aluminium plates. The dried films made of EOs and chitosan are then peeled and stored. Table 2 showed a food packaging applications of chitosan with their properties.

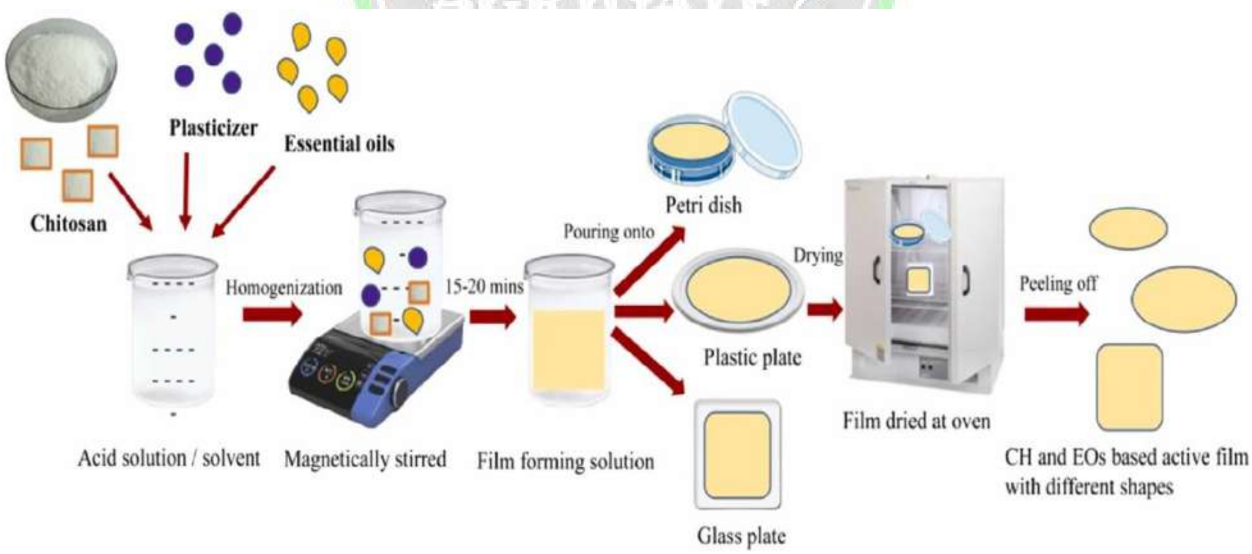


Fig. 1. Casting method for the preparation of chitosan and EOs based active film Source: https://doi.org/10.1016/j.fpsl.2022.100962

Table: 2. Food packaging applications of chitosan

Sr. No	Material type	Additive	Property	References
1.	Chitosan film	Zinc oxide	Moisture barrier Mechanical strength Antimicrobial activity	Priyadarshi, R., & Negi, Y. S. (2019)
2.	Chitosan film	Purple-fleshed sweet potato extract	pH sensing Antioxidant activity	Yong *et al.* (2019)
3.	Chitosan film	Curcumin	Antimicrobial activity Antioxidant activity	Roy & Rhim (2020)
4.	Chitosan film	Cinnamon essential oils	Mechanical strength Moisture barrier Food shelf life extension	Ojagh, *et al.* (2010)

Conclusion

Food packaging based on active chitosan serves as vital for food preservation since it shields food from light, heat, and water vapour. Furthermore, the food sector and the scientific community are beginning to recognise the potential antibacterial and antioxidant activity of chitosan-based films for novel uses in the food sectors. Furthermore, when EOs are combined with chitosan instead of a pure chitosan film, the mechanical and physical qualities of the active films are improved. Because chitosan and EOs contain beneficial components that improve food quality and prolong its shelf life, the composite film has the potential to replace artificial additive ingredients in food preservation.

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UNLOCKING THE NUTRITIVE POTENTIAL OF LITTLE MILLET TOWARDS GLOBAL NUTRITIONAL SECURITY

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Abstract

Little millet (*Panicum sumatrense*), an ancient cereal grain native to the Indian subcontinent, has been cultivated in Asia for over 4,000 years. Predominantly grown in the hilly regions of India, Nepal, and Western Burma, it is known for its resilience to drought and heat. However, its cultivation has declined due to the rise of subsidized rice and wheat, despite its overlooked potential during the Green Revolution. Little millet is rich in nutrients and fiber, contributing significantly to agro-diversity, soil conservation, and food security in marginal areas. It is cultivated on 2.34 lakh hectares in India, producing 1.27 lakh tonnes with an average yield of 544 kg ha^{-1}. Little millet contains its nutritional benefits including high antioxidant content and it helps to diabetes management, cholesterol reduction, and weight loss makes it a valuable food source. As a naturally gluten-free grain, little millet is ideal for those with celiac disease or gluten sensitivity. The processing of little millet into value-added products like flour, flakes, puffs, and ready-to-cook mixes not only enhances its culinary versatility but also boosts its market appeal, offering both health benefits and economic potential.

Keywords: Little millet, Nutritional benefits and Value-added products

Introduction

Little millet (*Panicum sumatrense*) is a small cereal grain native to the Indian subcontinent and has been cultivated in Asia since around 2700 B.C. This crop is widely grown in hilly regions of India, Nepal, and Western Burma, with significant cultivation in Tamil Nadu, Madhya Pradesh, Chhattisgarh, Karnataka, Odisha, Andhra Pradesh, Jharkhand, and Bihar. Despite its resilience to drought and heat, little millet has seen a decline in cultivation due to the increased availability of subsidized rice and wheat through India's Public Distribution System. The Green Revolution largely overlooked millets, resulting in reduced productivity despite their valuable traits (Vetrivendhan *et al*., 2021). It is rich in nutrients and crude fiber, making it a key food source, while it's straw serves as an animal feed. It also plays a vital role in maintaining agro-diversity, preventing soil erosion, sequestering carbon, and ensuring food security in drylands. However, it is less productive than other grains. To address this, mutation breeding and traditional breeding has been used to enhance its productivity and resilience. Little millet was cultivated on 2.34 lakh hectares in India, producing 1.27 lakh tonnes with an average productivity of 544 kg/ha. Known by various names across India, little millet is crucial for both nutrition and climate resilience.

Origin of Little millet is Southeast Asia and now extensively cultivated across India, especially in the temperate zones of Tamil Nadu, Madhya Pradesh, Odisha, Jharkhand, and Uttar Pradesh. It is also grown in tropical regions such as the Caucasus, China, and East Asia. This hardy crop is known for its resilience, capable of withstanding both drought and flooding, and is cultivable at altitudes up to 2,000 meters above sea level.

Climate and soil

Little millet, commonly referred to as samai, is a fast-growing, short-duration cereal that thrives in challenging conditions. It can tolerate both drought and waterlogging, making it suitable for cultivation in marginal and tribal areas where other crops may struggle. Despite its ability to grow in less fertile soils, it is often favoured in regions where agricultural options are limited.

Season

Little millet is predominantly cultivated during the monsoon ("kharif") season, with sowing beginning in June. Its short growth cycle and water efficiency make it adaptable to a wide range of growing conditions, including rainfed and low-fertility areas at altitudes up to 2,100 meters. Little millet is typically inter-cropped with legumes, gram, or sesame, requiring minimal inputs and it is enables farmers to maximize land use by cultivating areas unsuitable for other staple crops like rice and wheat.

Pest and Disease management

Little millet is generally more resistant to pests and diseases compared to other cereals, although it remains vulnerable to shoot-fly infestations. To mitigate this risk, farmers employ strategies such as early planting, reduced planting densities, and intercropping. Moreover, Little millet has the advantage of being storable for long periods without significant insect damage, offering a vital source of food security and dietary diversity during times of scarcity.

Mighty Millet: Tiny Grain endowed with Big Nutrition

Little millet (*Panicum sumatrense*) is a highly nutritious grain that offers numerous health benefits, making it an excellent addition to a balanced diet (Vetrivendhan *et al*., 2021). Hundred grams of little millet provides approximately 353 Kilo calories of energy, 67.5 grams of carbohydrates, 9.7 grams of dietary fiber, and 7.7 grams of protein, with minimal sugars and about 3.8 grams of total fat, including saturated, monounsaturated, and polyunsaturated fats. Rich in essential vitamins and minerals, little millet contains 0.10 milligrams of thiamine (B1), 0.02 milligrams of riboflavin (B2), 1.7 milligrams of niacin (B3), and 25 micrograms of folate (B9), along with 32 milligrams of calcium, 9.3 milligrams of iron, 119 milligrams of magnesium, 283 milligrams of phosphorus, 205 milligrams of potassium, and 2.5 milligrams of zinc. This gluten-free grain is particularly beneficial for those with gluten intolerance or celiac disease, and its high dietary fibre content supports digestive health. Additionally, the abundance of minerals like iron and magnesium makes it valuable for maintaining healthy blood and bones. While nutritional values may vary slightly based on factors such as growing conditions and processing methods, little millet remains a valuable source of nutrients, particularly in regions where it has been traditionally consumed (Indirani, 2021).

Health benefits of little millet

i) Strong Antioxidants*:* Little millet is packed with strong antioxidants and polyphenols compared to millet flour or flakes. This tiny grain is also rich in tannins and flavonoids, offering protection against a range of health issues including diabetes, heart disease, cataracts, cancer, inflammation, and gastrointestinal problems, while also helping to delay the aging process (Guha *et al*., 2015).

ii) Aids in the Treatment of Diabetes: Little millet is well-known for its high dietary fiber content and low glycemic index, making it particularly beneficial for managing diabetes. The slow release of glucose into the bloodstream helps maintain stable blood sugar levels, providing an advantage for diabetics who need to control the rapid fluctuations in blood glucose (Rana and Bhandari, 2023).

iii) Aids in Lowering Cholesterol: Little millet is rich in magnesium, which supports heart health, and contains a significant amount of niacin, known for its cholesterol-lowering properties (Rana and Bhandari, 2023).

iv) Aids in Weight Loss: Little millet is an excellent aid for weight loss, thanks to its phosphorus content, which also helps in tissue repair and energy generation after intense exercise. Its high water-soluble fiber content promotes satiety, delays stomach emptying, and aids in detoxification, making it beneficial for those dealing with lifestyle issues such as obesity, diabetes, and cardiovascular conditions (Dey *et al*., 2022).

v) Gluten-Free: Little millet is naturally gluten-free, making it an ideal option for those on a gluten-free diet or those suffering from celiac disease or gluten sensitivity.

Processing & Little Millet-Based Value-Added Food Products

Processing little millet into value-added food products involves several key steps:

Cleaning and Sorting: Begin by removing impurities, stones, and damaged grains from the little millet to ensure quality.

Milling: The cleaned millet is then ground to obtain either flour or semolina, depending on the desired end product.

Little Millet Flour: This gluten-free flour is perfect for baking breads, cakes, and other baked goods. It can be used alone or mixed with other flours to create a variety of textures and flavors.

Little Millet Flakes: Similar to rolled oats, Little Millet flakes are a convenient option for quick and healthy breakfasts. They can be used in porridge, granola, or as a topping for yogurt and smoothie bowls.

Little Millet Puffs: A crunchy snack option, Little Millet puffs can be enjoyed on their own, mixed with nuts and dried fruits for a homemade trail mix, or used as a topping for salads and soups.

Ready-to-Cook Mixes: For those with busy lifestyles, ready-to-cook mixes made with Little Millet offer a quick and nutritious meal solution. These mixes are available for a variety of dishes, including upma, pongal, and even desserts like kheer.

Millet-Based Noodles and Pasta: Little Millet is increasingly being used in gluten-free noodles and pasta, offering a nutritious alternative to traditional wheat-based products. These products are perfect for those looking to reduce their gluten intake while still enjoying their favorite dishes.

Baking: Little millet flour is also suitable for baking, leading to products like little millet bread or cookies.

Packaging: Finally, the processed products are packaged to maintain freshness and quality, ensuring they are ready for market distribution.

Conclusion

Little millet (*Panicum sumatrense*) stands out as a resilient and nutritious grain with immense potential to contribute to food security and nutritional balance, especially in regions with challenging growing conditions. Despite its historical decline in cultivation due to the rise of more commercial crops, the renewed focus on little millet highlights its significant role in promoting agro-diversity, supporting smallholder farmers, and addressing modern health concerns. Its adaptability to various climates and soils, combined with its rich nutrient profile, makes it an essential component of sustainable agriculture and a valuable ingredient in diverse, health-conscious diets. By processing little millet into value-added products, there is a growing opportunity to reintroduce this ancient grain into mainstream consumption, providing both health benefits to consumers and economic opportunities to farmers. As awareness of its benefits continues to grow, little millet is poised to make a big impact on the future of global food systems and a boost to bio economy.

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ALLEVIATION OF MOISTURE STRESS BY RHIZOBIAL (RE) AND PASSENGER ENDOPHTES (PE)

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Abstract

Moisture stress, one of the most critical environmental issue that affects plant growth and productivity in the face of climate change. As the moisture stress is categorized into transient, chronic, and intermittent types, each having specific effect on plants physiological and morphological characteristics. In this context, this study describes the endophytic organisms that plays a vital roles in alleviating the moisture stress by enhancing root growth, osmoprotectant production, and antioxidants together with several hormonal changes under this stress condition along with their role in promoting soil health. This provides a new area in the biofertilizer technology that offers promising strategies for enhancing crop resilience and advancing sustainable agriculture.

Keywords: nitrogenase, osmoprotectants, reactive oxygen species, *Rhizobium*, stomatal closure

Introduction

Moisture stress, often referred as drought stress, is a significant environmental factor that adversely affects the plant growth, productivity, and survival. It is developed when the availability of water in soil falls below the required levels which is optimal for plant function, leading to various physiological, morphological, and biochemical changes. Knowledge on moisture stress is essential, especially in the context of global climate change, where irregular rainfall patterns and rise in temperatures are expected to increase drought conditions.

Types of Moisture stress

Moisture stress are categorized into three types: transient, chronic, and intermittent.

1. **Transient moisture stress** occurs on short-term water deficits, such as irregular rainfall or brief droughts, causing immediate physiological responses like stomatal closure to minimize water loss.
2. **Chronic moisture stress**, is associated with prolonged periods of water deficit, which results in adverse impact on plant growth, causing stunted growth, reduced yields, and, in extreme cases, plant death.
3. **Intermittent moisture stress** are caused by alternating periods of adequate moisture and drought, which are often seen in rainfed agriculture systems, which causes plants to develop adaptive mechanisms along with fluctuating growth patterns and yields.
4. Apart from these categories, **agricultural drought** is evolved when the moisture content of the soil does not satisfy the moisture requirement of the crops during their growth period that leads to reduced crop productivity and crop quality which is induced by various factors like low rainfall, high temperatures, and evapotranspiration.

Effect of moisture stress on plants

Moisture stress has a wide range of complex consequences on plants. They affect both physiological and morphological characters of plants. Moisture stress affects various physiological characters like reduction in photosynthesis due to stomatal closure, which restricts CO_2 uptake, thereby reducing the amount of energy available for plant growth. Additionally, this causes oxidative stress, which is defined by rise in reactive oxygen species (ROS) that can harm DNA, proteins, and cellular structures, ultimately resulting in a reduction in plant health.

In terms of morphological parameters, moisture stress frequently results in the modification of root-to-shoot ratio, wherein plants produce more roots than shoots in order to improve their ability to absorb water from deeper soil layers. This response to moisture stress conditions reduces the above-ground biomass and is advantageous for water collection. Plants also minimize water loss through transpiration by reducing their leaf area or by dropping them, which limits photosynthesis but also conserves water.

In order to maintain cellular osmotic equilibrium and to protect against dehydration, plants under moisture stress biochemically store osmoprotectants such proline and glycine betaine. Hormonal changes also occur in these plants, such as elevated levels of abscisic acid (ABA), a stress hormone that initiates both drought response mechanisms and retards the plant development.

The overall changes physiological, morphological, and biochemical characters results in the in reduced yield and declining of crop quality. Additionally, prolonged period of moisture stress impairs both productivity and quality of the crop by causing flowers and fruits to shed prematurely, which directly reduces crop yield.

Role of Rhizobial Endophytes (RE) in Alleviating Moisture Stress

While dealing with the negative effects of moisture stress on plants, especially leguminous crops like groundnuts (*Arachis hypogaea* L.), rhizobial endophytes (RE) play a crucial role in the alleviating the moisture stress. These endophytes forms a symbiotic association with the host plant by forming root nodules which are known to fix atmospheric nitrogen into plant available form of nitrogen (i.e. ammonia) by means of biological nitrogen fixation aided by nitrogenase enzyme. These nitrogenase enzyme is produced by a group of nitrogen fixing endophytes namely *Rhizobium*. Under moisture stress conditions, when the supply of nitrogen becomes a limiting factor for plant development, this symbiotic connection becomes much more important. RE reduces moisture stress through a variety of intricate methods, including modifications in root development, synthesis of osmoprotectants, development of antioxidant defense, and the modulation of stress hormones.

One of the primary mechanism by which RE alleviate moisture stress is by enhancing root growth and modifying root architecture. These endophytes stimulate root development, increases the root surface area and enables the plants to access water from deep layers of soil, which is a critical adaptation under drought conditions. They alters the root architecture, making it more robust and efficient for water absorption, which is crucial for plant survival during extended periods of moisture stress. Another significant contribution of RE is the enhancement of osmoprotectant like proline and glycine-betatine production in host plants. These compounds play a key role in maintaining cell turgor pressure and osmotic balance under water deficit conditions by stabilizing proteins and membranes and protecting the plant cells from dehydration. Along with this the RE, enhances the antioxidant defense mechanisms by increasing the production of enzymes like superoxide dismutase (SOD) and catalase (CAT) that has the ability to scavenge ROS, thereby reducing oxidative damage under moisture stress. By preventing damage to essential cellular components and preserving cellular integrity, this decrease in ROS levels improves cellular survival and productivity under stress.

Moreover, RE are involved in the regulation of stress-related hormones, namely abscisic acid (ABA), which is essential for the plant drought response. In order to balance the plant development and stress responses, RE affects the production of ABA. Through the precise regulation of ABA production, RE helps the plants more effectively to withstand the negative effects of moisture stress without compromising the development of plant. Apart from stress hormone regulation, RE has the ability to influences the synthesis of hormones that promote plant growth, such auxins and cytokinins, which directly increases the plant development even in critical circumstances. In the context of mitigating moisture stress, RE is a vital solution because of its dual properties of promoting growth and in mitigating stress, especially in leguminous crops like groundnuts where nitrogen fixation is crucial for plant growth and production and in water-limited environments.

Role of Passenger Endophytes (PE) in Alleviating Moisture Stress

Passenger endophytes (PE) also known as non-symbiotic endophytes, are another group of beneficial microorganisms that significantly contribute to the alleviation of moisture stress in plants. Unlike Rhizobial endophytes, which are primarily associated with nitrogen fixation in leguminous plants, PE that colonize various plant tissues, including roots, stems, and leaves, without causing any harm to the plants. These endophytes are primarily involved in several beneficial activities with their host plants, by promoting growth, enhancing nutrient uptake, and providing protection against various environmental stresses, including moisture stress.

PE increases the water use efficiency (WUE) in plants, which is one of the main mechanisms to mitigate moisture stress. When there is a deficit in the moisture level, PE can increase the hydraulic conductivity of roots and improves their ability to absorb water which reduces the effects of drought. PE may also affect the stomatal conductance, which helps to optimize the ratio of CO_2 intake for photosynthesis to water loss through transpiration. The generation of induced systemic resistance in plant is one of the other important effect of PE, which improves the plant defence mechanism against moisture stress successfully. They also play a crucial role in promoting soil health, by enhancing the soil microbiome, which indirectly supports the plant resilience towards moisture stress. By encouraging the development and activity of several advantageous soil microorganisms, these endophytes strengthens the soil microbiome and their capacity to sustain plant health under moisture stress. Additionally, PE contributes to the creation of well enriched rhizosphere environment that supports the plant development even under the effect of moisture stress by increasing beneficial microorganisms and decreasing pathogenic populations. PE also alters the plant hormone release, including ethylene, a stress hormone that can hinder the development of plants under dry environments. Numerous PE generate the ACC deaminase enzyme, which breaks down ethylene precursors and declines the ethylene production and reduces the detrimental effect of ethylene on plant development. Further, the PE stimulate the production of several plant growth promoting hormones like indole acetic acid, gibberellins and cytokinins which promote cell division and growth of plants under moisture stress conditions.

Application of RE and PE in plants under moisture stress conditions

Several researches have demonstrated the role of rhizobial and passenger endophytes in overcoming the moisture stress particularly in crops like wheat, maize and groundnut where their application has resulted in significant improvements in plant growth promotion. In groundnut, inoculation with specific strains of rhizobial and passenger endophytes has enhanced the drought tolerance by promoting root growth, increasing osmoprotectant production, and boosting the antioxidant defence mechanisms. They also resulted in improved plant yield in drought prone areas compared to non-inoculated plants.

Conclusion

The development of bioinoculants using rhizobial and passenger endophytes provides a significant development for enhancing crop resilience towards moisture stress. Understanding the complex interactions between endophytes and their host plants, more effective endophytic strains can be tailored specifically to a specific crop and environmental conditions. These finding creates a new opportunity to develop a next generation biofertilizers namely synthetic microbial communities (SynComs) which are very efficient towards the mitigation of several environmental stresses. The integration of bioinoculant technology into sustainable agricultural practices significantly reduces the usage of chemical fertilizers and irrigation, thereby contributing to more resilient and sustainable farming systems.

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ACCELERATING CROP IMPROVEMENT PROGRAMMES: THE PROMISE AND POTENTIAL OF SPEED BREEDING IN AGRICULTURE

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Introduction

The human population is expected to reach nine billion by 2050. Crop improvement programs involving traditional breeding methods have contributed for the development of several high yielding varieties to meet the food demands of the growing population. These traditional plant breeding methods, while effective, are often time-consuming, with the development of new varieties typically taking several years or even decades. The increased incidence of biotic and abiotic stresses under changing climate scenario warrants breeding for climate resilient varieties at a faster pace is essential to ensure food and nutritional security for the growing population. In this context, speed breeding has emerged as a novel groundbreaking solution that accelerates varietal development within a short time scale, compared to conventional methods.

Need for speed breeding

A major bottle neck in developing improved cultivars through conventional breeding approaches is the long breeding cycle. Generally, conventional breeding consumes 8-12 years or more for developing varieties, starting from selection of parents, initiating crosses, raising and evaluating segregating generations, selecting of superior genotypes, evaluating their agronomic performance through yield trials followed by seed multiplication and commercial release of the variety. This lengthy process can hinder rapid responses to emerging threats such as new plant diseases or changing environmental conditions. Speed breeding addresses this challenge as an innovative agricultural technique that accelerates crop breeding cycles, allowing for faster development of new plant varieties with desirable traits.

Concept of speed breeding

The concept of speed breeding has its genesis from a space exploration programme initiated by NASA in 1980s that aimed to grow crops in space. The successful demonstration of accelerating wheat growth cycle in the space station by NASA scientists through alterations in light conditions in their early experiments led to the first wheat variety USU-Apogee, Inspired by these results, a team of scientists at University of Queensland, coined the term speed breeding and applied the principle for crop improvement on earth.

Definition

Speed breeding refers to a set of techniques that aim to accelerate the growth cycle of crops by hastening flowering and seed set, through manipulation of core environmental conditions. Speeding up the reproductive phase shortens the breeding cycle, there by enabling more than 2-3 generations of a crop to be raised in a year, compared to the conventional breeding methods.

Core components of speed breeding

Speed breeding relies on manipulating several key environmental factors such as light, temperature, humidity, carbondioxide levels and nutrient optimisation that are essential for growth and development of crops. However, basic components of speed breeding comprises of growing crops in growth chambers under controlled light, temperature and humidity conditions.

Photoperiod: Plants are classified as short day or long day plants depending upon their light requirements to induce flowering. One of the primary techniques used in speed breeding is to optimise the day length by manipulating the daily light period. This is typically achieved using a combination of natural and artificial light sources, which can be tailored to provide optimal light intensity and spectra for plant growth. For instance, in short day crops, supplemental lighting through LED lights up to 22 hours of light per day, enables upto five generations per year by stimulating rapid growth and early flowering. Similarly far red light has been used to induce early flowering in long day ornamental plants

Temperature *:* Temperature is a critical factor that influences the rate of development of crops during various phonological stages. For speed breeding, the temperature regime during vegetative stage and reproductive stage for each crop should be optimised taking into consideration the photoperiod requirements, since there exists a strong interaction between these two factors in inducing flowering.

Humidity : Maintaining an ideal relative humidity is essential for physiological processes such as leaf growth rate and photosynthesis. While maintaining controlled humidity conditions is challenging, sophisticated infrastructural facilities like phytotrons are employed for the purpose. Relative humidity of 60-70% is recommended commonly for most crops, however it can reduced further for crops adapted to dryland and arid conditions plant growth.

Nutrient Optimization: To support accelerated growth, plants in speed breeding programs require carefully balanced nutrient solutions. These are typically delivered through hydroponic or aeroponic systems, allowing for precise control of nutrient availability.

CO_2 Levels: Elevated CO_2 concentrations can enhance photosynthesis and promote faster growth. Many speed breeding facilities maintain higher-than-ambient CO_2 levels to further accelerate plant development. Reduction in days to flowering has been achieved in crops like rice, soybean and cowpea with increased CO_2 levels.

Achievements

The first speed breeding variety DS Faraday in spring wheat was released in 2017 by the University of Queensland. Since then, speed breeding has been successfully applied in few crops like barley, canola, chickpea and pigeonpea. Researchers at the John Innes Centre in the UK have used speed breeding to develop wheat varieties with improved disease resistance and quality traits. They achieved up to six generations per year, compared to one or two in the field. Applying speed breeding technology, Lee Hickey and his team introgressed multiple disease resistance into the Scarlett variety known for malting and brewing quality in 2017.

Several breeding programs are utilizing speed breeding to rapidly develop crop varieties adapted to specific climate change scenarios, such as heat-tolerant wheat or drought-resistant sorghum.

Advantages of speed breeding

Plants grown under artificial controlled conditions are prevented from seasonal cues enabling them to grow faster and transition quickly from vegetative to reproductive phase, followed by early seed harvest. The shortened life cycle helps to raise several generations (5-6) per year throughout the year compared to 1-2 generations in conventional breeding methods. By increasing the number of generations that can be produced in a given time frame, it is possible to rapidly integrate desirable traits such as disease resistance, drought tolerance, or improved nutritional content. This leads to faster progress in breeding programs and more efficient selection of superior plant lines in the varietal development pipeline for climate resilient cultivars. Further, by condensing the breeding cycle, speed breeding can reduce the overall resource requirements for crop improvement programs. such as land, water and labour inputs. IRRI, has developed the first speed breeding protocol for rice known as 'SPEEDFLOWER', wherein a single generation can be produced in 58-71 days. ICRISAT has been making a significant stride in optimising speed breeding protocols for other agriculturally important crops like chickpea and pigeonpea.

Challenges in speed breeding

Speed breeding facilitates faster pace of development of modern cultivars through rapid generation advancement to address the global crisis of food security in the changing climate scenario. Speed breeding requires cutting edge infrasturcural facilities and the initial investment in such infrastructure can be substantial, limiting adoption by smaller breeding programs or in developing countries. Currently speed breeding protocols have been optimised only for a limited number of crops such as rice, wheat, chickpea, pigeon pea. Optimising the spee breeding protocols for important crops species is challenging due to variations in light and temperature requirements among different crops. Imposing intensive controlled conditions may result in limiting plant growth and development, resulting in reduced seed set. The impact of continuous breeding under the controlled conditions can affect the performance of the breeding lines when raised in different environments. Hence stringent evaluation and field trials are required for ensuring stable performance before releasing them as commercial cultivars. While speed breeding can accelerate the breeding cycle, it must be effectively integrated with other modern breeding technologies such as genomic selection, marker-assisted selection, and gene editing to maximize its potential.

Conclusion

Speed breeding dramatically accelerate crop improvement programs, by shortening breeding cycles and enabling rapid trait integration for tailoring climate smart crops. This technique provides a powerful tool for addressing the complex challenges facing global agriculture in the 21st century. The ability to quickly develop new crop varieties with enhanced yield, resilience, and nutritional qualities could play a crucial role in ensuring food security for a growing global population in the face of climate change. Continued research and development are needed to refine speed breeding protocols, reduce energy consumption, and integrate this technique with other advanced breeding technologies.

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EXPLORING THE NUTRITIONAL AND HEALTH POWER OF SORGHUM

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Introduction

Sorghum (*Sorghum bicolor*), a hardy and adaptable grain, is gaining recognition not only for its ability to thrive in challenging climates but also for its impressive nutritional benefits. Packed with dietary fiber, protein, and essential vitamins and minerals, sorghum is emerging as a powerhouse of nutrition. Though low in fat (around 3%), it contains beneficial fatty acids such as oleic and linoleic acid and is a good source of B vitamins (thiamin, riboflavin, niacin) and vitamin E. Essential minerals like phosphorus, magnesium, iron, and zinc contribute to its role in supporting growth, metabolism, and overall health. What sets sorghum apart is its rich content of bioactive compounds, including polyphenols, tannins, sterols, and phytic acid, which possess antioxidant, anti-inflammatory, and potential anticancer properties. These compounds not only protect the body from oxidative stress but may also lower the risk of chronic diseases like heart disease, diabetes, and certain cancers. Additionally, sorghum's high fiber content promotes digestive health, aids in weight management, and contributes to heart health by helping to regulate cholesterol levels. Despite its exceptional nutritional and functional potential, sorghum remains underutilized in many parts of the world. However, as interest in ancient grains and plant-based diets grows, sorghum is poised to take its place as a vital food source for sustainable and healthy living. This versatile grain offers a host of benefits for both human health and environmental sustainability, making it an important addition to our diets.

Nutritional profile of sorghum

Sorghum, a highly valued cereal, is cultivated extensively in India, the United States, and many African countries. Recognized for its robust nutritional profile, it serves as a staple food in regions like Africa and India and is an important feed for livestock in developed nations. Sorghum offers 8-18% protein, 70-80% carbohydrates, 19% dietary fiber, and various essential minerals. Its higher prolamin content makes it tougher than other grains, and its gluten-free nature, due to the absence of gliadin and glutenin proteins, makes it ideal for those with gluten intolerance. The grain is also a great source of slow-releasing carbohydrates, primarily starch, which delivers steady energy, and contains hydrophobic kafirins, which enhance resistance to environmental stress. The unique fatty acid profile of sorghum which includes linoleic and oleic acids, both beneficial for heart health. It also contains 6.7g of dietary fiber per 100g, helping in digestion, lowering cholesterol, and assisting in blood sugar regulation. Additionally, sorghum is rich in B-complex vitamins like thiamine, riboflavin, and niacin, as well as key minerals such as phosphorus, magnesium, and iron, all contributing to overall metabolic and bone health. The grain's antioxidant compounds, including 3-deoxy anthocyanins, help reduce inflammation and lower the risk of cancer. The nutritional value of sorghum can vary based on the variety and cultivation techniques used, with grain sorghum generally having more protein and fat compared to sweet sorghum.

Table 1. Nutritional composition of sorghum

Nutrients	**Amount per 100g**
Energy	329 kcal
Protein	8–13g
Carbohydrates	72.1g
Dietary Fiber	6.7g
Total Fat	3.0 g
Prolamins	3.6–5.1g
Lysine	1.06–3.64%
Starch	58–65g
Fatty acids	
Linoleic Acid (18:2)	47.1% of total fat

Oleic Acid (18:1)	32.5% of total fat
Palmitic Acid (16:0)	13.9% of total fat
Linolenic Acid (18:3)	3.1% of total fat
Stearic Acid (18:0)	3.4% of total fat
Vitamins	
Thiamine (B1)	0.35 mg (29% of RDI
Riboflavin (B2)	0.14 mg (11% of RDI)
Niacin (B3)	2.93 mg (18% of RDI)
Vitamin E	0.50 mg (3% of RDI)
Minerals	
Phosphorus	287 mg (41% of RDI)
Magnesium	165 mg (39% of RDI)
Iron	4.40 mg (24% of RDI)
Copper	0.28 mg (31% of RDI)
Zinc	1.67 mg (15% of RDI)
Potassium	350 mg (7% of RDI)
Calcium	13 mg (1% of RDI)
Antioxidants	3-Deoxy Anthocyanins, Polyphenols

(Espitia-Hernandez *et al.*, 2022)

Bioactive compounds

Bioactive compounds are essential for health promotion and disease prevention, mainly concentrated in the bran and dispersed throughout the endosperm of grains. These include vital vitamins such as the B-complex, along with fat-soluble vitamins like D, E, and K, as well as non-nutrient components like polyphenols and carotenoids. Minerals like zinc, copper, and manganese, known for their antioxidant properties, help neutralize free radicals and reduce oxidative damage. Phenolic compounds, including phenolic acids, flavonoids, and tannins, are abundant in sorghum and contribute to its strong antioxidant properties. The primary phenolic acid in sorghum is **ferulic acid**, known for its role in protecting against oxidative stress. Other phenolic acids include **protocatechuic acid** and **p-coumaric acid**. It also contains other beneficial compounds like flavonoids and natural pigments, such as quercetin, kaempferol, naringenin, apigenin, and luteolin. Additionally, sorghum provides carotenoids like lutein, zeaxanthin, and β-carotene, though typically in lower amounts than other grains. It also contains antioxidants such as α-tocopherol and α-tocotrienol in trace amounts. Its bioactive profile is further enhanced by polyamines like spermidine and spermine, as well as phytosterols including β-sitosterol, campesterol, and stigmasterol, which vary in concentration based on the compound.

Bioactive Compound	Class	Examples	Health Benefits
Phenolic Acids	Polyphenols	Ferulic acid, Protocatechuic acid, p-Coumaric acid	Antioxidant activity, protects against oxidative stress, reduces inflammation
Flavonoids	Polyphenols	Quercetin, Apigenin, Luteolin, Naringenin, Kaempferol	Antioxidant, anti-inflammatory, anticancer properties
Tannins	Polyphenols	Condensed tannins (proanthocyanidins)	Antioxidant, reduces risks of chronic diseases, improves gut health
Anthocyanins	3-Deoxy Anthocyanins	Luteolinidin, Apigeninidin	Antioxidant activity, helps in reducing inflammation, anticancer effects
Carotenoids	Carotenoids	Lutein, Zeaxanthin, β-Carotene	Eye health, antioxidant effects, protection against oxidative stress
Phytosterols	Sterols	β-Sitosterol, Campesterol, Stigmasterol	Lowers cholesterol levels, improves heart health
Polyamines	Organic compounds	Spermidine, Spermine, Putrescine, Cadaverine	Cell growth regulation, antioxidant effects, supports tissue repair
Vitamin E	Tocopherols	α-Tocopherol, α-	Antioxidant, reduces

		Tocotrienol	risk of chronic diseases, supports skin health

(Tanwar *et al.*, 2023)

Conclusion

Sorghum millet is a highly nutritious, gluten-free crop rich in fiber, protein, and essential minerals, with strong antioxidant and diabetic benefits. Its drought resistance and adaptability make it vital for improving food security in climate-vulnerable regions. Sorghum-based products, such as flour, porridge, and beverages, are increasingly popular in health-conscious diets. Beyond food, sorghum has potential in biofuel, genetic improvement, and disease resistance. Advancing genomics and food processing could enhance its nutritional value and sensory qualities. As a key crop in sustainable agriculture and nutrition, sorghum merits continued research and investment.

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AGROECOLOGY: A PATHWAY TO SUSTAINABLE FARMING

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Introduction

Agroecology is a cutting-edge method of farming that combines ecological concepts with traditional agricultural methods in an effort to build resilient and sustainable food systems. With the world facing more pressing issues including soil erosion, food insecurity, and climate change, agroecology provides a comprehensive approach that highlights the relationship between agriculture and the environment. Fundamentally, agroecology acknowledges that productive farming depends on healthy ecosystems. It encourages methods that build soil health, increase biodiversity, and lessen dependency on artificial inputs, all of which contribute to a more sustainable agricultural environment.

By combining ancient wisdom with contemporary research, this method develops systems that are both environmentally benign and profitable for farmers. Agroecology stands out as a means of attaining food sovereignty and ecological balance as the globe works to feed a growing population while addressing environmental problems. The basic ideas of agroecology are examined in this introduction, which also emphasizes the significance of agroecology in creating resilient agricultural systems that coexist peacefully with the environment.

Practices in Agroecology

Promoting ecological balance, strengthening soil health, and boosting agricultural resilience all depend on diverse farming methods. Through the integration of diverse crops, livestock, and agroforestry techniques, these systems have the potential to maximize resource utilization and minimize reliance on chemical inputs. In addition to promoting biodiversity, this diversity aids in farmers' adaptation to shifting market conditions and climate change.

Furthermore, by offering a more consistent and diverse supply of nutrients and promoting a sustainable partnership between agriculture and the environment, mixed farming techniques can increase food security. In the end, accepting a variety of farming practices creates a more resilient agricultural environment that is advantageous to both producers and consumers.

Intercropping

Intercropping is the practice of growing two or more crops near to one another in the same field in order to make the most use of the resources available. By fostering coexistence of crops with varying nutrient requirements, this technique improves nutrient usage by lowering competition and raising total production. For example, combining nutrient-demanding cereals with legumes that fix nitrogen can greatly increase soil fertility. Intercropping can also break up pest cycles since different plant varieties confuse pests and lessen the chance of infections. Because it naturally controls pests and makes optimum use of available space and resources, intercropping is a sustainable technique that improves ecological health and productivity

AgroForestry

Agroforestry creates a multipurpose farming system by incorporating trees and shrubs into agricultural settings. This method gives cattle and crops shade, which can improve growth and lessen water stress in the summer. By providing habitats for a variety of species, trees increase biodiversity and contribute to a more balanced ecosystem. Furthermore, by stabilizing the soil and improving water retention—both essential for preserving the health of the soil—tree roots aid in the prevention of soil erosion. Additionally, agroforestry systems can produce a variety of goods like timber, fruits, and nuts, giving farmers extra revenue streams and enhancing their ability to withstand changes in the market.

Cover Cropping

Planting some crops during the off-season, when the primary crops are not growing, is known as cover cropping. These cover crops, like rye or clover, are essential for improving the fertility and structure of the soil. Their root systems aid in enhancing water infiltration, reducing soil erosion, and fostering the growth of advantageous microbes. Water quality is improved by cover crops because they absorb excess nutrients as they develop and keep them from leaking into streams. They replenish the soil with organic matter, improving nutrient availability and supporting a robust soil ecology. In general, cover crops are an essential tactic for sustainable agriculture since they maintain the productivity and health of the soil throughout time.

Organic Farming

Ecological health, biodiversity, and sustainability are given top priority in organic farming, which is a comprehensive approach to agriculture. While it is not the same as agroecology, both have fundamental ideas about building resilient farming systems. In organic farming, natural alternatives that improve soil fertility and pest control are used instead of synthetic fertilizers and pesticides. Crop rotations, composting, and green manure are all encouraged by this method because they enhance soil structure and increase nutrient cycling. Organic farming promotes ecological balance and a diverse environment that can lower disease prevalence and improve pest management by utilizing natural predators. Furthermore, organic farming frequently places a high priority on animal welfare, encouraging humane care and free- range methods.

BENEFITS OF AGROECOLOGY

Environmental Benefits

Agroecology contributes to environmental sustainability in several ways:

Soil Conservation

Through the application of techniques that lessen soil erosion and improve soil health, agroecology plays a critical role in soil conservation. Crop rotation, cover crops, and reduced tillage are a few strategies that assist preserve soil structure and stop topsoil deterioration. Compost and green manures are examples of organic additions that increase soil fertility by fostering microbial activity and contributing necessary nutrients. These methods improve the soil's resistance to extreme weather events as well as its capacity to hold moisture. Agroecology reduces the effects of erosion and nutrient loss while ensuring the long-term production of agricultural areas by promoting healthy soil ecosystems.

Biodiversity Conservation

Through the creation of diverse ecosystems that support a wide range of species, including pollinators, beneficial insects, and soil creatures, agroecology promotes biodiversity. Various cropping methods, such as agroforestry and intercropping, offer food sources and habitats that improve the stability of ecosystems. The resilience of agricultural systems as a whole, natural pest control, and crop pollination all depend on this biodiversity. Agroecological techniques lessen the need for chemical inputs, promote a healthier agricultural landscape, and stop the spread of pests and diseases by preserving a diverse range of plant and animal life.

Climate Change Mitigation

Because agroecology employs techniques that improve carbon sequestration and lower greenhouse gas emissions, it makes a substantial contribution to mitigating climate change. Agroecology raises soil and vegetation carbon storage levels by supporting agroforestry and perennial cropping systems. By increasing soil organic matter and reducing the need for synthetic fertilizers, sustainable land management techniques like organic farming and less tillage help further cut emissions. Furthermore, farmers can adapt to changing conditions and simultaneously support international efforts to reduce climate change since agroecological systems are more resilient to the effects of climate change. Agroecology contributes to environmental sustainability and the preservation of our food systems by means of these integrated activities.

Economic and Social Benefits Adaptability

Agroecological systems are resilient by nature, easily adjusting to changes in the market and adverse weather. These agricultural systems lessen their susceptibility to pests, illnesses, and environmental stresses by including a diversity of crops and livestock. By ensuring that other crops may flourish in the event of a drought or flood, crop diversification gives farmers a steady stream of income. Furthermore, techniques like permaculture and organic farming improve soil health and water retention, making farms more resilient to harsh weather. In addition to helping farmers, this resilience ensures that communities have access to dependable food sources during erratic times, therefore promoting food security.

Economy

Through its support of local food systems and smallholder farmers, agroecology plays a critical role in bolstering local economies. Agroecological methods improve food sovereignty by emphasizing local production and consumption, giving communities more control over their food supplies and farming methods. By promoting direct communication between farmers and customers, this model builds trust and makes sure that a larger portion of the economic gains remain in the local economy. Localized food systems lessen reliance on international supply lines, lowering market volatility risk and fostering small-scale farmers' ability to make a living. In the end, this strategy fosters a feeling of community and shared accountability for food production in addition to supporting local businesses.

Food Systems

Agroecology prioritizes the development of nutrient-dense foods, which helps create healthy food systems. Agroecological systems generate food that is not only more nutrient-dense but also residue-free because they steer clear of synthetic chemicals and prioritize organic farming methods. These methods encourage diversification in crops, which can improve food quality and supply a greater variety of vitamins and minerals. Local food systems also guarantee fresher and more flavourful produce by cutting down on the length of time and distance that food travels. Agroecology contributes significantly to better public health outcomes, a decrease in diet-related illnesses, and the development of a more sustainable nutrition strategy that is advantageous to both individuals and communities by promoting the production of healthful foods.

CHALLENGES IN AGROECOLOGY

Adoption Barriers

Knowledge deficits:

Lack of knowledge and training among farmers is one of the major obstacles to the implementation of agroecological approaches. It's possible that many smallholder farmers are unaware of the advantages or methods related to agroecology, which can make it more difficult for them to adopt sustainable farming methods. There are frequently few extension services available, especially in rural regions, that offer instruction on soil health, crop diversity, pest management, and organic farming methods. This knowledge gap may prolong the use of traditional techniques, which may not be long-term economically or sustainably feasible. It is imperative to close this gap by working with research institutes, conducting focused training programs, and organizing workshops in order to empower farmers and speed up the shift to agroecological systems that are more robust.

Support for Policy:

Current agricultural policies tend to support industrial farming practices, giving high input, monoculture systems that mainly rely on synthetic pesticides and fertilizers priority. Given that they usually receive less support or acknowledgment, agroecological methods may face substantial obstacles as a result of this regulatory environment. Policies may not provide enough incentives for sustainable farming practices or may not adequately take into account the demands of smallholder farmers attempting to use agroecological techniques. Policy changes that support sustainable agriculture are required to allow these methods to flourish. These reforms should include financial assistance, subsidies for organic inputs, and acknowledgement of the contributions that agroecology makes to environmental sustainability and food security. Promoting a change in policy can help to establish the conditions necessary for agroecology to thrive.

Market Access

It might be difficult for smallholder farmers to find markets for their goods, which can restrict the applicability of agroecological techniques. Various factors, including insufficient infrastructure, elevated transportation expenses, and insufficient market intelligence, may impede their capacity to efficiently connect with customers. Furthermore, a lot of smallholders manufacture organic or specialty goods that might not have established distribution routes, which makes it challenging for them to compete with bigger industrial producers. Developing local and regional markets that prioritize and promote agroecological products, strengthen supply chain links, and enable direct sales opportunities are critical to improving market access. In order to increase their negotiating strength and guarantee fair prices, smallholder farmers might also benefit from the establishment of cooperatives and support networks. By addressing these market access issues, agroecological practices can become more economically viable and sustainable for smallholder farmers.

Climate and Environmental Challenges

Severe Weather

Extreme weather events have become more frequent and intense due to climate change, which puts agroecological systems at serious danger. Agroecology farmers face obstacles such protracted droughts, copious amounts of rainfall, and fluctuating growing seasons, which can upset customary agricultural methods. Some resilience is provided by the diversity seen in agroecological systems; planting a variety of crops, for example, might lessen the effects of particular weather events. Nonetheless, farmers must constantly adapt, coming up with new ideas and changing their methods in order to stay in business. This could entail modifying planting schedules, introducing water-saving measures, and choosing crop cultivars with greater resilience. Research, training, and access to climate data are needed to facilitate this adaptation.

Management of Diseases and Pests

Even though biodiversity in agroecological systems improves disease resilience and natural pest control, controlling pests and diseases without artificial inputs can still be difficult. In the absence of chemical pesticides, farmers are forced to control pest populations using ecological techniques including crop rotation, intercropping, and introducing beneficial insects. To properly recognize and handle new risks, though, this calls for continuous monitoring and a thorough grasp of the regional ecosystems. Furthermore, when climate conditions change, some illnesses and pests may become more widespread, making management efforts more difficult. Farmers must have access to information and tools, such as integrated pest management (IPM) techniques and support systems that encourage knowledge exchange, in order to overcome these obstacles. Improving community resilience by cooperation and education can give people more power.

THE FUTURE OF AGROECOLOGY

Agroecology has a bright future ahead of it as the globe struggles with urgent issues like food security, climate change, and environmental degradation. There is a shift toward more resilient and sustainable farming methods that agroecology offers as knowledge of the shortcomings of traditional industrial agriculture rises.

Technology Integration

Technological developments will be critical to the development of agroecology. Drones and soil sensors are two examples of precision agricultural equipment that can assist farmers in monitoring their ecosystems more successfully. This allows farmers to make data-driven decisions that maximize yield while reducing environmental impact. Digital platforms can also help farmers embrace agroecological methods by facilitating knowledge sharing and connecting them to markets, resources, and training.

Policy Acknowledgment and Support

Agroecology has to flourish, and for that to happen, agricultural policy need to change to reflect the importance of sustainable practices. Institutions and governments must encourage the use of agroecological practices, support financing for research, and establish advantageous circumstances for smallholder farmers. Increased investment in regional food systems can result from policies that support agroecology, benefiting local populations both socially and economically.

Community Participation

Agroecology's future also hinges on active community involvement and education.

Creating networks between farmers, scientists, and customers can help to promote the sharing of knowledge and insights. Agroecological education programs will equip the next generation of farmers with the information and abilities they need to prosper in a changing global environment.

Global Collaboration

Finally, the future of agroecology will benefit from global collaboration. Sharing knowledge and best practices across regions can enhance the adaptability and innovation of agroecological systems worldwide. International organizations, NGOs, and research institutions can work together to support agroecological initiatives, ensuring that smallholder farmers have access to resources and expertise.

Conclusion

The concept of agroecology is essential for tackling the interrelated problems of climate resilience, environmental sustainability, and food security. Agroecological methods prioritize biodiversity, ecological balance, and local knowledge to improve farming system production while simultaneously fostering the well-being of communities and ecosystems. Agroecology provides creative answers to address the constraints of industrial agriculture and the reality of climate change, empowering smallholder farmers and promoting locally sustainable food systems.

Cooperation is necessary if agroecology is to reach its full potential. This entails encouraging laws and regulations, easier access to resources and education, and robust social networks that promote information exchange. By incorporating technology into these techniques, farmers will be able to improve their produce in a sustainable manner and adjust to changing conditions. In conclusion, adopting agroecology is essential for ensuring a robust, just, and sustainable food supply in the future—it is not merely a decision for farmers. We can foster a more harmonious relationship with our environment and ensure that future generations inherit a planet that can support diversified and vibrant agricultural systems by making agroecological principles a priority.

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RED SANDERS: THE ENDANGERED JEWEL OF INDIA'S FORESTS

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Abstract

Pterocarpus santalinus Linn.f., commonly known as Red Sanders, is a valuable tree species endemic to the Eastern Ghats of India. It is globally recognized for its distinctive and highly sought-after timber, which has applications in various industries such as furniture making, cosmetics, and traditional medicine. Despite its economic importance, *P. santalinus* is listed as endangered due to overexploitation and illegal harvesting. This article provides a comprehensive review of the botanical characteristics, distribution, cultivation practices, chemical constituents, and economic significance of *Pterocarpus santalinus*. The urgent need for sustainable management and conservation strategies is emphasized to ensure the long-term survival of this species.

Keywords: Endangered Species, Sustainable Management, Conservation Strategies, Chemical Constituents

Introduction

Pterocarpus santalinus Linn.f., commonly referred to as Red Sanders, is a deciduous tree belonging to the Fabaceae family. It is primarily found in the dry deciduous forests of the Eastern Ghats of India, particularly in Andhra Pradesh and Tamil Nadu (Singh & Singh, 2011). The species is listed as endangered by the International Union for Conservation of Nature (IUCN) due to illegal logging and habitat destruction (Kukrety et al., 2013).

Red Sanders has a rich history of use in traditional medicine and the dyeing industry. Its heartwood is known for its deep red color and is used to produce the natural dye santalin. The wood is highly valued in international markets, particularly in Japan and China, for the manufacture of high-end furniture, musical instruments, and decorative items (Indu et al., 2019). However, its illegal trade has led to a drastic reduction in natural populations, necessitating urgent conservation efforts.

Taxonomy

- **Kingdom**: Plantae
- **Division**: Magnoliophyta
- **Class**: Magnoliopsida
- **Order**: Fabales
- **Family**: Fabaceae
- **Genus**: *Pterocarpus*
- **Species**: *P. santalinus* Linn.f.

Distribution

Pterocarpus santalinus is native to the Eastern Ghats of India but has also been reported in some areas of Nepal and Sri Lanka (Singh & Singh, 2011). However, these populations are sparse and may not represent natural growth. The species thrives in dry deciduous forests, often on rocky and hilly terrain at elevations ranging from 150 to 900 meters above sea level (Kukrety et al., 2013).

Botanical Characteristics

P. santalinus is a small to medium-sized deciduous tree, reaching heights of up to 8 meters. It has a thick, dark brown to black bark that peels off in rectangular plates. The heartwood is dense, hard, and dark purple to almost black in color, making it highly desirable for various uses (Singh & Singh, 2011).

Morphology

The leaves are typically trifoliate, with three leaflets that are broadly ovate and glossy. The tree produces small, yellow flowers in axillary racemes during the flowering season from April to July. The fruit is a flat, disc-shaped pod, about 5 cm in diameter, containing one or two seeds (Indu et al., 2019).

Phenology

P. santalinus has a distinct seasonal pattern. It sheds its leaves from January to March and flowers from April to July. The fruiting season extends from September to February, with the pods taking nearly 11 months to mature (Patel et al., 2018).

Cultivation Practices

Propagation

The most effective method of propagation for *P. santalinus* is through seeds, which retain their viability for up to one year under optimal storage conditions. The best time for seed collection is in March when the fruits mature. Seeds are sown in raised nursery beds in sandy loam soil and require pretreatment to enhance germination (Patel et al., 2018).

Nursery Techniques

Nursery raising is usually done in March, April, or May. Seeds are treated with water soaking or scarification to break dormancy. They are sown in raised beds and covered with a thin layer of soil or hay. Germination typically occurs within 10 to 15 days. Seedlings are ready for transplanting after one year, or stumps can be prepared for field planting (Patel et al., 2018).

Field Planting

Land preparation involves plowing and harrowing to create a fine tilth. Pits of size 45 × 45 × 45 cm are dug at a spacing of 4 × 4 meters. The pits are filled with topsoil mixed with 10-15 kg of farmyard manure and 10 g of lindane dust to protect against soil-borne fungi. The best time for planting is from May to June, coinciding with the onset of the rainy season (Indu et al., 2019).

Maintenance and Irrigation

The young plants require regular irrigation, especially during the first few months after transplanting. Fertilizer application, including 150:100:100 g of NPK per plant per year, is recommended for the first five years. Weeding and soil loosening around the plants are essential to promote healthy growth (Patel et al., 2018).

Disease and Pest Control

Leaf-eating caterpillars are the primary pest affecting *P. santalinus*. They can be controlled by spraying with 0.2% Monocrotophos twice at weekly intervals during April and May. Fungal infections can be mitigated by applying a 0.3% solution of Topsin (Patel et al., 2018).

Chemical Constituents

The heartwood of *P. santalinus* contains several bioactive compounds, including santalin A and B, isopterocarpolone, pterocarpdiolone, and acetyloleanolic acid. These compounds are known for their anti-inflammatory, antipyretic, and anticancer properties (Indu et al., 2019). Recent studies have also highlighted the hepatoprotective and wound healing properties of these constituents (Chakraborty et al., 2022).

Therapeutic Properties

In traditional medicine, *P. santalinus* has been used to treat a variety of ailments, including fever, inflammation, dysentery, and skin diseases. The decoction of its heartwood is known for its astringent and tonic effects. The wood paste is used topically for boils, infections, and headaches, while the powdered wood is used to control bleeding and inflammation (Singh & Singh, 2011).

Economic Significance

The economic value of *P. santalinus* is immense due to its multiple applications. The timber is highly sought after in international markets, especially in Japan, for its use in the production of musical instruments, furniture, and decorative items. The heartwood is also used in traditional medicine and as a natural dye in the food and pharmaceutical industries (Indu et al., 2019).

Trade and Illegal Harvesting

The high demand for Red Sanders wood has led to rampant illegal harvesting and smuggling, significantly depleting natural populations. Despite being listed under Appendix II of the Convention on International Trade in Endangered Species (CITES), illegal trade continues to be a significant threat (Kukrety et al., 2013). The wood is sold at exorbitant prices, making it a lucrative target for illegal loggers.

Conservation Strategies

The conservation of *Pterocarpus santalinus* is a challenging task that requires a multi-faceted approach. Effective conservation strategies include stricter enforcement of anti-poaching laws, habitat restoration, and the establishment of community-based conservation programs (Kukrety et al., 2013).

In Situ and Ex Situ Conservation

In situ conservation involves protecting the natural habitats of *P. santalinus* by creating protected areas and implementing habitat restoration projects. Ex situ conservation includes cultivating the species in botanical gardens and establishing seed banks to preserve genetic diversity (Indu et al., 2019).

Sustainable Harvesting Practices

Promoting sustainable harvesting practices, such as selective logging and rotation cycles, can help reduce the pressure on natural populations. Community participation in conservation efforts is crucial for the success of these programs (Kukrety et al., 2013).

Conclusion

The study of *Pterocarpus santalinus* highlights its ecological, economic, and cultural importance. The continued exploitation of this endangered species underscores the urgent need for effective conservation measures. Sustainable cultivation practices, combined with stricter enforcement against illegal harvesting, are essential to preserving this valuable species for future generations. Exploring alternative sources or synthetic substitutes for the unique properties of Red Sanders could also help alleviate some of the pressures on natural populations.

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KIGELIA PINNATA: A SEMI-DECIDUOUS TREE WITH MEDICINAL, ECOLOGICAL, AND CULTURAL IMPORTANCE

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Abstract

Kigelia pinnata, also known as the sausage tree, is a semi-deciduous species with broad utility across ecological, medicinal, and ornamental applications. This research investigates the tree's floral morphology, pollination ecology, and reproductive dynamics, emphasizing comparisons between fruiting and non-fruiting trees. Floral traits such as pollen viability, pollen tube length, and stigma phenol content were measured to understand reproductive efficiency. The tree's interaction with pollinators, including bats and insects, is explored in relation to flower opening times and nectar availability. Additionally, biometric data, including tree height, girth, and branching patterns, were documented. This comprehensive study enhances the knowledge of *K. pinnata's* unique reproductive strategies and its adaptability in various habitats, as well as its commercial potential for agroforestry, herbal medicine, and ornamental use.

Key words: Reproductive, Floral biology, pollination, Traditional uses

Introduction

Kigelia pinnata (Hindi - balam kheera, hathi bailan; Luo yago; Tamil - shiva kundalam) is a semi deciduous tree. The genus name comes from the Mozambican Bantu name, kigeli-keia, while the common names sausage tree and cucumber tree refer to the long, sausage-like fruit. A tree widespread in Africa, found primarily in wet savannah woodland spreading into gallery woodland and along rivers in moist forests. In open woodland and in riverine fringes, it occurs at low altitudes. Sausage trees are sacred to many communities and are often protected when other forest trees are cut down. In Kenya, the Luo and Luhya people bury a fruit to symbolise the body of a lost person believed to be dead.

It is a deciduous tree with dense round canopy with opposite leaves crowded near the branch ends but sometimes deciduous when there is long dry season .It produces a striking dark meroon coloured bisexual flower. It grows in areas with rainfall of about 600-1400mm and at an altitude of about 0-1800m. The soil condusive for its growth is peat and medium loam.

The tree is native to South Africa. It is introduced in Ecuador and southwest Mexico.lt is cultivated in other tropical countries and is used as an ornamental tree in Australia, the USA and parts of South-East Asia (Orwa el al., 2009).

Every part of the tree is used in herbal medicines (eg for digestive and respiratory disorders, and to treat infections and wounds). The sausage tree is used in a variety of commercial applications to treat skin complaints. Research into its anti-bacterial, anti-fungal and anti-tumour activity is ongoing. Ripe fruits are inedible, although slices of baked fruit are added to beer to aid in fermentation of local honey beer, for example throughout East Africa. In times of food shortage, the seeds are roasted in hot ashes and eaten. When the flowers and leaves fall to the ground they are eaten by game and livestock. The large, maroon flowers attract bees and are a source of bee forage. Wood is moderately heavy (air-dry 720 kg/cubic m). The wood is easy to work and produces a good-quality timber for general use. The sapwood is whitish or yellow and, although rather soft, has been used for planking, yokes, fruit boxes and shelving. Heartwood is light brown and is used for drums, utensils and cutlery. In South Africa, inhabitants of the areas along larger rivers, especially the Chobe and Zambezi, make their dugout canoes from *Kigelia pinnata*. A black dye can be produced from the fruit. Tannin can be extracted from the roots and stem bark.

The fruit extract is reported to have molluscicidal properties. Raw fruit are poisonous to humans. Bark and leaves are used for bladder trouble/kidney disease, an enema or drink of the boiled root and stem bark for piles; wounds, sores and cuts are treated with a leaf and bark decoction or bark; bark and leaf decoctions are antidotes for snakebite. The unripe fruits are said to be poisonous but are taken as a remedy for syphilis and rheumatism, and boiled fruit is massaged into the body for lumbago. In South Africa, the fruits are used as a dressing for ulcers or to increase the flow of milk in lactating women. In northern Nigeria, the fruit is used in some districts as a purgative, and in others to treat dysentery. The leaf alone, or with other ingredients, is useful for diarrhoea and dysentery. The fruits and bark, ground and boiled in water, are taken either orally or as an enema in treating children's stomach ailments. The fruits and roots of *K. africana* are boiled along with the stem and tassels of a plantain for postpartum haemorrhage. Decoctions of the stem bark are used for spleen infection, gonorrhoea and syphilis. A cream made from fruit extract is used to remove sunspots known as 'solar keratosis', particularly on the face and hands.

The sausage tree is suitable for riverbank stabilization. It makes a good shade tree, casting dense shade, though it is not advisable to park a vehicle or to put up a tent underneath a sausage tree during the fruiting period. The 'sausages that drop every so often weigh up to 12 kg and can cause considerable damage (Bein, 1996). With its fast growth rate, spreading canopy and interesting flowers and fruits, it makes a good street tree and is popular for this purpose in various towns in the countries north of South Africa and in Australia. It can be used successfully for bonsai, the thick stem being an attractive feature. In Nigeria pieces of fruit soaked in water, together with small pieces of metal are sprinkled with young palm fronds, stimulate the germination of yam tubers as well as promote a good harvest.

Reproductive traits

Kigelia pinnata is a medium to large tree, up to 25 m in height, with a dense rounded crown; bark grey, generally smooth in large specimens, flaking in thin, round patches. Leaves opposite, crowded near the ends of branches, compound, with 3-5 pairs of leaflets plus a terminal leaflet; leaflets oblong, up to 6 x 10 cm, leathery, roughly hairy on both surfaces, rather yellowish-green above, paler green below, apex broadly tapering to rounded; base square, asymmetric in the lateral leaflets, symmetric in the terminal leaflet; margin entire, sometimes obscurely toothed, wavy; the lower leaflets shortly petiolulate, the terminal pair without petiolules: petiole up to 15 cm long (Roodt, 1992).

The flowers only open at night and are pollinated by bats and hawk- moths. They are dark red, which is unusual for a bat-pollinated species (bats are normally attracted to white flowers), but the strong unpleasant smell of the flowers is thought to attract bats. Flowering occurs during March to May and fruits in June. Flowers striking, dark maroon with heavy yellow veining on the outside, cup shaped, asymmetric, up to 15 cm across the mouth, unpleasant smelling: in 6- to 12-flowered, lax, pendulous sprays up to 90 cm long. Calyx shortly tubular with 2-5 ribbed lobes; corolla widely cup shaped with 5 broad spreading lobes; stamens 4, slightly protruding beyond the mouth of the corolla tube; ovary 1-chambered (Anthony et al., 2009).

Fruit very unusual, sausage shaped, up to 1 m x 18 cm, greyish- brown, heavily dotted with lenticels, indehiscent, heavy, weighing up to 12 kg, containing a fibrous pulp in which are embedded many seeds. Seeds 10 x 7 mm. numerous, wingless, embedded in a fibrous pulp; testa coriaceous; cotyledons folded (Diniz. 1988). The conservation status of the tree is Least Concern (LC) in the Red List.

Floral biology and pollination behavior

- Sequence of flowering: In all the trees, flowering proceeded from the top to bottom.
- Number of flowers per inflorescence: Is ranged from 3 to 4 per tertiary branch.
- Length of inflorescence: ranged from 89 to 110 cm with an average of 95cm.
- Number of rachis per inflorescence: Is ranged from 11 to 15 with an average of 12 per inflorescence.
- Time of anthesis: Anthesis occurred during the evening hours. Based on the data obtained from 15 mature buds per tree, the mean anthesis time is 4.00 PM to 4.30 PM.
- Peak anthesis time: It was observed during the night hours, it starts from 7.30 PM and completed around 8.00 PM.
- Time of maximum insect visit: Insects (ants, bees) and Bat are the predominant visitors. They visited at the time between 7.30 PM on the day of peak anthesis and on to the next day morning depending on the availability of nectar.
- Anther length: Is ranged from 1.3 to 1.2cm with an average of 1.2cm.
- Anther breadth: Is ranged from 0.5 cm to 0.6 cm with an average of 0.5 cm for non fruiting tree and 0.6cm for fruiting tree.
- Length of the filament: Is ranged from 7.2 to 7.9 cm and the mean value is 7.6 cm.
- Style length: The length of the style length is ranged from 10 to 10.4 cm and the mean value is 10.2 cm.
- Length of the stigma: Is ranged from 1 to 1.3 cm and the mean value is 1.2cm.
- Breadth of the stigma: Is ranged from 0.5 to 0.6 cm and the mean value is 0.6cm.
- Pollen perimeter: The pollen perimeter is ranged from 381 to 149µm with an average perimeter of 173.95 µm for non fruiting tree and 149.65 µm for fruiting tree.

Pollen viability test

Among the four stains used IKI gives the best fixation. So the viability of pollen at different stages of stigma maturation were observed using IKI stain. It found to be that the viability starts decreasing after full opening of flower but the pollen are hundred percent viable in a matured unopened bud.

Pollen tube length in sucrose medium

The pollen tube length ranged from 0.11 to 0.64 mm with an average 0.64mm for non fruiting tree at 10% concentration of sugar and 0.5mm for fruiting tree at 15% concentration. The pollen tube length for non fruiting tree is found to be maximum in 10% concentration of sugar and for fruiting tree the maximum growth is observed in 15% concentration of sugar.

Pollen germination percentage in sucrose medium

The pollen germination was found to be maximum at 10% concentration of sugar for non fruiting tree whereas for fruiting tree the maximum growth was observed in 15% concentration. The average pollen germination percentage for non fruiting tree is 36.7% and for fruiting tree it is 38.85%.

Phenol content of the stigma

The phenol content of the stigma ranged between the phenol content of the stigma is found to be similar in both non fruiting and fruiting tree. The phenol content starts to decrease from the bud to mature stage.

Biometrical characters

The mean performance of the seven morphological traits/biometric characters of the tree.

Tree height

The tree height was measured using Haga Altimeter .The height of the tree ranged from 6-8m and the maximum was observed in Black thunder tree.

Girth

The girth of the tree ranged from 150 to 165 cm with average of 160cm.

DBH

The DBH of the tree ranged from 43 to 45 cm with an average of 44cm.

Number of branches per tree

The number of primary branches per tree ranged from 4 to 5 and the average number of primary branches is 4.

The number of secondary branches per tree ranged from 12 to 16 and the mean no of secondary branches is 14.

The number of tertiary branches ranged from 56 to 70 and the mean no of tertiary branches is 65.

Number of inflorescence per tree

The number of inflorescence per tree ranged from 288 to 431 with an average of 330.

Conclusion

The research on *Kigelia pinnata* reveals significant insights into the species' reproductive traits and pollination mechanisms, shedding light on the tree's adaptation to its environment. Notable variations between fruiting and non-fruiting trees, including differences in pollen germination rates, tube growth, and phenol concentration, suggest an intricate reproductive process influenced by external factors. The tree's primary pollinators—bats and nocturnal insects—highlight its specialized pollination system. This study underscores the value of K. pinnata not only in environmental conservation efforts, but also in its applications for medicinal use, street shading, and ornamental horticulture. Future research should delve deeper into its ecological role and explore further commercial opportunities, particularly in sustainable agriculture and pharmaceutical development.

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BOOSTING FARMER'S INCOME BY INTRODUCTION OF HIGH YIELDING RICE VARIETIES IN KARIMNAGAR DISTRICT BY KVK, JAMMIKUNTA

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Introduction

KVK Jammikunta is located in the Karimnagar district of Telangana, within the Northern Telangana Zone. Most farmers in this district primarily cultivate paddy for seed production. However, over the past five years, yields have been declining due to the reliance on older varieties that are highly susceptible to pests and diseases.

Problem

Continuous cultivation of older varieties leads to issues such as crop lodging, grain shattering during harvest, and increased susceptibility to pests like stem borer, BPH and diseases such as blast, bacterial leaf blight along with longer duration.

Rationale

Seeds are a vital input in agriculture, and the availability of quality seeds significantly impacts sustainable yields and family income. With this in mind, KVK Jammikunta has introduced non-lodging and low grain-shattering medium-duration coarse grain paddy varieties, such as JGL-24423 and KNM-118, along with fine-grained, blast-tolerant short-duration (125 days) paddy varieties like RNR-15048 and KNM-1638.

Methodology

For the past five years, during the minikit stage, KVK has tested these varieties in farmers' fields and raised awareness among farmers through on-farm trials (OFTs), field days, training programs, and both electronic and print media.

Table 1: Interventions carried out to promote the technology:

Sl.No	Name of the intervention	No of Activities	No of farmers participated
1	**FLDs** - Introduction & popularization of high yielding varieties.	4	40
2	**Field days** on Introduction & popularization of high yielding varieties.	4	220
3	**Training programs** on Introduction & popularization of high yielding varieties.	12	510

Accessibility to the farmers

KVK has taken up seed production in KVK farm and made available at door step of the farmers after checking seed quality and germination percentage. Demonstrations and training programs played crucial role in bringing easy access to the farmers.

Table 2: Spread of the technology- For the past five years, KVK has been engaged in seed production at its farm.

Sl.No	Variety	Seed Produced (Quintal)	No.of Farmers	Area Spread (ha)
1	RNR-15048	442.00	1041	706
2	JGL-24423	1412.25	2235	2258
3	KNM-118	1301.50	2386	2080
4	KNM-1638	462.75	570	738
	Total	**3618.25**	**6232**	**5782**

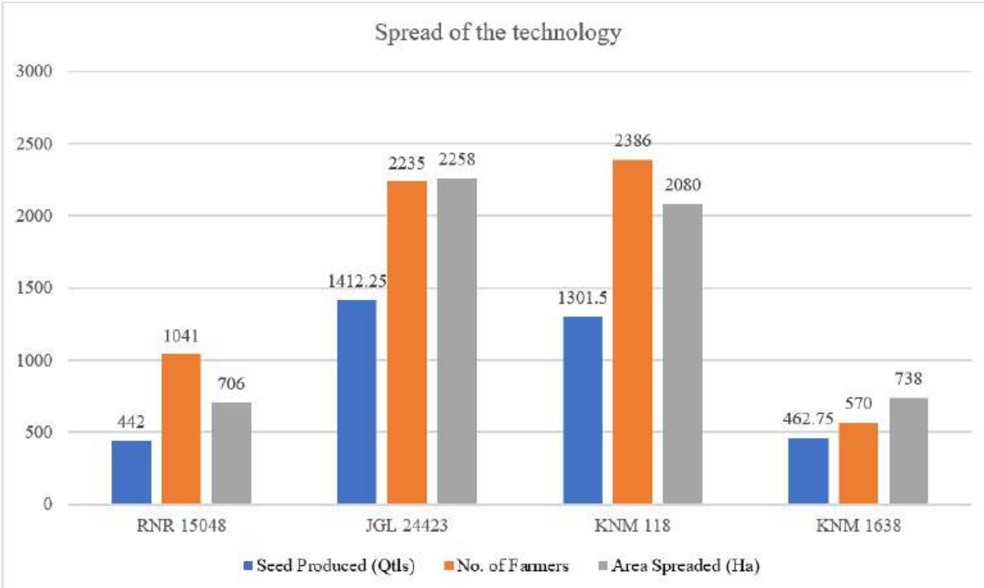

Fig 1: Spread of the technology over a period of 5 years

Economic Parameters

After introducing these varieties to farmers, many of the farmers expressed that they recorded good yields and higher net returns. Based on the farmers perceptions we have randomly selected 500 no of farmers and recorded average yields and calculated their net returns.

Sl. No.	Name of the parameter	MTU-1010	JGL-24423/ KNM-118	BPT-5204	RNR-15048/ KNM-1638
1	**Duration of the crop**	**120 Days**	**125 Days**	**150 Days**	**125 Days**
2	Cost of Cultivation	51,375/-	50,250/-	54,650/-	51,250/-
3	**Yield (Qt/ha)**	**68.75**	**71.25**	**61.25**	**65.00**
4	Gross Income (Rs/ha)	1,40,250/-	1,45,350/-	1,24,950/-	1,32,600/-
5	**Net Income (Rs/ha)**	88,875/-	95,100/-	70,300/-	81,350/-
6	**C:B Ratio**	**1: 2.72**	**1:2.89**	**1:2.28**	**1:2.58**
6	**C:B Ratio**	**1: 2.72**	**1:2.89**	**1:2.28**	**1:2.58**

Notable increases in yields were observed due to the varieties being non-shattering and resistant to pests and diseases, in comparison to MTU-1010 and BPT-5204, with an average yield increase of 3 quintals per hectare.

Output

Introduction of these varieties has led to higher yields due to their specific traits, such as non-shattering and resistance to pests and diseases, compared to older varieties. These new varieties have also demonstrated greater net returns per hectare, benefiting both producers and consumers. Over the years, the adoption of these varieties has increased, resulting in improved rice productivity and higher income for farmers.

With the adoption of newly released improved varieties, farmers are experiencing an average additional income of Rs. 8,637 per hectare.

The total additional income gained by the farmers in 5782 hectares is 4,99,39,134/-

Impact

For the past five years, KVK has been engaged in seed production at its farm, supplying 3,618.25 quintals of quality foundation seed to 6,232 farmers across an area of 5,782 hectares.

Conclusion

The success stories of improved rice varieties JGL 24423, KNM 118, RNR 15048 and KNM 1638 highlight their economic advantages for broader adoption. These varieties have significantly impacted the rice farming sector, especially in regions such as Telangana, Andhra Pradesh, Karnataka, Tamil Nadu, and Chhattisgarh.

These improved rice varieties have not only enhanced productivity and income for farmers but have also tackled specific challenges such as pest resistance, consistent yields, and economic viability. Their success emphasizes the need for ongoing research and development in agriculture to meet the changing demands of farmers and consumers.

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IMPACT OF FOOD PROCESSING INDUSTRIES ON CARBON FOOTPRINT

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Abstract

Carbon emissions are driving global climate change, posing risks to human security and environmental systems. Efficient food supply chain management aims to reduce emissions, enhance environmental outcomes, and improve food safety. The food processing industry's carbon footprint includes energy use and greenhouse gas emissions from production, distribution, and packaging disposal. Key tasks in the agri-food sector include reducing food waste, promoting sustainable economic growth, and maintaining natural resource management.

Introduction

Growing carbon emissions are the main cause of global climate change, endangering both human security and environmental systems. The amount of greenhouse gases produced is used to measure the environmental impact, which is known as the carbon footprint. When analyzing sustainability factors including global warming, energy use, user waste production, and improvements in manufacturing and recycling processes, carbon footprint analysis is essential. Carbon footprint and water conservation are two examples of sustainable practices that can be used to achieve this. (Shabir, I., *et. al.* (2023)). Given that both of these metrics have a fundamental connection to the life cycle management phenomenon, organizations may use them as sustainability indicators. It is necessary to determine the impact of carbon footprint on international trade relationships for goods and services and to analyze the many factors governing this.

Reduced carbon emissions, better environmental results, and increased food safety are the goals of efficient food supply chain management. The food processing business is a growing crucial global sector that employs millions of people. The organized and unstructured sectors of the food processing business have different energy requirements, and as a result, their carbon footprints fluctuate significantly. Increased greenhouse gas (GHG) emissions, which cause climate change and global warming, are frequently linked to increasing energy demand (Liu *et. al.* (2023)). The food industry's carbon footprint (CFP) is a measurement of the energy consumption and greenhouse gas emissions resulting from the preparation, distribution, and disposal of food packaging. Reducing food waste and overproduction, guaranteeing that everyone has access to wholesome food and water, promoting sustainable feeding and economic growth, cutting back on pollutant emissions to the atmosphere, land, and water, and maintaining sustainable natural resource management are some of the main tasks related to the agri-food sector.

One of the major causes of CFP (carbon footprint) and the consequent rise in global temperature is food waste. Reducing food waste and, in turn, CFP (carbon footprint) is important. To have a beneficial effect on the CFP (carbon footprint) and the environment worldwide, food waste must be treated using various sustainable approaches. Food waste (FW) is defined as the end products of various food processing businesses that are not recycled or used for any other purpose. The cost of collecting and recovering these non-product raw material flows for recycling outweighs their economic value. They are therefore dismissed as garbage. (Bhatia, L. *et. al.* (2023)).

Impact of the food industries on carbon footprint

In the food manufacturing sector, carbon dioxide is widely employed in a variety of food processing activities. Commercially, it comes in many forms such as dry ice., low-pressure chilled liquid, and high-pressure cylinder gas. Its primary application is as a chilling agent in food refrigeration. CO2 finds use in a multitude of applications. It can be used as an atmosphere modifier to preserve the vitamins and aroma of packaged fruits and vegetables, as a precipitant for casein, as an eluent in supercritical fluid extraction to produce decaffeinated coffee, as a stunning agent for animals before slaughter, and as a producer of deoxygenated water. (Liu *et. al.*

(2023)). There are enormous volumes of greenhouse gas emissions caused by the food system, which includes agricultural and post-production. Emissions at the farm stage are mostly caused by changes in land use that correlate with livestock and agricultural production. During the manufacturing stage, food manufacturing operations such as processing, packaging, and transportation are the main sources of greenhouse gases. Greenhouse gas emission is also a result of post-production activities like retail, consumer travel, home consumption, and the disposal of food waste. Thus, the food sectors have a significant influence on carbon footprint.

Impact of the dairy industries on carbon footprint

Negative effects of dairy farming on the environment typically include soil erosion, a decrease in biodiversity, and pollution of water bodies from fertilizer and pesticide runoff (eutrophication). Emissions of greenhouse gases (GHG) such as carbon dioxide (CO2), nitrous oxide (N2O), and methane (CH4) are characteristic of dairy production. Farm-gate life cycle assessment (LCA) studies are used to carefully quantify these emissions internationally. However, contradictory findings show how sensitive the life cycle assessment method is to various modeling strategies and greenhouse gas estimations. Furthermore, the wide range of climate variables, soil conditions, and agronomic management techniques that dairy farming systems are subject to result in various modeling inputs and variables that affect the computations. (Galloway, C. *et. al.* (2024)).

Impact of the beverage industries on carbon footprint

Food and beverage manufacturing and related corporate supply chains are collectively referred to as the food and beverage industry or FBI. the food and beverage business actively consumes and processes carbon dioxide in addition to any carbon flows that result from energy, heat, and steam. For instance, carbon dioxide is used by the industry as an "increasingly popular refrigerant." In addition, carbon can be employed directly to carbonize drinks, create deoxygenated water, precipitate casein, pretreat olives, act as an acidifier, and extend the shelf life of select fruits and vegetables. Farming and dairy stockbreeding produce significant emissions of methane and other short-lived greenhouse gases. (Sovacool, *et. al.* (2021))

Alcoholic beverages significantly impact the environment through their carbon footprint, primarily from the cultivation of raw materials, fermentation, and distillation, packaging, and transportation. The use of fertilizers, pesticides, and irrigation in crop production releases greenhouse gases, while the energy used in distillation contributes to land use change.

Techniques to reduce food products' carbon footprint

Reducing carbon footprints is an essential strategy for combating the greenhouse effect. A portion of the Sun's infrared radiation enters the atmosphere and is reflected out in all directions by clouds and greenhouse gas molecules, causing the greenhouse effect. A location's claim on broader geographic regions and its base of renewable resources must be taken into account while managing it sustainably. Modifications in consumer eating habits may help reduce greenhouse gas emissions associated with food by 29–70% while also improving human health. Eating fruits and vegetables like tomatoes, carrots, and raspberries can help reduce greenhouse gas emissions considerably (Shabir, I., *et. al.* (2023)). diets high in protein can cut down on greenhouse gas emissions by replacing meat with plant-based diets. In actuality, few people are aware of the tactics employed to lower CF. This problem might be resolved with communication. Future consumer behavior may be changed by promoting communications that highlight the most effective ways to lower food-related CF. By doing this, the effects of anthropogenic climate change will be mitigated.

The process of decarbonization aims to achieve net-zero emissions by lowering the amount of carbon emissions in the atmosphere. This is essential to reducing the effects of climate change, which is brought on by the atmospheric build-up of greenhouse gases like carbon dioxide (CO2).

Conclusion

The food processing industry's carbon footprint is a major concern, requiring efficient supply chain management, sustainable agricultural practices, and improved waste management. Targeted strategies like modifying consumer eating habits, promoting plant-based diets, and enhancing communication about carbon footprint reduction can significantly reduce emissions, promoting sustainable development and a more sustainable future.

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IMPORTANCE OF COMMUNICATION TECHNOLOGIES IN NEW VARIETAL INTRODUCTION TO FARMERS

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Introduction

In the rapidly evolving agricultural landscape, the introduction of new crop varieties plays a crucial role in enhancing productivity, ensuring food security, and adapting to climate change. However, the success of these new varietals largely depends on the effective dissemination of information to farmers. These technologies, including digital platforms and social media, play a crucial role in disseminating essential information about the benefits and cultivation practices of these varieties (Jones & Brown, 2022). By leveraging these tools effectively, stakeholders can reach a wider audience of farmers and agricultural experts, thereby facilitating informed decision-making and accelerating the adoption of innovative agricultural practices (Johnson *et al.*, 2021). This integration not only enhances agricultural productivity but also contributes to sustainable food production and global food security (Robinson, 2020). Thus, integrating communication technologies is vital for successfully introducing and gaining acceptance for newly released plant varieties in contemporary agriculture.

Communication technologies have emerged as a pivotal tool in bridging the information gap between agricultural researchers and farmers. These technologies, ranging from traditional radio broadcasts to modern mobile applications, facilitate timely and accurate transfer of knowledge, thereby empowering farmers in various aspects (FAO, 2019). Traditional methods of communication, such as extension services and community meetings, have their limitations in terms of reach and efficiency. In contrast, modern communication technologies can disseminate information quickly and widely, overcoming geographical barriers and providing real-time updates. For instance, mobile phones enable farmers to receive weather forecasts, pest alerts, and advisory services directly, thus significantly impacting their farming practices and productivity (Mittal & Mehar, 2016). Additionally, social media platforms and online forums create interactive spaces where farmers can share experiences, seek advice, and access a wealth of information from both experts and peers (Aker, 2011).

In India, communication technologies have historically played a significant role in the successful adoption of new crop varieties. For example, during the Green Revolution in the 1960s and 1970s, radio programs and print media were extensively used to educate farmers about high-yielding varieties of wheat and rice. These efforts were instrumental in transforming India's agricultural landscape, leading to increased food production and self-sufficiency (Pingali, 2012). More recently, the use of mobile-based platforms such as Kisan Call Centers and various agricultural apps has further enhanced farmers' access to crucial information, helping them adopt new varieties that are more resilient to pests, diseases, and climatic variations (Glendenning, Babu, & Asenso-Okyere, 2010).

The integration of communication technologies in agriculture not only improves the adoption rates of new varietals but also enhances overall agricultural practices. As the global population continues to grow, the need for sustainable agricultural development becomes more pressing. Leveraging communication technologies to introduce and promote new crop varieties is a vital strategy to meet this demand and ensure a resilient agricultural sector (World Bank, 2017).

Promising Communication Technologies in Agriculture

Communication technologies have played a crucial role in agriculture, both in the past and present. The evolution of these technologies has significantly influenced the efficiency and effectiveness of agricultural practices, particularly in the dissemination of information about new crop varieties.

1. Traditional Communication Technologies

a. Radio: One of the earliest forms of communication technology used in agriculture was the radio. These programs provided vital information on cultivation techniques, pest control, and weather forecasts, enabling farmers to adopt new practices and varieties successfully (Pingali, 2012).

Community radio stations in rural India have played a vital role in educating farmers about new agricultural technologies and practices. These stations broadcast programs in local dialects, covering topics such as crop diversification, organic farming, and climate-resilient agriculture. By addressing local issues and providing context-specific information, community radio has successfully promoted the adoption of new crop varieties among smallholder farmers (World Bank, 2017).

b.Print Media: Newspapers, pamphlets, and agricultural magazines also played a significant role. They offered detailed articles, success stories, and practical advice, which were crucial in spreading awareness about new crop varieties.

2. Modern Communication Technologies

a. Mobile Phones: The advent of mobile technology revolutionized agricultural communication. Mobile phones allow for real-time communication, enabling farmers to receive weather updates, pest alerts, and personalized advice from agricultural experts. Services such as SMS-based advisories and helplines, like the Kisan Call Centers in India, have empowered farmers with timely information (Mittal & Mehar, 2016).

b. Internet and Social Media: The internet has opened new avenues for information dissemination. Farmers can now access a wealth of information online through agricultural websites, forums, and social media platforms. These platforms facilitate knowledge sharing, peer-to-peer learning, and direct interaction with experts. Social media groups and YouTube channels dedicated to agriculture provide tutorials, expert advice, and success stories, encouraging farmers to adopt new technologies and practices.

c. Digital Platforms and Portals: Several digital platforms and portals have emerged as hubs for agricultural information dissemination in India. Websites like "e-NAM" (National Agriculture Market) facilitate online trading of agricultural commodities, connecting farmers directly with buyers and markets across the country. These platforms leverage communication technologies to promote transparency and efficiency in agricultural marketing, benefiting farmers by ensuring fair prices and reducing intermediaries (FAO, 2019).

d. Mobile Applications: Numerous agricultural apps have been developed to assist farmers. These apps provide a range of services, including crop management advice, market prices, weather forecasts, and pest and disease identification. Apps like "mKrishi" and "RML Farmer" have been particularly successful in India, providing tailored information to farmers based on their location and specific needs (Glendenning, Babu, & Asenso-Okyere, 2010).

How Communication Technologies Aid in Varietal Adoption

The process of adopting new crop varieties involves several stages, from initial awareness to the decision to adopt and ultimately, the continued use of the new variety. Communication technologies aid in each of these stages:

1. Awareness and Education: Communication technologies create awareness about the availability and benefits of new crop varieties. Radio programs, mobile advisories, and online articles educate farmers about the advantages of adopting these varieties, such as higher yields, disease resistance, and better adaptability to local conditions. This initial awareness is crucial for farmers to consider trying out new varieties (FAO, 2019).

During the Green Revolution in the 1960s and 1970s, India witnessed significant advancements in agricultural productivity, largely facilitated by communication technologies of that era, such as radio broadcasts and print media. These technologies played a crucial role in disseminating information about high-yielding varieties of wheat and rice, leading to widespread adoption among farmers and transforming India into a self-sufficient nation in food production (Pingali, 2012).

Launched by the Government of India, Kisan Call Centers provide toll-free helpline services to farmers across the country. Farmers can access information on agricultural practices, pest management, weather updates, and market prices directly through phone calls. This initiative has empowered millions of farmers by providing timely and personalized agricultural advice, contributing to improved crop yields and livelihoods (Mittal & Mehar, 2016).

2. Knowledge Transfer: Detailed information about the cultivation practices of new varieties is essential for successful adoption. Mobile apps and online platforms provide step-by-step guides, video tutorials, and expert advice on planting, fertilizing, and pest management. This knowledge transfer ensures that farmers are well-equipped to handle the new varieties and achieve optimal results (Aker, 2011). Apps like the "mKisan" app by the Government of India delivers agricultural advisories and information on schemes directly to farmers' mobile phones in their local languages.

3. Real-Time Support: One of the significant advantages of modern communication technologies is the ability to provide real-time support. Farmers can receive instant feedback and solutions to their problems through helplines, chatbots, and social media groups. This real-time support helps farmers overcome challenges and increases their confidence in adopting new varieties (Mittal & Mehar, 2016).

4. Community and Peer Influence: Social media and online forums create communities of farmers who share their experiences with new crop varieties. Success stories and testimonials from fellow farmers serve as powerful motivators, encouraging others to adopt the new varieties. This peer influence is often more persuasive than information from external sources (Glendenning, Babu, & Asenso-Okyere, 2010).

5. Monitoring and Feedback: Communication technologies also facilitate the monitoring of new variety adoption and provide feedback to researchers and extension services. Mobile surveys and online feedback forms allow for the collection of data on the performance of new varieties, which can be used to make further improvements and tailor support services to farmers' needs (World Bank, 2017).

Limitations of Communication Technologies

Despite the numerous benefits, communication technologies face several limitations in agricultural contexts:

1. Digital Divide: Access to modern communication technologies is not uniform. Many rural areas lack reliable internet connectivity and mobile network coverage, limiting the reach of digital advisory services. Additionally, there is a gap in digital literacy among older farmers, making it challenging for them to utilize these technologies effectively (FAO, 2019).

2. Information Overload: The abundance of information available online can overwhelm farmers. Distinguishing between credible and non-credible sources is difficult, leading to potential misinformation and confusion. This can hinder the adoption of new practices and technologies (Aker, 2011).

3. Language and Content Relevance: Many communication platforms provide information primarily in national or global languages, which may not be accessible to all farmers, especially those who speak regional dialects. Furthermore, the content may not always be tailored to the specific local conditions and needs of different farming communities (Glendenning, Babu, & Asenso-Okyere, 2010).

Potential Tools for Further Exploration

To overcome these limitations and enhance the effectiveness of communication technologies in agriculture, several promising tools and approaches can be explored:

1. AI and Machine Learning: Artificial intelligence (AI) and machine learning can be used to analyze vast amounts of agricultural data, providing personalized recommendations to farmers. AI-powered chatbots can offer real-time support and answer queries in multiple languages, improving accessibility (World Bank, 2017).

2. Blockchain Technology: Blockchain can ensure transparency and traceability in agricultural supply chains. It can be used to verify the authenticity of information regarding new crop varieties, preventing the spread of misinformation (FAO, 2019).

3. Internet of Things (IoT): IoT devices, such as soil sensors and weather stations, can collect real-time data on environmental conditions. This data can be integrated with mobile applications to provide precise and timely advice to farmers, enhancing decision-making (Mittal & Mehar, 2016).

Government Interventions

Governments play a crucial role in promoting the use of communication technologies in agriculture:

1. Infrastructure Development: Investing in rural internet and mobile network infrastructure is essential to bridge the digital divide. Governments can partner with telecom companies to extend network coverage to remote areas, ensuring that all farmers have access to digital advisory services (World Bank, 2017).

2. Training and Capacity Building: Governments can organize training programs to enhance digital literacy among farmers. These programs can teach farmers how to use mobile applications, access online resources, and verify the credibility of information. Extension workers can be trained to provide on-ground support (FAO, 2019).

3. Policy Support: Developing policies that support the integration of communication technologies in agriculture is crucial. This includes subsidizing mobile phones and internet services for farmers, promoting public-private partnerships, and encouraging innovation in agri-tech (Mittal & Mehar, 2016).

Challenges Faced by Farmers vs. Challenges Perceived by Experts

There is often a disconnect between the challenges perceived by agricultural experts and the actual challenges faced by farmers:

1. Access to Technology: Experts may assume that farmers have easy access to modern technologies, but in reality, many farmers struggle with poor connectivity, lack of digital devices, and low digital literacy (Aker, 2011).

2. Relevance of Information: While experts focus on providing technical information, farmers often need practical, location-specific advice. Generalized information may not be applicable to their unique conditions, leading to ineffective adoption of new practices (Glendenning, Babu, & Asenso-Okyere, 2010).

3. Socio-Cultural Factors: Experts may overlook the socio-cultural barriers that impact technology adoption. Factors such as traditional farming practices, community norms, and resistance to change play a significant role in farmers' decision-making processes (Mittal & Mehar, 2016).

Role of Media

The media has a significant role in promoting the adoption of new crop varieties in various ways and means. Below mentioned paragraphs provide a brief idea about the its role.

1. Raising Awareness: Media outlets, including radio, television, and online platforms, can raise awareness about the benefits of new crop varieties. They can highlight success stories and showcase innovative practices, inspiring farmers to adopt new technologies (Pingali, 2012).

2. Educational Content: Educational programs and documentaries on agricultural practices can provide valuable information to farmers. Media can collaborate with agricultural experts to produce content that addresses farmers' specific needs and challenges (FAO, 2019).

3. Advocacy and Policy Influence: Media can advocate for policy changes and highlight the importance of investing in agricultural communication technologies. By bringing attention to farmers' issues, media can influence government and stakeholder actions (World Bank, 2017).

Future Thrust

To maximize the potential of communication technologies in agriculture, future efforts should focus on:

1. Enhancing Connectivity: Continued investment in rural internet and mobile infrastructure is essential. Governments and private sector partnerships should work towards achieving universal connectivity (FAO, 2019).

2. Developing Inclusive Technologies: Technologies should be designed to be user-friendly and accessible to all farmers, regardless of their digital literacy levels. Multilingual support and localized content are crucial (Mittal & Mehar, 2016).

3. Promoting Innovation: Encouraging innovation in agri-tech through research and development, startups, and public-private partnerships will drive the creation of new tools and solutions that address farmers' evolving needs (World Bank, 2017).

4. Strengthening Extension Services: Integrating modern communication technologies with traditional extension services can provide a comprehensive support system for farmers. Training extension workers in digital tools will enhance their effectiveness (Glendenning, Babu, & Asenso-Okyere, 2010).

5. Monitoring and Evaluation: Regular monitoring and evaluation of the impact of communication technologies on agricultural practices will help identify gaps and areas for improvement. Feedback from farmers should be used to refine and adapt the technologies (Aker, 2011).

Conclusion

The integration of communication technologies in agriculture has revolutionized the dissemination and adoption of new crop varieties. From traditional media like radio to modern mobile apps and internet platforms, these technologies enhance agricultural extension services by providing timely and relevant information, which boosts productivity and resilience. Despite challenges such as information overload and the need for localized content, emerging technologies like AI, blockchain, and IoT offer promising solutions. Government interventions, including infrastructure investment and policy support, along with media's role in awareness and education, are critical. Moving forward, enhancing connectivity, developing inclusive technologies, and promoting innovation are essential for further progress. Collaboration among all stakeholders will ensure the full potential of communication technologies in creating a more connected and sustainable agricultural sector.

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FLOWER-BASED PHARMACEUTICALS: TRADITIONAL MEDICINE

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Introduction

Flowers, beyond their aesthetic appeal, hold significant therapeutic and pharmaceutical potential. Flowers have been used for their medicinal properties for centuries, offering a natural and often gentle way to treat various ailments. Many flowers contain active compounds with therapeutic effects, such as antioxidants, anti-inflammatory agents, and antimicrobial properties. These compounds can help in treating conditions ranging from digestive disorders to skin ailments and even more serious diseases like cancer. They are not only a source of beauty and delicacy but also fountain heads of health and joy.

Medicinal Uses of Flowers

Flowers have been used in traditional medicine for centuries. Modern medicine also utilizes flower extracts due to their medicinal properties. The therapeutic benefits of flowers are evaluated based on factors such as colour, odour, and flavour components. These components influence antioxidant activity, scavenging reactive oxygen radicals, and even have potential against cancer.

Health Benefits and Bioactive Compounds

A recent review studied 119 species of flowers with agri-food and health relevance. 87% of the floral species studied contain toxic compounds, making them inedible. However, specific molecules from these species have been used in medicine. 76% of the species can be consumed in low doses by infusion. 97% of the species have reported medicinal uses, with 32% related to the immune system. 63% of the species could be used in the bioremediation of contaminated environments. More than 50% of the species were only analyzed for total concentrations of carotenoids and phenolic compounds, indicating a gap in identifying specific bioactive molecules.

Bioactive Properties of Plants:

Plant-derived compounds have diverse properties, including analgesic, antioxidant, antimicrobial, anti-inflammatory, anti-cancer, and chemotherapeutic effects. Studies have shown that herbal remedies derived from plants are more effective than placebos in treating physical illnesses like inflammatory bowel disease and ulcerative colitis. Additionally, plant-based natural products have been investigated for use in cancer therapy due to their anti-inflammatory and antioxidant properties.

Flowers aren't just visually appealing; many of them possess remarkable pharmaceutical properties.

Calendula (*Calendula officinalis*):

- Family – Asteraceae
- Origin – Southern Europe
- Flowers are bright yellow to orange in colour.
- Also known as marigold, calendula has skin-healing properties.
- It is commonly used in creams, ointments, and salves to soothe minor cuts, burns, and skin irritations.

Chamomile (*Matricaria chamomilla*):

- Family – Asteraceae
- Origin – Southern Europe

- The ray florets are white, while the disc florets are yellow.
- Chamomile flowers are well-known for their calming effects.
- Used to make soothing teas that help with stress, anxiety, and insomnia.
- Chamomile has anti-inflammatory properties.

Lavender (*Lavandula angustifolia*):

- Family – Lamiaceae
- Origin – Mediterranean region
- It bears small blue-violet flowers on spikes with blue-green needle-like foliage.
- Lavender flowers have a delightful fragrance and are used in aromatherapy.
- They promote relaxation, reduce anxiety, and aid in sleep.
- Lavender essential oil is also used topically for minor skin issues.

St. John's Wort (*Hypericum perforatum*):

- Family – Hypericaceae
- Origin – Europe

- St. John's Wort flowers are bright yellow in colour.
- These flowers are used to make herbal preparations that may help with mild depression.

Honeysuckle (*Lonicera japonica*):

- Family – Caprifoliaceae
- Origin – East Asia
- Flowers are white tubular and turn yellow as they age.
- Honeysuckle flowers have antibacterial and anti-inflammatory properties.
- They're used in traditional medicine for various ailments, including sore throats and skin infections.

Jasmine (*Jasminum officinale*):

- Family – Oleaceae
- Origin – Asia
- Flowers are star shaped and white.
- Jasmine flowers are known for their sweet fragrance.

- They are used in teas and essential oils.
- Jasmine tea is believed to have digestive and ulcer-healing properties.


Angelica Herb (*Angelica archangelica*):

- Family – Apiaceae
- Origin – Northern Europe and Asia
- Plant produces large globular umbels of small yellowish or greenish yellow flowers.
- Angelica flowers are part of a larger plant known for its medicinal properties.
- The herb is used as a digestive and respiratory aid.
- It is also believed to have immune-boosting effects.


Black Cohosh (*Actaea racemosa*):

- Family – Ranunculaceae
- Origin – Eastern North America
- Produces tall, white flower spikes.
- Black Cohosh flowers are used primarily for women's health.

- They're considered a potent uterine stimulant and are used to manage menopausal symptoms.

Blood Root (*Sanguinaria canadensis*):

- Family – Papaveraceae
- Origin - Eastern North America
- Plant produces delicate white flowers.
- Blood Root flowers contain alkaloids with antimicrobial and anti-inflammatory properties.
- They've been used traditionally for skin conditions and respiratory issues.

Blue Lobelia (*Lobelia inflata*)

- Family – Campanulaceae
- Origin - Eastern North America
- The plant produces violet-colored flowers that are tinted yellow on the inside.

- Blue Lobelia flowers have been used for respiratory health.
- They're believed to help with syphilis and lung treatment. However, caution is necessary due to its potency.


Conclusion

Flowers have long been utilized as a curative for a wide range of illnesses. These are the natural medicines that are used to restore the changes that foreign organisms or any kind of bodily malfunction have made to the normal physiological system. Proper documentation of medicinal plants and their potential to promote health and hygiene through an environmentally friendly method is vital.

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SMALL SCALE LEAF PLATES ENTERPRISE IN SUBTROPICAL REGION OF HIMACHAL PRADESH

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Introduction

Forest plays an important role in ameliorating environment and providing livelihood to the local masses residing in and around it. Enterprises based on forest resources are generally known as small and medium forest enterprises (SMFES) which plays a significant role in the upliftment of the socio-economic condition of the rural masses. These enterprises are either run by individual or group. Leaf plates (Pattal) making is one of the many small and medium forest enterprises in Himachal Pradesh which is based on natural forest resource i.e. leaf. Leaf plates are commonly known as Pattal in the local markets. This enterprise is being practised by a particular group of the society which are generally landless poor and having small or marginal land holdings.

Making pattal is a hereditary profession of most rural people in these three states. The profession cannot be run through out the year, so the people can not be totally dependent on this for their livelihood. Therefore, they have to engage themselves in some other works also. This enterprise mostly practised in the subtropical region or lower belts of these states because the raw material i.e. tree leaves, is available in this region only.

Raw Material

Principally, the leaves of *Bauhinia vahlii* commonly known as Taur or Maljhan are used to make the pattal. This is a woody climber which grows up by taking the support of other trees. This plant is mainly found abundantly in subtropical forests of Solan, Sirmour, Bilaspur, Hamirpur, Mandi and Kangra districts of Himachal Pradesh. In addition to this, the leaves of other species like Sal (*Shorea robusta*),

Tremal (*Ficus roxburghii*) or other species of *Ficus* are also used for pattal making. These species are found between an elevation of 300 -800 m above mean sea level. The raw material obtained from private or own land is in very small or negligible proportion.

Collection: The leaves of Taur for pattal making are collected between month of May and September. While collecting the leaves, precautions has to be taken that the collected leaves should not be torn or splited, stained, perforated and then staked carefully in bundle so that the material could not be damaged during lifting to home. Collection process is very tedious job because to collect the leaves one has to travel a distance of 2 to 3 km or even more. There is no ban on collection of these leaves by the State Forest Department unless heavy damage caused to the trees by lopping.

Pattal Making:

Generally pattals are made by hand. All the family members are involved in pattal making. Females contributed much more than their counterparts and children also get involved off and on. For pattal making, the leaves are tied together with small sticks of grass or bamboo to give them round shape. In some places like Kangra in HP, a grass locally known as Gayana is used to bind the pattal which is available in the marked @ 40-50/kg. An adult can make 300-400 pattal per day or 100-150 if done it part time. Electric machine is also used in some of the Panchayat which is provided by the State Forest Department in Himachal Pradesh. But it is not used as the cost of pattals increased and peoples are not accustomed of it. The people mostly preferred to prepare it by hand.

Demand and Supply:

The demand of the leaf plates is diminishing now a day because of unorganized marketing. Mostly pattals are consumed locally in ceremonial, social or religious functions. Bulks of plates are also used in temples of Himachal Pradesh. But in the present scenario, people prefer plates made up of glazed paper or thermocoal, which are attractive, sturdier and more sophisticated. Presently in most of the temples steel plates are being used instead of pattals and thereby reduce the demand of pattals.Other reason of diminishing the demand is the low self life and discolouration of the pattal's. The green leaf plates have more moisture content and when stored in ordinary conditions they get attacked by white fungus and become blacken so they are not preferred by the consumers and people can not wholly depends on this profession for their livelihood. Local demand is met by the pattals makers but huge demand can not be met because the supply is totally depends on the availability of green leaves in the forest. The supply of the pattal is also restricted to a particular season and therefore, the supply can't match the demand of the market. Hence this profession become a seasonal activity.

Marketing:

Marketing of pattal's mainly involves three channels:

i) Producers to Local consumer (on demand)

ii) Producers to Shopkeepers (Direct)

iii) Producer to Market (through middleman)

In Himachal Pradesh first channel is widely used. Third channel is used when there is surplus of product or some agency may collect it for further marketing. In Jammu & Kashmir second channel is mostly preferred and used because they required money immediately and have nearby market. Other channels are also used depending upon the local demand and surplus of product or agency involved. Local price of the pattal varies from Rs. 30-40 and in market Rs. 40-50 per hundred depending upon the demand and supply.

Future of the Enterprise:

In the present scenario of urbanization and industrialization the new generation did not take up this profession because it involves lot of uncertainties, hard work, unorganized market and low income. The new generation migrate to urban areas in search of job or other works. As a result, this hereditary profession is on the verge of extinction. Only the inhabitants of remotely located villages have continued this profession as they do not have any other source of income generation.

Limitations in adoption of this profession:

The following are the limitations which pose hindrance in adoption of this profession:

i) Low availability of raw material

ii) Collection of raw material is time consuming

iii) More competition with paper plates

iv) Demand is locally restricted i.e. low demand

v) Low self life
vi) Unorganized market
vii) Low price

Suggestions to gear up this Enterprises:

i) People practised this profession should be organised in groups like Self Help Groups or society.
ii) Sensitization and skill up gradation through training and visit programme.
iii) To ensure marketing through involvement of some local NGOs or traders.
iv) Plantation of these species should be included in the plantation programme.
v) Some incentives should be given to promote this profession by the government.

Effort in Himachal Pradesh:

The State Forest department of the Himachal Pradesh provided Eclectic machine to prepare the Leaf plates through organising Self Help Group or Village societies for those communities but could not found desired success. In the year 2006, Regional centre, National Afforestation and Eco-development Board, Ministry of Environment and Forests which was located in the Campus of Dr. YS Parmar University of Horticulture & Forestry, Nauni, Soaln (HP) had promoted this enterprises in Dehra Forest Division of Kangra district by preparing Self Help Groups of those people who engaged in this profession. These groups were trained in making good pattals through trainings at their villages. These groups were also exposed to different markets in order to make aware them about market status and channels. But after the project, these groups were not sustained. In December 2010, the Himachal Pradesh Tourism Department has initiated “Dham” in their hotels which will be served on leaf plates i.e. Pattal, in order to attract more tourists and provide them opportunity to taste the local dishes in order to promote this clean business. Recently, the Government of Himachal Pradesh has made use of Pattal mandatory in the Main temples for serving the Langar (food) in Shimla city by signing the MoU with Pattal making SHGs from Sunni area of district Shimla on defined rates. It is a good initiative to promote this profession and raise the economy of the people engaged in this profession. Further, there is still need to emphasize the use of this biodegradable product (Leaf plates) in the social parties or gatherings like local dham, marriages and other parties, so that the demand can be increased and this clean green tradition may alive along with sustaining the economy of the local folk.

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INSECTS THREAT TO PIGEONPEA PRODUCTION IN TAMIL NADU

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Introduction

Pigeonpea, (*Cajanus cajan* L.) is one of the important pulse crop and provides an indispensable source of supplementary protein to vegetarian diet and often referred as poor man's meat. Pigeonpea have a wide range of climatic adaptation and performs differently to changing agriculture scenario. India is the largest producer in the world with 26 per cent share in global production by producing 25.23 million tonnes of pulses with total area of 29.99 million hectares. The average productivity of country is about 841 kg ha^{-1} against average global productivity of 1023 kg ha^{-1} (DES, 2018). In Tamil Nadu, among legume crops, the area under pigeonpea occupies huge area with the state average yield of 720 kg ha^{-1}. Adoption of traditional farming system and non-adoption of recommended package of practices due to lack of awareness, knowledge and conviction about the latest technologies to combat insect pests lead to the major decline in pigeonpea. This article was aimed to know the major insect pests that feeds on buds, flowers, pods and seeds (Table 1) with integrated approaches to reduce the insect pest incidence thereby paving way for increased potential yield.

The best strategy in insect pest control is to adopt the timely management practices by following the strategies given

Monitor pests: Monitor insect population development in fields to determine if and when control measures are warranted. Monitor and consider natural enemies when making control decisions. After treatment, continue monitoring to assess pest populations and their control.

Focus on Agro-ecosystem analysis: Insecticides should be used only as when all other non chemical management options are exhausted and P:D ratio is above 2:1. Apply biopesticides /chemical insecticides judiciously after observing unfavourable P: D ratio and when the pests are in most vulnerable life stage. Use application rates and intervals as per label claim.

Ecological Engineering for Pest management: Flowering plants that attract natural enemies as well as plants that repel pests can be grown as border/intercrop.

Take an integrated approach to managing pests: Use as many different control measures as possible viz., cultural, mechanical, physical, biological etc.

Select insecticides with care and consider the impact on future pest populations and the environment. Avoid broad-spectrum insecticides when a narrow-spectrum or more specific insecticide will work. More preference should be given to green labeled insecticides.

Mix and apply carefully: While applying insecticides care should be taken for proper application of insecticides interms of dose,volume, timing, coverage, application techniques as per label claim.

Alternate different insecticide classes: Avoid the repeated use of the same insecticide, insecticides in the same chemical class, or insecticides in different classes with same mode of action and rotate/alternate insecticide classes and modes of action.

Table 1. Insects of economic importance in pigeonpea

S.No	Insect	Symptoms	Adult
1.	**Gram podborer**, *Helicoverpa armigera*		
2.	**Spotted podborer**, *Maruca vitrata*		

3.	**Blue butterfly,** *Catechrysops cnejus*		
4.	**Plume moth,** *Exelastis atomosa*		
5.	**Podfly**, *Melanagromyza obtusa*		
6.	**Podbug**, *Riptortus pedestris*		
7.	**Blister beetle**, *Mylabris pustulata*		

General Management options to be followed in Pigeonpea ecosystem

- For pod borers, raise one row of sunflower as intercrop for every 9 rows of pigeon pea and plant maize as border crop.
- Use of Pheromone traps for *Helicoverpa armigera* 12/ha
- Installation of Bird perches 50/ha
- Mechanical collection of grown up larva and blister beetle
- Application of *Ha* NPV 3 x10^{12} POB/ha in 0.1% teepol
- Apply any one of the following insecticides on need based
    - ✓ Azadirachtin 0.03 % WSP 2500-5000 g/ha
    - ✓ *Bacillus thuringiensis* serovar *kurstaki* (3a,3b,3c) 5%WP1000-1250 g/ha
    - ✓ Dimethoate 30% EC 1237 ml/ha
    - ✓ Emamectin benzoate 5% SG 220 g/ha
    - ✓ Indoxacarb 15.8% SC 333 ml/ha
    - ✓ Chlorantraniliprole 18.5 SC 150ml/ha
    - ✓ Spinosad 45%SC 125-162 ml/ha
    - ✓ NSKE 5% twice followed by triazophos 0.05%
    - ✓ Neem oil 2%
    - ✓ (Spray fluid 625 ml/ha) Note : Insecticide / Ha NPV spray
- Conserve natural enemies like *Euderus lividus, Eurytoma* sp., *Euderus agromyzae*
- Spray Carbaryl 50 WP 1.5 kg or lambda cyhalothrin 5 EC 400 -500 ml or Lufenuron 5.4 EC 2.5 L with 700 L water/ha for podfly

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MICROGREEN FARMING: NUTRIENT-RICH HARVESTS IN URBAN CONFINES

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Abstract

Microgreens are young, edible greens harvested shortly after germination. Sourced from various seeds, including vegetables and herbs, they are celebrated for their vibrant colours, diverse flavours, and high nutrient content. Their popularity has surged in both traditional and urban gardening contexts. In urban settings, advanced farming techniques, such as vertical farms with automated irrigation and lighting systems, effectively address land scarcity and changing lifestyles. This innovation allows for efficient cultivation in limited spaces. To enhance nutritional value, strategies like careful seed selection, optimizing growing media, and adjusting light conditions are employed. Although microgreens have a brief shelf life, pre-harvest treatments can extend their viability. This growing interest underscores the importance of microgreens in modern agriculture, catering to the demand for nutrient-rich, flavourful produce among urban dwellers. Ultimately, they represent a sustainable solution for healthy eating in confined environments.

***Keywords**:* microgreens, edible greens, nutritional value, urban agriculture

Introduction

Microgreens are young, tender, edible greens harvested at an early stage of growth, typically when the first true leaves emerge. Grown from the seeds of various vegetables, herbs, or grains, they are usually ready for harvest within 7 to 21 days after germination, depending on the specific plant variety. These miniature greens are more developed than sprouts but not as mature as baby greens or fully grown plants. In recent years, microgreens have gained widespread recognition for their exceptional nutritional profiles and remarkable versatility. These vibrant, young greens have captivated the attention of home gardeners, chefs, and health enthusiasts alike. Known for their impressive array of health benefits, they are rich in nutrients, antioxidants, and minerals. Microgreens grow rapidly and adapt well to confined spaces, requiring minimal resources to thrive. They can be cultivated in both soil and hydroponic systems, further enhancing their appeal. Their intense flavours and vivid colours make microgreens a popular choice for elevating the taste and appearance of various dishes. They can enhance the flavour and nutritional content of salads, sandwiches, and soups, or serve as eye-catching garnishes that add a touch of elegance to any plate.

Nutritional benefits

Microgreens are a powerhouse of essential vitamins, including A, C, E, and K, along with vital minerals such as calcium, magnesium, and potassium. They are also rich in powerful antioxidants like polyphenols and flavonoids, and beneficial phytonutrients, often providing higher concentrations of these nutrients compared to their mature counterparts. With the growing focus on healthy eating and sustainable gardening, microgreens are increasingly becoming a staple in both home kitchens and professional restaurants.

The abundant vitamins and antioxidants found in microgreens can bolster and support the immune system, enhancing the body's ability to combat infections and illnesses. Additionally, many microgreens, such as radish and mustard greens, are high in dietary fibre, which aids digestive health by promoting regular bowel movements and improving gut function. Low in calories, microgreens are an ideal choice for those aiming to maintain or lose weight while still enjoying a rich array of nutrients.

Culinary uses

Microgreens can be used fresh, dried, or powdered, making them a versatile addition to various culinary creations. They can enhance salads by adding texture and nutrients, serve as a flavourful alternative to traditional lettuce in sandwiches and wraps, and act as eye-catching garnishes for soups and main dishes. Additionally, blending microgreens into smoothies offers an easy way to boost nutrition while subtly enhancing flavour. Incorporating microgreens into the meals is a delicious way to enjoy their health benefits.

Growing Microgreens

Microgreens have a unique anatomy, consisting of a central stem, cotyledon leaves, and the first pair of immature true leaves. With sizes varying by variety, microgreens typically range from 1 to 1.5 inches in length. Crucially, harvesting must take place within this size range to maintain the classification as microgreens, beyond which they become petite greens.

One of the most attractive features of microgreens is how easy they are to cultivate. They can be grown both indoors and outdoors, in soil or using hydroponic systems, making them ideal for urban environments with limited space. There are several effective methods for growing microgreens, each suited to different environments and preferences. They are soil-based growing and hydroponics growing. Soil-based growing involves using shallow trays or containers filled with a well-draining growing medium of soil. Seeds are scattered evenly, lightly covered with a thin layer of soil or coco peat, and regularly misted. This method offers a simple setup, natural growing conditions, and ease of harvesting. In contrast, hydroponic growing uses a system where seeds are grown in nutrient-rich water instead of soil, often in trays with a water reservoir and nutrient solution. This method provides efficient use of space and resources, promotes faster growth, and reduces the risk of soil-borne diseases.

Benefits of growing microgreens

- **Nutrient-dense**: Microgreens are packed with a higher concentration of essential vitamins, minerals, and antioxidants compared to their mature counterparts. Studies have shown that certain varieties, like red cabbage, cilantro, and radish microgreens, can contain up to 40 times more nutrients than fully grown vegetables. This makes them a powerful addition to a healthy diet, especially for those looking to boost their intake of nutrients without consuming large amounts of food.
- **Fast growth cycle:** One of the most appealing aspects of growing microgreens is their rapid growth cycle. Typically, they are ready to harvest within 7 to 21 days after planting. This short time frame allows for quick, continuous harvests, making them an ideal option for people who want fresh, homegrown produce on a regular basis. With such a fast turnaround, microgreens provide a consistent and reliable source of food.
- **Space-efficient:** Microgreens don't require much room to grow. They can be cultivated in small trays or pots, making them suitable for windowsills, balconies, rooftops, or even vertical gardens. For city dwellers who may not have access to a backyard or large gardening space, microgreens offer the perfect solution for growing fresh produce in

confined spaces. This makes them highly accessible to urban populations, even in high-density areas.

- **Urban adaptability:** Microgreens are well-suited for urban gardening, as they thrive in environments where space is limited. They can easily be grown indoors or outdoors in compact areas like apartments or small homes. Additionally, they don't require much natural light, meaning they can still grow well under artificial lighting. This adaptability makes microgreens an ideal option for individuals living in cities, where outdoor gardening opportunities are often scarce.
- **Year-round cultivation:** Microgreens can be grown indoors, making it possible to cultivate them all year long, regardless of the climate or season. With the use of simple tools like grow lights, trays, and basic gardening supplies, anyone can produce fresh microgreens even during the winter or in locations with limited outdoor gardening conditions. This means you can have access to fresh, nutritious produce throughout the year, no matter where you live.
- **Improved flavour**: Despite their small size, microgreens pack a punch when it comes to flavour. Their robust flavours allow them to enhance dishes without the need for large quantities, making them a popular choice among chefs and home cooks alike. From salads to sandwiches and smoothies, microgreens elevate both the taste and nutritional value of meals.
- **Low resource requirements**: Growing microgreens is an environmentally friendly practice because they require minimal resources. They use little soil, water, and light, making them highly efficient crops. For people in urban environments with limited access to gardening supplies, this makes microgreens a sustainable option. Additionally, because they are grown locally (often indoors), they eliminate the need for transportation and packaging, reducing their carbon footprint.
- **Vertical farming and space maximization:** Microgreens are an excellent crop for vertical farming, a technique that maximizes space by stacking layers of plants on top of each other. In urban settings where horizontal space is limited, vertical farming allows for high-density production in smaller areas. This method is particularly useful in cities, where innovative approaches to agriculture are needed to meet the demands of growing

populations. Vertical farming makes it possible to cultivate large amounts of microgreens in confined spaces like warehouses, greenhouses, or even rooftops.

- **Income opportunities for urban farmers:** Growing microgreens can also be a profitable venture for urban farmers or individuals looking to earn extra income. Because they are highly sought after by restaurants, grocery stores, and health-conscious consumers, microgreens have become a lucrative niche in the urban farming industry. Even small-scale growers can sell their produce at local farmers' markets or directly to customers, offering a fresh, high-quality product that is in demand. The quick growth cycle and low resource requirements make it a cost-effective option for those looking to start a small business.

Here's a simple guide to grow your own microgreens:

1. Choose your seeds

You can use a variety of seeds such as groundnut, wheatgrass, sesame, pea, cowpea, black gram, horse gram, chickpea, sunflower, basil, radish, coriander, chia, cauliflower, broccoli, amaranthus, and mustard greens. However, it's best to avoid seeds from plants like tomato and brinjal, as they are not suitable for microgreens cultivation.

2. Preparation of growing medium

You can use coco peat, vermicompost, or a combination of both, or even opt for a hydroponic setup. Ensure the growing medium is well-draining and free from contaminants. For containers, you can use plastic trays, paddy trays, or similar options.

3. Sow the seeds

Evenly sprinkle the seeds densely over the surface of the growing medium and press them down gently. Cover them with a thin layer of soil or coco peat to ensure they are properly covered, and lightly water by misting. Place a tray over the setup for two days to help accelerate germination. Once the seeds have sprouted, remove the cover tray. For even faster germination, you can consider using pre-soaked seeds.

4. Water and sunlight

Mist the seeds gently with water regularly to ensure they are adequately moistened. Place them in a location with sunlight or under grow lights. Microgreens need about 4 hours of direct sunlight. Maintain a temperature between 15-24°C for optimal growth.

5. Check growing conditions

Ensure the growing environment has good air circulation and is not too humid, as these conditions can promote mould growth. Excess moisture in the growing medium or from misting can also contribute to mould issues.

6. Harvest

Microgreens are generally ready to harvest within 7 to 21 days, indicated by the emergence of the first set of true leaves. To harvest, use scissors to cut the greens just above the soil line, including both the shoot and cotyledons. Rinse them well and enjoy them fresh in salads, smoothies, or as garnishes. Avoid cooking microgreens, as this can reduce their nutritional value.

7. Storage

Microgreens can be stored in the refrigerator for up to 10 days without significant loss of their nutritional content. To maintain their freshness, keep them in a sealed container or a plastic bag with some ventilation. Make sure they are dry before storing, as excess moisture can lead to spoilage.

Conclusion

Microgreens are a sustainable and nutritious addition to any diet, bringing a wealth of flavours and health benefits to the table. Their ease of cultivation makes them a viable option for gardeners of all levels, regardless of space constraints, from urban apartments to traditional gardens. With their rapid growth and minimal space requirements, microgreens can be grown indoors or outdoors, offering a practical and rewarding gardening experience.

Incorporating microgreens into your meals not only enhances the flavour and presentation of your dishes but also significantly boosts your intake of essential nutrients. Rich in vitamins, minerals, and antioxidants, these tiny greens can contribute to improved overall health and well-being. Whether you choose to grow them yourself or source them from a local market, microgreens offer a simple yet impactful way to elevate your culinary creations and nourish your body. Their versatility extends beyond the kitchen, making them an excellent choice for adding a nutritional punch to salads, sandwiches, soups, and more. By embracing microgreens, you can enjoy both the practical benefits of easy cultivation and the profound impact they have on your health and diet.

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NUTRITIONAL AND ANTI NUTRITIONAL FACTORS IN MUSTARD

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Abstract

People all across the world include mustard in their diets because of its flavor and application as a spice. Its apparent anti-nutritional qualities, however, restrict its application and consumption in diets based on both humans and animals. Phytic acid, total glucosinolates, and sinapine content are examples of anti-nutritional elements. Substantial anti-oxidative qualities comprise ferrous ion chelating activity, reducing activity, and DPPH scavenging activity. explaining the presence of significant basic phytochemicals and their distribution in various coat color mustard genotypes. The findings indicate that Brassica juncea has the highest concentration of total glucosinolates, methionine, and total antioxidative capacity. This supports the idea that methionine is a metabolic precursor of glucosinolates, and that Brassica juncea has the highest total antioxidative capacity among the three genotypes. Interestingly, the S. alba genotypes that are commonly utilized in the European region have intermediate levels of phytochemicals when compared to the genotypes of black and brown seed mustard, yellow mustard.nutritional factors in mustard like protein ,vitamins,fatty acids etc . Additionally, people use mustard, so it becomes necessary to assess the nutritional and anti-nutritional aspects of this.

Key Words: Antinutritional factor, nutritional factor, Substantial.

Introduction

Demands on agriculture are increased by an overpopulation. The World Health Organization (WHO) reports that 80% of the world's population lives in disadvantaged nations and relies mostly on local plant resources for medical treatment. The Brassicaceae family, also known as by it's traditional name, Cruciferae, is a significant angiospermic family of plants with medicinal, scientific, and commercial value. (ICPD 2021). "The brassicaceae family," includes 3,700 species which is distributed in 338 genera (Biondi et al., 2021). Brassica juncea, sometimes known as the "spice king," is a plant belonging to this economically significant family that has been used globally and cherished in India for its potential as a medicinal and nutritious food. The root, stems, leaves, and seeds are just a few of the plant parts that have been modified to serve as food. Due to its versatility, yielding potential, and comparatively greater resistance to important diseases, pests, and stresses that usually affect other Brassica species, Indian mustard, sometimes referred to as Oriental mustard, is the most widely grown species (Bora et al., 2021). (Salehi et al. 2021) state that mustard seeds are spherical in shape, tiny (1 to 2 mm), and can range in color from yellow to black. As per Favela-González et al. (2020), Indian mustard provides an abundant supply of protein (32–41%) and oil (37–45%). Since brassica has antimicrobial properties, seed-released compounds like allyl and benzyl isothiocyanates may use it as packaging material (Bahmid et al., 2020). What most interests me is the increasing the use of its seeds as feed for ruminants and non-ruminants (Gacek et al., 2018). Mustard beneficial health effects highlight its unique part of a person's diet (Frazie et al., 2017). Moreover, in preventing exposure to substances that cause cancer (Ahmed et al., 2020).

Antinutritional elements

Natural or artificial substances that obstruct nutrient absorption are known as antinutrients. For a number of causes, antinutrients can be found in practically all foods at some degree. Phytates, glycosinolates, phenolics, and fiber are examples of antinutritional ingredients found in rapeseed-mustard. These lower the value of the total seed quality when compared to soybean and restrict the use of rapeseed/mustard as a source of protein in non-ruminant food and feed (Yoshi-Stark et al., 2006; Sadeghiet al., 2009).Because of this, only ruminant feeding and organic fertilizer applications are made using Brassica defatted meal .

Brassicaceae plants, including mustard, contain physiologically active chemicals called glucosinolates. Moreover, glucosinolates may be advantageous for the following reasons: Antioxidant activity: By removing reactive oxygen species, glucosinolates can aid in oxidative stress protection. Anticancer effects: glucosinolate which may help prevent cancer. The direct antibacterial effects of glucoseolates are demonstrated (Kamal et al.,2022). Effects on the heart and nervous system: Glucosinolates have the potential to guard against heart-related and neurological illness High glucosinolate concentrations in cattle can lead to liver and kidney diseases, anemia, goiter, and decreased growth. Hypothyroidism may result from glucoseolates' interference with iodine absorption and thyroid hormone production. These are the adverse effect of glucosinolate(Lopezetal.,2020).

Fig: Different Mustard Seeds

Mustard seeds contain phytic acid, a naturally occurring chemical that can bind to minerals and prevent the body from absorbing them. Over time, this can result in mineral deficiencies, although for most individuals who consume a well-balanced diet, this is not a problem (Gupta et al.,2015). The following are some physiological effects of phytic acid: Mineral absorption: Iron, zinc, calcium, magnesium, and manganese can all be inhibited by phytic acid. Absorption of vitamin D: Phytic acid has the ability to decrease the intestinal absorption of vitamin D. But phytic acid also offers certain health advantages (Zhou et al.,2021). A kind of phytic acid called myo-inositol phosphates may help reduce the development of kidney stones, atherosclerosis, and colon cancer. Less than six phosphate residues in myo-inositols may also assist avoid the problems of diabetes. Before extracting the oil, mustard seeds can be microwaved to lower the phytic acid level and increase the oil's nutritional value.

Acetylcholinesterase inhibitors like sinapine have been demonstrated to provide therapeutic benefits in Parkinson's, myasthenia gravis, Alzheimer's, and ataxia. Sinapine's anticancer and antioxidantproperties have drawn increased interest from scientists in recent years(singh et al.,2015).

Nutritional elements

Mustard oil contains total Antioxidant Content Metabolic activities, which operates as a coenzyme.

Anti-aging: The vitamins A, C, and E found in mustard seeds can help prevent wrinkles and rejuvenate your appearance. It is Rich in PUFA and antioxidants, mustard oil can lower inflammation and promote heart health . Mustard contains folic acid, thiamin, riboflavin, vitamin B6, and vitamins C and E.

The human body uses tryptophan mostly for the production of muscle and protein tissues. Although the human body cannot produce it, tryptophan-rich meals can provide it. Dairy products are among the dietary sources of tryptophan for adult humans.

Methionine is an essential amino acid that the body cannot produce on its own; it must come from diet. Methionine is involved in many bodily processes; it may also function as an antioxidant and aid in the repair of damaged tissues. Methionine is used to treat a variety of illnesses, including breast cancer, liver problems, viral infections, and birth defects, but there isn't enough solid scientific data to support these claims.

β-carotene has anti-diabetic and skin-protective properties. Additionally, it has antioxidant properties that may lower the risk of heart disease. Supplementing with beta-carotene may raise a person's risk of cancer and heart disease if they smoke or drink excessively. According to a study, smokers who consumed large amounts of beta carotene were more likely to develop lung cancer and other smoking-related malignancies.these are Possible negative effects of β-carotene (Ahmed et al., 2020).

The main component of mustard oil is monounsaturated fatty acids (Trusted Source). Mustard oil, 100 grams (g), contains the following approximately59 grams of monosaturated fat, approximately 21 grams of polyunsaturated fats , approximately 11 grams of saturated fat. Free fatty acids is obtain in mustard oil like erucic acid, oleic acid ,palmitic acid , stearic acid, linoleic acid ,linoleic acid. Erucic acid, found in mustard oil, has the potential to be harmful. Myocardial lipidosis is a heart ailment that may be brought on by erucic acid, according to research conducted on animals. In the US, pure mustard oil is not permitted for human ingestion by the Food and Drug Administration (FDA). These are the health hazardous effect of erucic acid .

Table 1: Nutritional and Anti-nutritional Metabolites.

Sr No.	Black mustard	Brown musatrd	Yellow mustard
Nutritional metabolites			
Methionin e Content (g/100g protein)	1-2	1-3	1-2
Tryptopha n Content (g/100g protein)	1-2	1-2	1-2
β-carotene content (ppm)	4 -5	3 -5	3 -5
Anti-nutritional Metabolites			
Phytic acid	1 -3	1-2	1-2
glucosinolates	48-90	57-85	62-108
sinapines	3-10	2-10	2 -12

Conclusion

In summary, mustard seeds have a diverse combination of antinutritional and nutritional properties. Positively, they are a great source of vital nutrients like proteins, healthy fats, vitamins, and minerals that support a number of health advantages like increased antioxidant activity and heart health. On the other hand, anti-nutritional elements such as phytates and glucosinolates can hinder the absorption of nutrients and can be harmful if ingested in excess. Mustard seeds should be included in a balanced diet, cooked to the right degree to minimize the effects of their anti-nutritional components, and consumed in moderation in order to reap the most benefits of mustard while limiting the negative effects of them.

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NOURISHING LIVES: A COMPREHENSIVE GUIDE FOR NATIONAL NUTRITION MONTH-2024

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Introduction

National Nutrition Month 2024, themed "Beyond the Table," encourages a deeper exploration of nutrition beyond just what's on our plates. This year's focus is on understanding how our food choices impact not only our health but also our communities, food systems, and the environment. From ensuring balanced diets to adopting sustainable and mindful food practices, National Nutrition Month offers a comprehensive approach to better nutrition and overall wellness. Here are key nutrition guidelines that embody the "Beyond the Table" theme, with an emphasis on holistic well-being.

1. Eat a Variety of Foods to Ensure a Balanced Diet:

The foundation of good nutrition lies in variety. Consuming a diverse range of foods ensures that the body receives all essential nutrients. A balanced diet, rich in cereals, pulses, fruits, vegetables, dairy, and protein sources, provides vitamins, minerals, and antioxidants essential for health maintenance and disease prevention.

2. Ensure Provision of Extra Food and Healthcare During Pregnancy and Lactation:

Nutrition during pregnancy and lactation directly influences both the mother and the child's health. Extra food and healthcare, particularly rich in protein, iron, calcium, and vitamins, are necessary for proper fetal growth and maternal health. A balanced diet during this stage can prevent complications like anemia and malnutrition.

3. Ensure Exclusive Breastfeeding for the First Six Months and Continue Breastfeeding Till Two Years and Beyond:

Exclusive breastfeeding for the first six months provides infants with the essential nutrients and antibodies needed for optimal growth and immunity. Breastfeeding, as recommended by the World Health Organization (WHO), should continue for up to two years, with complementary foods introduced at six months.

4. Start Feeding Homemade Semisolid Complementary Foods Soon After Six Months:

After six months, it's vital to introduce homemade semisolid complementary foods, such as mashed fruits, cereals, and pulses, alongside breastfeeding. These foods are essential for meeting the growing energy and nutrient requirements of infants. Homemade options provide the best nutrition and reduce the risk of exposure to processed foods.

5. Ensure Adequate and Appropriate Diets for Children and Adolescents in Health and Sickness:

Proper nutrition is critical for children and adolescents, particularly in periods of rapid growth or illness. A diet rich in proteins, vitamins, and minerals strengthens immunity and supports development. Even during sickness, nutrient-dense foods help accelerate recovery and ensure long-term health.

6. Eat Plenty of Vegetables and Legumes:

Vegetables and legumes are nutrient powerhouses that provide dietary fiber, vitamins, and minerals while promoting digestive health. Regular consumption of these plant-based foods can reduce the risk of chronic diseases such as heart disease and diabetes.

7. Use Oils/Fats in Moderation, Choose a Variety of Oilseeds, Nuts, and Nutri-Cereals:

Healthy fats are necessary for brain function and hormone production, but their consumption should be moderate. Using oils like olive, mustard, or coconut oil in small amounts, and incorporating seeds, nuts, and cereals, ensures a balanced intake of essential fatty acids.

8. Obtain Good Quality Proteins and Essential Amino Acids (EAA) Through Appropriate Combination of Foods:

High-quality proteins are essential for building and repairing tissues. Combining plant and animal sources-like pulses, dairy, and meat-provides all essential amino acids, without the need for protein supplements. A natural diet rich in protein supports muscle development and overall health.

9. Adopt a Healthy Lifestyle to Prevent Abdominal Obesity and Overall Obesity:

Maintaining a healthy weight is a key component of disease prevention. Abdominal obesity, in particular, is linked to metabolic disorders such as type 2 diabetes and heart disease. Adopting a balanced diet, practicing portion control, and staying active help prevent weight gain and obesity-related health issues.

10. Be Physically Active and Exercise Regularly:

Physical activity is a crucial part of overall health. Regular exercise not only helps maintain a healthy weight but also improves cardiovascular health, strengthens muscles and bones, and boosts mental well-being. A combination of aerobic exercises, strength training, and flexibility workouts should be incorporated into daily routines.

11. Restrict Salt Intake:

Excessive salt intake is linked to high blood pressure, which increases the risk of cardiovascular diseases. The World Health Organization recommends limiting daily salt intake to no more than 5 grams (about one teaspoon) to help reduce hypertension and heart disease.

12. Consume Safe and Clean Foods:

Food safety is essential to avoid foodborne illnesses, which can range from mild gastrointestinal distress to serious health conditions. Ensuring proper storage, handling, and cooking of food minimizes the risk of contamination and enhances nutritional value.

13. Adopt Appropriate Pre-cooking and Cooking Methods:

Healthy cooking methods like steaming, boiling, and grilling preserve the nutrient content of foods. Avoid overcooking, as it can destroy essential vitamins and minerals. Using less oil and salt, and adding herbs and spices, can enhance flavor while keeping meals nutritious.

14. Drink Adequate Quantity of Water:

Water is essential for life. It aids in digestion, nutrient absorption, and toxin elimination. Staying hydrated is crucial for maintaining healthy skin, regulating body temperature, and ensuring optimal physical and cognitive performance. Adults should aim to drink at least 2-3 liters of water daily.

15. Minimize the Consumption of High Fat, Sugar, Salt (HFSS), and Ultra-Processed Foods (UPFs):

High fat, sugar, and salt (HFSS) foods, especially ultra-processed foods (UPFs), are linked to an increased risk of obesity, diabetes, and cardiovascular diseases. Minimizing their consumption and replacing them with whole, nutrient-rich foods is key to maintaining long-term health.

16. Include Nutrient-Rich Foods in the Diet of the Elderly:

As people age, their nutrient needs change. The elderly need foods rich in vitamins D and B12, calcium, and proteins to maintain bone density, muscle mass, and cognitive function. Incorporating nutrient-rich foods like dairy, nuts, seeds, and fruits supports healthy aging.

17. Read Information on Food Labels and Make Healthy Food Choices:

Reading food labels is a simple but effective way to make informed decisions about what we eat. Nutritional information on packaging helps consumers assess calorie content, ingredients, and nutrient values, making it easier to avoid unhealthy choices and adopt a balanced diet.

Conclusion: Beyond the Table

National Nutrition Month 2024's "Beyond the Table" theme underscores the importance of a holistic approach to nutrition. By following these guidelines, we can ensure better health outcomes for individuals and communities. From ensuring food safety and mindful eating to embracing sustainability in food choices, National Nutrition Month encourages us to think critically about the role food plays in our lives and our world.

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BEYOND MEALS: A HOLISTIC APPROACH TO NUTRITION FOR NATIONAL NUTRITION MONTH-2024

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Introduction

National Nutrition Month 2024, celebrated throughout September, brings a fresh perspective to how we view food and nutrition. This year's theme, "Beyond the Table," encourages us to think about nutrition not just as what we consume but as an interconnected system that influences our lives, communities, and the environment. The campaign emphasizes that food is not merely about individual meals but is tied to social, cultural, economic, and environmental factors. This holistic approach highlights the far-reaching impact of nutrition on health, sustainability, and overall well-being.

The 2024 Theme: "Beyond the Table"

The theme "Beyond the Table" is a call to action that urges us to go beyond just focusing on our plates and explore how nutrition affects broader aspects of life. It asks us to consider the entire food system from food production to consumption and its role in shaping public health, food security, and environmental sustainability.

Understanding Food as a System

The traditional approach to nutrition is centered around what we eat, but this theme urges us to recognize that food systems involve everything from agricultural practices to food processing, distribution, consumption, and waste management. The quality and availability of nutrition are affected by multiple layers of influence:

1. **Agricultural methods** and their impact on soil health and food quality.
2. **Food security and accessibility**, where geographical and socio-economic barriers affect people's ability to get nutritious food.
3. **Cultural practices and social influences**, which shape food preferences, traditions, and dietary habits.

Focus on Public Health

Beyond simply eating healthy, nutrition plays a critical role in the public health sector, contributing to the prevention of non-communicable diseases (NCDs) and improving life expectancy. The 2024 campaign highlights that addressing nutrition is essential to combating health challenges like obesity, malnutrition, and chronic diseases. For instance:

- Obesity rates are rising in India, driven by poor dietary choices and the overconsumption of calorie-dense, nutrient-poor foods.
- Malnutrition remains a pressing issue in marginalized communities, particularly affecting children and women of reproductive age, leading to stunting and wasting in children.

Thus, improving access to nutritious foods is crucial to better public health outcomes.

Nutrition and Sustainability

Another vital aspect of the "Beyond the Table" theme is the relationship between food production and environmental sustainability. Food systems are a significant contributor to global environmental issues, including climate change, deforestation, and biodiversity loss. National Nutrition Month 2024 emphasizes the need for:

- Sustainable farming practices, like regenerative agriculture, which enrich soil health, conserve water, and increase biodiversity.
- Reducing reliance on processed foods, which have a larger carbon footprint due to their production processes and packaging.
- Encouraging plant-based diets, as they are generally less resource-intensive and contribute less to greenhouse gas emissions compared to animal-based diets.

The campaign promotes sustainable food consumption patterns, which include reducing food waste, eating seasonally, and supporting local producers to minimize the environmental impact of long food supply chains.

Food Security and Economic Impact

The theme also explores the link between nutrition and economic stability. Healthy populations are the backbone of productive economies, and the absence of proper nutrition can lead to long-term economic burdens due to increased healthcare costs and reduced workforce productivity. Food insecurity and poverty continue to plague many parts of India, leading to nutrition gaps that exacerbate inequality. During National Nutrition Month, there is an emphasis on:

- Addressing food insecurity by supporting government food aid programs like Public Distribution System (PDS) and Poshan Abhiyaan, which aim to make nutritious food accessible to vulnerable populations.
- Developing local food economies that support smallholder farmers, create jobs in agriculture, and encourage communities to buy locally produced foods.

Cultural and Social Influences on Nutrition

The theme further urges us to think about the cultural dimension of nutrition. Food habits, preferences, and traditions are deeply rooted in cultural practices, which shape dietary choices and influence how nutrition is perceived. In many cases, cultural beliefs can promote healthy eating habits, but they can also lead to imbalances in nutrition when they prioritize certain foods over others or encourage unhealthy practices.

The Role of Food Literacy

National Nutrition Month 2024 also stresses the importance of food literacy-teaching people about the origins of their food, the nutritional value of different ingredients, and the impact their choices have on health and the environment. By increasing public awareness and promoting better food choices, the campaign aims to empower individuals to make informed decisions that go beyond the immediate satisfaction of hunger.

Key Messages for 2024

1. **Food is More than Just What We Eat**: It’s part of a complex system that affects health, the economy, and the environment.

2. **Public Health Focus**: Nutrition is central to preventing diseases, supporting healthy lifestyles, and ensuring food security for all.
3. **Sustainability**: Our food choices impact the environment. Eating sustainably supports ecological health and reduces climate change impacts.
4. **Food Literacy**: People need to understand where their food comes from, how it's produced, and its broader impacts on society and health.
5. **Economic Impact**: Investing in nutrition improves health outcomes, reduces healthcare costs, and drives economic productivity.

Conclusion: Going Beyond the Plate

National Nutrition Month 2024's "Beyond the Table" theme challenges us to rethink how we approach food and nutrition. It's a reminder that the choices we make about what to eat have far-reaching implications for our health, our communities, and our planet. By understanding food as part of a larger system, we can make more thoughtful, sustainable, and equitable choices that support a healthier future for all.

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ROSE APPLE – AN UNDERUTILIZED TROPICAL FRUIT

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Introduction

Rose apple botanically *Syzygium jambos* L. (Alston) belongs to the family Myrtaceae is an evergreen medium sized tree which adapted well under tropical climatic conditions. It is native of Southeast Asia, however well naturalized in tropical regions of India and Sri Lanka. Rose apple is commonly known as Jambu, Plum rose, Malay apple and Malabar plum at different places and considered as one of the underutilized tropical fruits of India. This is mainly grown as a backyard fruit in Kerala, Tamil Nadu, Karnataka, and Odisha. Rose apple has a great market potential owing to its fruit quality and typical rose aroma. It can be a viable option for diversification and value addition in fruit crops provided improved varieties, quality planting materials and scientific cultivation practices are available.

Botany

The rose apple is grown as a shrub but is generally a tree reaching the height of 7 to 12 m, and has a dense crown of slender, wide-spreading branches, often the overall width exceeding the height. The evergreen leaves are opposite, lanceolate or narrow-elliptic, tapering to a point; 10 to 22 cm long, and 2.5 - 6 cm wide; somewhat leathery, glossy, dark-green when mature, rosy when young. The flowers are creamy-white or greenish-white, 5 to 10 cm wide, consisting mostly of about 300 conspicuous stamens, a 4-lobed calyx, and 4 greenish-white, concave petals. There are usually 4 or 5 flowers together in terminal clusters. Capped with the prominent, green, tough calyx, the fruit is nearly round, oval, or slightly pear-shaped, 4 to 5 cm long, with smooth, thin, pale-yellow or whitish skin, sometimes pink-blushed, covering a crisp, mealy, dry to juicy layer of yellowish flesh, sweet and resembling the scent of a rose in flavor. In the hollow center, there are 1 to 4 brown, rough-coated, medium-hard, more or less rounded seeds, 1 to 1.5 cm thick, which loosen from the inner wall and rattle when the fruit is shaken.

Origin and Distribution

The rose apple is native to the East Indies and Malaya. It was introduced into Jamaica in 1762. In Guatemala, the tree may be planted as a live fence or in hedgerows around coffee plantations. For this purpose, it is drastically pruned to promote dense growth.

Variety

Arka Neelachal Akshay, a high yielding variety of rose apple, has been developed through seedling selection at Central Horticultural experiment Station (ICAR-IIHR), Bhubaneswar, Odisha. The variety has been released by the ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka on the basis of its quality, drought tolerance and market potential. It is an early maturing variety as fruit ripening occurs in March-April. Flowering starts in December and continues till January. Flower appears terminally and axially in a group of 5-9 buds. Fruit maturation is completed in about 85-90 days which is evident with the appearance of bright yellow peel colour. It has fairly large fruit size (30.2 ±3.2 g) with high yield potential (10-12 kg/plant). Fruit is characterized with high pulp content (77.5±2.4%), pulp thickness, firm texture, TSS (15°Brix), sugar content (12.5±1.0%) and intense rose flavour. Fruits contain 1-2 large, unarmoured seeds, lying loose in a slightly fluffy cavity when ripe. It is rich in vitamin C, and mineral contents such as calcium and iron. The variety is almost free from any major disease and fruit fly incidence (<1.5%).

Climate

The rose apple flourishes in the tropical and semi tropical climates only. In India, it ranges up to 4,400 ft (1,350 m). It does best on the banks of canals and streams and yet tolerates semi- arid conditions. Prolonged dry spells, however, are detrimental.

Soil

A deep, red loamy soil is considered ideal for the rose apple cultivation.

Propagation

Most rose apple trees are grown from seeds, which are polyembryonic, but the seedlings are not true to type. In India, vegetative propagation has been undertaken with a view to standardizing the crop and to select and perpetuate dwarf types. It was found that hardwood cuttings does not root even with chemical growth promoters. Treated semihard wood gave 20% success. Air layers taken in the spring and treated with 1,000 ppm NAA gave 60% success. Air layers did not root in the rainy season. In budding experiments, neither chip nor T budding was successful. Veneer grafting in July of spring-flush scions on 1-year-old rootstocks was satisfactory in 31% of the plants. Fruiting can be expected within 4 years.

Planting

Prior to planting, the field is properly cleared and ploughed. Pits of 1 x 1 x 1 m size are dug at the distance of 5 to 6 m both ways. Usually, digging of pits is completed before the onset of monsoon. The pits are filled with a mixture of 75% top soil and 25% well rotten farmyard manure or compost. A spacing of 6 m × 7 m (238 plants/ha) may be opted for new plantation, however high density planting system with the spacing of 5 m × 5 m (400 plants/ha) may also be adopted by following annual pruning in the month of May–June.

Fertilizer Application

The rose apple trees are generally not manured. This is not because they do not require manuring or fail to respond to it but because they can stand a good deal of neglect. An annual dose of about 20 kg FYM during the pre-beating period and 50 kg per tree bearing trees is considered. The variety has low input requirement, however application of N, P and K @ 500, 300 and 600 g/plant/year, respectively in two splits i.e. October–November and January–February ensures better yield and fruit quality. On very rich soils, the trees have a tendency to put on more vegetative growth with the result that fruiting is delayed. When the trees show such a tendency, they should not be supplied with any manure and fertilizer and irrigation should be given sparingly and withheld in September-October and again in February-March. This helps in fruit bud formation, blossoming and in fruit setting. Sometimes this may not prove effective and even more drastic treatments such as ringing and root pruning may have to be resorted to.. A fruit grower has, therefore, to be cautious in manuring and fertilizing rose apple trees and hence, must adjust the doses according to the growth and fruiting of trees. A 4 to 5 years old rose apple plantation should be fed with the nutrients as tabulated below.

Nutrient	Quantity (per plant /year)
Nitrogen	500 gm
Phosphorus	200 gm
Potash	200 gm
FYM	50 kg

Irrigation

In early stages, the rose apple tree requires frequent irrigations but after the trees gets established, the interval between irrigations can be greatly decreased. Young trees require 8 to 10 irrigations in a year. The mature trees require only about half the number, which should be applied during May and June when the fruit is ripening. During autumn and winter months, just occasional irrigation may be applied when the soil is dry. This will also save the trees from the ill effects of frost in winter. Rose apple can thrive well under moisture-stress condition; however, fruit size gets increased if soil moisture is maintained during fruit development in the months of January to February).

Training and Pruning

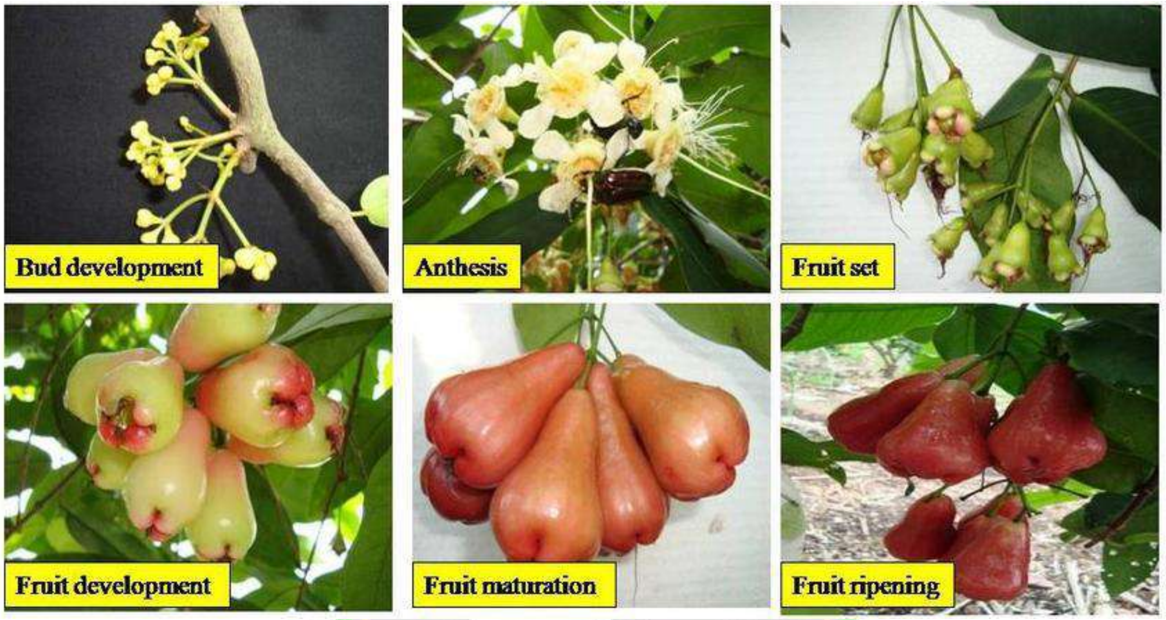
Regular pruning in rose apple is not required. However, in later years the dry twigs and crossed branches are removed. While training the plants, the framework of branches is allowed to develop above 60 to 100 cm from the ground level. The average yield of fruits from a full grown seedling tree is about 3-5 kg and from a grafted one 6-8 kg per year.

Pest and disease

The tree is fairly tolerant to diseases. Trunks are also vulnerable to termite attacks. Foliage is affected by sap-feeders, defoliators, miners, and borers. Beetles often attack the foliage of young trees. However fruit fly is the major pest of rose apple as they lay eggs on fruits, resulting in larvae boring into the flesh. They can be controlled by bagging the fruits and appropriate field sanitation practices. Infested fruits on the tree and the ground should be removed and the soil under the tree should be dug to remove the pupae. Whereas the IIHR released improved variety has the distinctive trait that it is almost free from major diseases and fruit fly.

Harvesting and yield

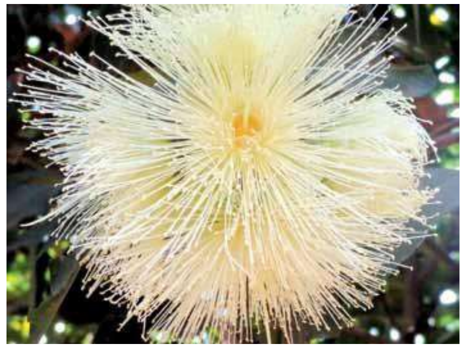
Normally, seedling rose apple trees start bearing at the age of 5 to 6 years while grafted or budded trees come into bearing in 4 to 5 years. The variety Arka Neelachal Akshay starts giving fruits after three years of planting, however economic yield is obtained after five years. Harvesting should be done with care as fruits are prone to bruising.



Different stages of fruit growth and development of Rose apple

Variability in Rose apple

Polyembryony



Flowering in Rose apple

Fruits of newly released rose apple variety Arka Neelachal Akshay

Ripening starts in the mid of March and continues till mid-April. Fruits may be graded on the basis of size for higher market price. Fruits weighing more than 30 g may be considered as Grade A; whereas fruit with weight between 25-30 g may be considered as Grade B. Fruits may be stored at 10-12 °C for 8-10 days. The cultivation of rose apple is highly profitable if it is carried out following scientific production technologies. The establishment cost of the orchard may be around Rs.50000/ha, whereas the cost of cultivation of well grown bearing plants may be Rs.70000/ha. Fruit yield of 3-4 t/ha/annum may be easily obtained with tentative income of 3.0 lakh. Thus a benefit of 2.00 lakh may be earned from one hectare plantation of this variety.

Conclusion

Commercial exploitation of underutilized fruit species is need of the hour for crop diversification as well as increasing fruit basket. In this endeavour, tapping the potential of important minor fruit crops and effective management of their genetic resources seems promising. Rose apple is one of such potential underutilized fruit crops with high market value. However, due to the unavailability of improved variety and quality planting materials, its cultivation is restricted to selected localities and in backyard plantation. Development of a high yielding variety of rose apple will be helpful in enhancing the area under cultivation as well as its commercial exploitation through production of quality planting materials by the Centre. Rose apple has the potential to become viable options for crop diversification due to fruit quality and higher yield. The variety has ability to thrive well in the moisture stress condition and thus can be cultivated in semi- arid regions, marginal uplands and problematic soils. Therefore, considering the possible inevitable impact of climate change on production efficiency of major fruits, underutilized fruit crop like rose apple may be an economically viable option for the fruit growers in tropical regions.

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SINGAPORE CHERRY – A MULTIFUNCTIONAL TREE FOR LANDSCAPING

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Introduction

Muntingia calabura , commonly known as the Singapore cherry, is a small to medium-sized tree that is native to Central and South America but has now spread throughout the tropics. In addition to its medicinal properties, the tree is also valued for its timber, which is used for making furniture, boxes, and crates. The wood is hard and durable and has a light yellowish-brown color. The tree was introduced to Singapore in the early 1900s as an ornamental plant, and it quickly became popular due to its attractive white flowers and edible red fruit. It is now commonly found throughout the country, especially in parks and gardens. Despite its popularity, the Singapore cherry is considered an invasive species in some countries, as it can quickly spread and outcompete native vegetation. As a result, it is sometimes referred to as a "weed tree. Also called as cotton candy berry, calabur tree, festival berry, Jamaican cherry, Panama berry, strawberry tree, ornamental cherry and jamfruit tree. Muntingia is a genus of plants in the family Muntingiaceae, comprising only one species, *Muntingia calabura*, named in honour of Abraham Munting, a Dutch botanist and botanical artist (1626-1683). It is native from Mexico south to Bolivia and Argentina.

Botany

It is a small tree 7-12 meters tall with tiered, spreading and slightly drooping branches. It has serrated leaves 2.5-15 cm long and 1-6.5 cm wide. The flowers are small and white, gives rise to 1-1.5 cm light red fruit. solitary or in inflorescences of two or three flowers, with five lanceolate sepals, hairy, five obovate white petals, many stamens with yellow anthers, and a smooth ovoid ovary. The flowers last only one day, their petals drop in the afternoon. The fruit is edible, sweet and juicy, and contains a large number of tiny (0.5 mm) yellow seeds. They are green when unripe turning into red when they are mature. Its pulp is light-brown and juicy, with very fine seeds; the pulp tastes like fig. It is a pioneer species that thrives in poor soil, able to tolerate acidic and alkaline conditions and drought. Its seeds are dispersed by birds and fruit bats. It is cultivated for its edible fruit and has become naturalised in some other parts of the tropics, including southeastern Asia.

1. The tree is small, white flowers that bloom year-round with bright red, cherry-like fruits.
2. The leaves, bark, and fruit of the tree have long been used in traditional medicine to treat a variety of ailments.
3. An evergreen tree that typically grows to a height of 5-12 meters.
4. It grows best in warm, humid climates with temperatures between 20-35°C.

Features

- Singapore cherry is a fast-growing tree that can reach up to 15 meters in height in the wild, although it is usually smaller when cultivated.
- It has a spreading canopy of light green leaves that provides shade and shelter for wildlife.
- The tree produces small, white flowers that bloom year-round and are followed by bright red, cherry-like fruits that are edible and sweet when ripe.
- It is a hardy plant that is resistant to pests and diseases

Care

Propagation

Singapore cherry can be propagated through seeds or cuttings. Seed propagation is the easiest method, but it can take several years for the tree to produce fruit. Cuttings can be rooted in a moist soil mixture, and they will usually start to produce new growth within a few weeks.

Soil

The tree prefers well-draining soil that is rich in organic matter. A soil pH range of 6.0 to 7.5 is ideal for optimal growth.

Climate

The tree prefers full sun but can also tolerate partial shade. It is important to ensure that the tree receives adequate sunlight for healthy growth and fruit production.

Singapore cherry tree

Singapore cherry flowering

Singapore cherry fruits

Fertilizer

The tree benefits from regular fertilization, particularly during its growing season. A balanced fertilizer with equal amounts of nitrogen, phosphorus, and potassium is recommended.

Watering

It requires regular watering, particularly during the hot and dry seasons. However, it is important not to overwater the tree as it can lead to root rot.

Pruning

Singapore cherry requires minimal pruning to maintain its shape and size. Remove any dead or diseased branches as soon as possible to prevent further damage to the tree.

Pests and diseases

It is generally resistant to pests and diseases. However, it can be susceptible to some fungal infections, particularly in humid conditions. Regular inspection of the tree can help prevent any potential problems.

Uses of Singapore cherry

1. **Food**: The fruit of Singapore cherry is edible and can be eaten raw or used in jams, jellies, and other food products. The fruit is high in vitamin C and antioxidants, making it a popular health food.
2. **Traditional medicine**: The leaves, bark, and fruit of Singapore cherry have long been used in traditional medicine to treat a variety of ailments, including diarrhea, dysentery, and fever. The plant contains several bioactive compounds that have demonstrated antibacterial, anti-inflammatory, and antioxidant properties in scientific studies.
3. **Timber**: The wood of Jamaican cherry is hard and durable and is used for making furniture, boxes, and crates.
4. **Ornamental value**: *Muntingia calabura* is also valued for its ornamental value, with its attractive white flowers and colorful fruits making it a popular landscaping plant in tropical regions.
5. **Environmental benefits:** The tree has environmental benefits, as it can help prevent soil erosion and provide shade and shelter for wildlife.
6. **Bee keeping:** The nectar produced by the flowers of Jamaican cherry is attractive to bees, making it a useful plant for beekeeping.
7. **Insect repellent:** The leaves of *Muntingia calabura* are sometimes used as a natural insect repellent, as they contain compounds that are believed to repel mosquitoes and other insects.

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PEST OF TOMATO AND THEIR MANAGEMENT

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Introduction

More than 80 % of the fruit get damaged under severe infestation of fruit borer and Tomato pin worm. Whitefly and thrips act as vector for certain viral diseases, which cause considerable yield reduction.

Fruit borer: *Helicoverpa armigera* (Noctuidae: Lepidoptera)

Bionomics

Larvae hide within the earheads and feeds on the grains. Earheads are partially eaten with chalky appearance. Fecal pellets are visible within the ear heads.

Adult is brown coloured moth with a 'V' shaped speck on forewings and dull black border on the hind wing. Larva is green with dark broken grey lines and dark pale bands. It shows colour variation of greenish to brown.

Management

- Collect and destroy the infested fruits and grown up larvae.

- Grow less susceptible genotypes Rupali, Roma, Pusa red plum.
- Grow resistant cultivars like BT 1, T 32, T 27, Punjab Kesri, Punjab Chuhashu,Pant Bahar, Azad Pusa Hybrid 4
- Grow simultaneously 40 days old African tall marigold and 25 days old tomato seedling at 1:10 rows to attract *Helicoverpa* adults for egg laying.
- Set up pheromone trap with Helilure at 15/ha and change the lure once in 15days.
- Release *T. chilonis* 6 times @ 50,000/ha per week coinciding with floweringtime based on ETL.
- Release *Chrysoperla carnea* at weekly interval at 50,000 eggs or grubs / hafrom 30 days after planting.

- Spray any of the following insecticides with 500 L water/ha
  - Azadirachtin 1.0% 1.0-1.5 L
  - Indoxacarb 14.5 SC 400-500 ml
  - Lambda cyhalothrin 5 EC 300 ml
  - Novaluron 10 EC 750 ml
  - Carbaryl 50 WP 1 kg
  - Quinalphos 1250 ml
- Do not spray insecticides after maturity of fruits.
- Encourage activity of parasitoid *Eucelatoria bryani*, *Campoletes*, *Chelonus* etc.,

Serpentine leaf miner: *Liriomyza trifolii* (Agromyzidae: Diptera)

An introduced pest becoming serious in the recent years.

Damage symptoms

Maggots mines into leaves and cause serpentine mines drying and drooping of leaves

Bionomics

Egg: 2-4 days. Female thrusts eggs into the epidermal layer of leaves.

Larva: 7-10 days. Minute orange yellowish apodous maggots.

Pupa: 5-7 days. Pupates within mines.

Adult: Pale yellow in colour.

Management

I. Collect and destroy mined leaves
II. Spray NSKE 5%

Leaf eating caterpillar: *Spodoptera litura* (Noctuidae: Lepidoptera)

Biology

It is found throughout the tropical and subtropical parts of the world, wide spread in India. Besides tobacco, it feeds on cotton, castor, groundnut, tomato, cabbage and various other cruciferous crops.

Eggs: Female lays about 300 eggs in clusters. The eggs are covered over by brown hairs and they hatch in about 3-5 days.

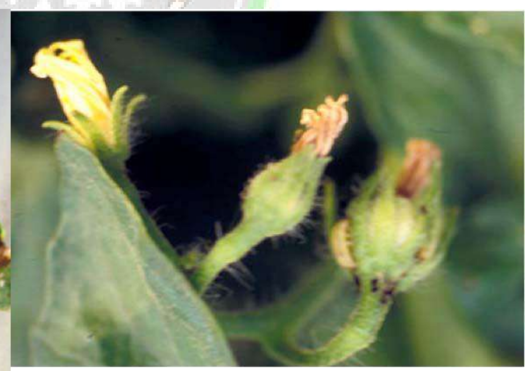
Larva: Caterpillar measures 35-40 mm in length, when full grown. It is velvety, black with yellowish – green dorsal stripes and lateral white bands with incomplete ring – like dark band on anterior and posterior end of the body. It passes through 6 instars. Larval stage lasts 15-30 days

Pupa: Pupation takes place inside the soil. Pupal stage lasts 7-15 days.

Adult: Moth is medium sized and stout bodied with forewings pale grey to dark brown in colour having wavy white crisscross markings. Hind wings are whitish with brown patches along the margin of wing. Pest breeds throughout the year. Moths are active at night. Adults live for 7-10 days. Total life cycle takes 32-60 days. There are eight generations in a year.

Damage symptoms

- In early stages, the caterpillars are gregarious and scrape the chlorophyll content of leaf lamina giving it a papery white appearance. Later they become voracious feeders making irregular holes on the leaves.
- Irregular holes on leaves initially and later skeletonization leaving only veins and petioles
- Heavy defoliation.
- Bored fruits with irregular holes
- Warm weather conditions and rainy conditions are favourable for multiplication.



Whitefly: *Bemisia tabaci* (Aleyrodidae: Hemiptera)

Biology

- Egg: Pear shaped, light yellowish Stalked
- Nymph: On hatching - Oval, scale-like, greenish white
- Adult: White, tiny, scale-like adult.

Damage symptoms

- Chlorotic spots, Yellowing, Downward curling and drying of leaves.
- Vector of tomato leaf curl disease.

Favourable conditions.

- Warm weather conditions are favourable for multiplication.

Thrips: *T. tabaci*, (Thripidae: Thysanoptera)

Damage symptoms

Vector of tomato spotted wilt virus. Feeds on flowers resulting in pre-mature dropping of flowers and also cause bud necrosis.

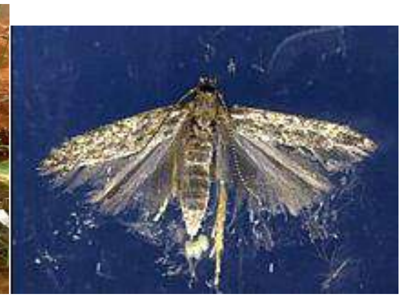

The thrips rasp and pierce the surface of the plant with their mouthparts, mostly choosing young plant growth. They then add digestive juices and suck up the fluids that seep from the wounds. As the plant part grows, so do the damaged regions, leaving silvery streaks. The more thrips that are present, the greater the area of plant damaged, reducing the area of foliage available for photosynthesis. At the same time more water is transpired and pathogens can find a way to gain entry. In severely damaged plants, leaves may wither and the whole plant may appear silvery; the crop ripens prematurely but the yield is greatly reduced.

Pinworm: *Tuta absoluta* (Gelechiidae, Lepidoptera)

Symptoms

Mining of leaves, stem and pinholes on fruits





Management

- Cyantraniliprole 10.26 OD 1.8ml/lit.
- Collect and destroy the pinworm affected plants and fruits
- Avoid solanaceous crops after tomato
- Use healthy seedlings for transplanting
- Keep pheromone traps @ 16 nos./ac to attract and kill the adult moths
- If needed, spray Chlorantraniliprole 18.5% SC @ 60 ml or Cyantraniliprole 10% OD @ 60 ml or Flubendiamide 20% WG @ 60 ml or Indoxacarb 14.5% SC @ 100ml or Neem formulation (Azadirachtin 1% or 5%) @ 400 – 600 ml/ac.

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CROWN MEALY BUG: A SEVERE THREAT TO SUGAR INDUSTRY

Article ID: AG-VO4-I09-64

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Introduction

Sugarcane is an important cash crop in many tropical and subtropical countries and is one of the main sources of sugar production in the world. Sugarcane is cultivated on about 26.0 million hectares, in more than 90 countries, with a worldwide harvest of 1.83 billion tons. Brazil is the largest producer of sugarcane in the world followed by India. Sugarcane crop incurs losses by insect pests under modern agriculture. Sugarcane is a long-duration crop of 12–14 months and moreover every part of cane endures attack from one or the other pest since planting to harvesting. Application of pesticides becomes much difficult once the crops reaches 5th month. In India, the high incidence of insect pests and diseases is a critical issue in achieving higher sugarcane production. Among the 220 species of pests occur on sugarcane the major damage and reduced productivity is attributed to the borer pests of Sugarcane but of late the change from minor to major pest status and occurrence in newer and sudden outbreak of sucking has been increasing.

Phenacoccus saccharifolii (Green), a mealybug infesting the crown region of sugarcane has has coused havoc to the sugarcane cultivation. Of the six mealybug species rreported to infest sugarcane in India, only *Saccharicoccus sacchari* (Cockerell) and *Kiritshenkella sacchari* (Green) are more common than *Pseudococcus saccharicola* Takahasi, *Antonina graminis* (Maskell), *Dysmicocccus carens* Williams and *P. saccharifolii* . Recently, *P. saccharifolii* has emerged as devastating pest causing severe damage to the cane from the early to later stages of crop.

Damage

The colonies of mealybug are primarily found to infest the top leaf of the sugarcane plant and hence, named as crown mealybug. It initially colonizes in the crown region of sugarcane foliage and remains in the whorl as huge colonies, sucking the sap. Affected plants show symptoms only when the crown region shows severe mottling, reddening and rotting with a dead heart. The young crawlers are found congregating around the unopened leaf. When the leaf unfurls, matured colonies with all stages of the mealybug can be found in crowded manner on both sides of the leaves. Excessive ant activity, honeydew secretion and sooty mould are the typical symptoms of the attack. The mature females are large with long ovisacs overlapping each other forming a white fluffy mat on the leaves. During population explosion the mealybugs spread to the inner side of the leaf sheath. Affected plants are stunted and often don't form canes. Ratoons are severely affected during summer. Loss of apical dominance induces tillering in young plants (tillering phase) or sprouting of aerial tillers in the case of a grand growth phase. Often, leaves of the new tillers, whether sprouted aerially or from the nodes at the ground level, were also infested and the whole sprouts withered away Upon peak infestation, the meristem dies leading aerial tillering in mature crops and subsurface tillering in young crops. These fresh tillers also die due to the spread of the pest. In many varieties, mealybug occurrence predisposes the plant to the twisted rot, compounding the problem.

A new colony of crown mealybug

Field identification of crown mealybug

Each colony has all the life stages with overlapping generations. The tubular ovisacs are long and loosely compressed, the egg masses are embedded in mealy threads of the ovisacs Fresh eggs were pale yellow and elongated and are laid in batches in the same ovisac as clusters (Figure 1 e). The prolifically emerging crawlers were yellow, highly active and moved in groups. The waxy filaments were prominent all around the body, with protrusions along the flank more pronounced in males. Two pairs of long waxy filaments in the caudal region flanked by another pair of filaments were observed at the base of the abdomen. While males pass through a true pupal stage, the females moult into an adult without metamorphosis.

Mealybug and Ants Interaction

In general, extended dry rainless periods with clement weather favour mealybug infestation and the rainy season decimates the attack. However, *P. saccharifolii* multiplication was profuse during summer rainfall as well as the monsoon period. The profuse honeydew produced by the mealybugs due to continuous and gregarious feeding, patronized ants. Copious honeydew secretion also led to extensive growth of sooty mould, *Capnodium* sp. mostly on the same leaves, unlike in the case of other sucking pests, wherein the leaves beneath the infested ones had the mould. When successive leaves were infested, the whole plant, specifically the crown, appeared dark and unhealthy due to heavy sooty mould development

The young mealybugs had a myrmecophilous association with ants, depending on the stage of the mealybugs or the species of ants. Nuclear colonies of mealybugs are protected by the ant nests

Colonies of CMB protected by ants nest

Infestation of CMB at the collar region in ratoon crop

.

Field infested with crown mealybug

Management

- Several Natural enemies like Leptomastix sp. Aenasius sp., *Cryptolaemus montrouzeri* , *sp.* , *Scymnus* sp, , *Spalgius apis* .has been reported in sugarcane , hence they can be conserved by leaving pockets of unsprayed area for the multiplication of natural enemies.

- Wide row planting and regular detrashing of canes makes monitoring of the infestation easy. During surveillance the inner whorls of the crown region to be monitored since the inner whorls harbour mealybugs than the outer leaves
- Sett treatment - Carbendazim 50 WP @ 2gm/lt. for 30 min. and imidacloprid 70 WS @ 1.5 ml/lt. for 5 min. before planting
- Monitor ant movement in the border rows at regular intervals
- Prophylactic measure - In endemic area, spray imidacloprid 17.8 SL @ 3 ml/10 lt. (or) chlorantraniliprole 18.5 SC 4 ml /10 lt. (or) clothianidin 50 WDG @ 5g/10 lt. (or) spirotetramet 150 OD @ 12.5 ml/10 lt. (or) Flonicamid 50 % WG @ 3 g/10 lit, in field borders (3 rows)
- If infestation cross ETL (10%), repeat the insecticide application at 20 days interval with rotation of above insecticides.
- Before spraying ensure de-trashing and it should be done at 5 months after planting.
- Spray should be directed towards central whorl for better control
- Ratoon cropping should be discouraged after two ratooning in the endemic areas

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BIODIVERSITY CONSORTIUM

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Introduction

India is one of 12 mega diversity countries of the world. The innumerable life forms harbored by the forests, deserts, mountains, other land, air and oceans provide food, fodder, fuel, medicine, textiles etc. There are innumerable species, the potential of which is not as yet known. Biodiversity i.e., the biological diversity is the variety and differences among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are a part. This includes genetic diversity within and between species and of ecosystems. Thus, in essence, biodiversity represents all life. India is one of the mega biodiversity centres in the world and has two of the world's 12 'biodiversity hotspots' located in the Western Ghats and in the Eastern Himalayas. The forest cover in these areas is very dense and diverse and of pristine beauty, and incredible biodiversity. Conservation and sustainable use of biodiversity is fundamental to ecologically sustainable development. Biodiversity is part of our daily lives and livelihood, and constitutes resources upon which families, communities, nations and future generations depend. Every country has the responsibility to conserve, restore and sustainably use the biological diversity within its jurisdiction. Food, agriculture, biodiversity, land-use and energy pathways consortium (FABLE) is a collaborative initiative, operating as part of the Food and Land Use Coalition, to understand how countries can transition towards sustainable land use and food systems. The Consortium of Scientific Partners on Biodiversity is a network of mostly national-level technical and scientific agencies with globally relevant contributions to the CBD and associated protocols. Its founding Memorandum of Understanding states that members will promote the effective implementation of the Convention and its Protocols through the organization of activities on policy, scientific and technical issues. Members share the below characteristics:

- Scientifically/technically competent to address the Aichi Targets
- Proven track record of contributing to the CBD and with other institutions and Parties at regional, sub-regional or global levels
- Supported by and providing technical support to their respective national governments.

BIODIVERSITY-RELATED CONVENTIONS

Several international conventions focus on biodiversity issues: the Convention on Biological Diversity (year of entry into force: 1993), the Convention on Conservation of Migratory Species, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (1975), the International Treaty on Plant Genetic Resources for Food and Agriculture (2004), the Ramsar Convention on Wetlands (1971), the World Heritage Convention (1972) and the International Plant Protection Convention (1952), the International Whaling Commission (1946).

Biodiversity-related conventions work to implement actions at the national, regional and international level in order to reach shared goals of conservation and sustainable use. In meeting their objectives, the conventions have developed a number of complementary approaches (site, species, genetic resources and/or ecosystem-based) and operational tools (e.g., programmes of work, trade permits and certificates, multilateral system for access and benefit-sharing, regional agreements, site listings, funds).

DEFINITION

"Biological Diversity" defined as the **variability among living organisms from all sources and the ecological complexes of which they are part and includes diversity within species or between species and of eco-systems** [Biological Diversity Act, 2002 of India].

OBJECTIVE

- The Consortium of Scientific Partners contributes to the successful implementation of the Strategic Plan for Biodiversity 2011-2020 and Aichi Biodiversity Targets.
- The MoU aims to ensure effective mainstreaming of biodiversity and the 2020 targets

into international programmes, projects, and initiatives.

- These are achieved through capacity-building of developing countries, and promoting and offering information, tools, and services.

BIODIVERSITY-RELATED CONVENTIONS

	CBD - Convention on Biological Diversity The objectives of the CBD are the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising from commercial and other utilization of genetic resources. The agreement covers all ecosystems, species, and genetic resources.
	CITES - Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) The CITES aims to ensure that international trade in specimens of wild animals and plants does not threaten their survival. Through its three appendices, the Convention accords varying degrees of protection to more than 30,000 plant and animal species.
	CMS - Convention on the Conservation of Migratory Species of Wild Animals The CMS, or the Bonn Convention aims to conserve terrestrial, marine and avian migratory species throughout their range. Parties to the CMS work together to conserve migratory species and their habitats by providing strict protection for the most endangered migratory species, by concluding regional multilateral agreements for the conservation and management of specific species or categories of species, and by undertaking co-operative research and conservation activities.
	International Treaty on Plant Genetic Resources for Food and Agriculture The objectives of the Treaty are the conservation and sustainable use of plant genetic resources for food and agriculture and the fair and equitable sharing of the benefits arising out of their use, in harmony with the Convention on Biological Diversity, for sustainable agriculture and food security. The Treaty covers all plant genetic resources for food and

	agriculture, while its Multilateral System of Access and Benefit-sharing covers a specific list of 64 crops and forages. The Treaty also includes provisions on Farmers' Rights.
	Ramsar - Convention on Wetlands (popularly known as the Ramsar Convention) The Ramsar Convention provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. The convention covers all aspects of wetland conservation and wise use, recognizing wetlands as ecosystems that are extremely important for biodiversity conservation in general and for the well-being of human communities.
	WHC -World Heritage Convention **(WHC)** The primary mission of the WHC is to identify and conserve the world's cultural and natural heritage, by drawing up a list of sites whose outstanding values should be preserved for all humanity and to ensure their protection through a closer co-operation among nations.
	IPPC - International Plant Protection Convention **(IPPC)** The IPPC aims to protect world plant resources, including cultivated and wild plants by preventing the introduction and spread of plant pests and promoting the appropriate measures for their control. The convention provides the mechanisms to develop the International Standards for Phytosanitary Measures (ISPMs), and to help countries to implement the ISPMs and the other obligations under the IPPC, by facilitating the national capacity development, national reporting and dispute settlement. The Secretariat of the IPPC is hosted by the Food and Agriculture Organization of the United Nations (FAO).

THE KEY PARTNERS OF BIODIVERSITY CONSORTIUM:

To enhance cooperation, the Secretariat of the Convention on Biological Diversity works with a number of partners. Partners include:

- The Rio Conventions

- The biodiversity-related conventions
- Other relevant conventions
- United Nations and other intergovernmental organizations
- Non-governmental organizations and civil society
- Indigenous organizations
- Scientific and technical research and assessment bodies
- Industry and the private sector.

MEMBER INSTITUTIONS OF THE CONSORTIUM OF SCIENTIFIC PARTNERS ON BIODIVERSITY

By September 2016, the following institutions have either signed on to the original Memorandum of Understanding or been invited by the Executive Secretary to join the CSP due to their exceptional capacity and track record in supporting the Convention. In addition, some have joined as observers.

- Botanische gärten der rheinischen friedrich-wilhelms-universität bonn
- Comisión nacional para el conocimiento y uso de la biodiversidad de méxico (conabio)
- Foundation for research on Biodiversity
- Fundacao oswaldo cruz (fiocruz)
- German federal agency for Nature Conservation
- Higashiyama botanical gardens
- Instituto alexander von Humboldt
- Instituto National de biodiversidad (inbio)
- Joint Nature Conservation Committee
- Missouri Botanical gardens
- Museum für naturkunde – leibniz Institute for research on Evolution and Biodiversity of Berlin
- National Museum of Natural history
- National commission for Wildlife conservation and development of the kingdom of Saudi Arabia
- Natural History Museum (United Kingdom)
- National Institute of Biological resources of Korea

- Royal Belgian Institute of Natural Sciences
- Royal Botanic garden Edinburgh (United Kingdom)
- Royal Botanic gardens, Kew
- Singapore Botanic gardens
- Smithsonian National Museum of Natural history
- South African National Biodiversity Institute
- Space for life Museum
- University of sao paulo (usp)
- Western Indian Ocean Marine Science Association
- Instituto National de Biodiversidad

Fig.1 POLICY

Fig.2 Biodiversity Consortium

DOCUMENTS:

Some of the documents include:

- Cooperation with other organizations, initiatives and conventions. UNEP/CBD/COP/7/19
- Cooperation with other bodies and contribution to the 10-year review of progress achieved since the United Nations Conference on Environment and Development. UNEP/CBD/COP/6/15
- ***The Rio Conventions*** Options for enhanced cooperation among the three Rio Conventions. UNEP/CBD/SBSTTA/10/INF/9.
- Implementation of United Nations Environmental Conventions: Reports of the Secretariats

of the Rio Conventions Submitted to the General Assembly. (2004).UNEP/CBD/SBSTTA/10/INF/2

- Opportunities for synergy in implementing the three Rio Conventions.UNEP/CBD/WS-Syn.Afr/1/2
- A conceptual design tool for exploiting interlinkages between the focal areas of the GEF. A report prepared by the Scientific and Technical Advisory Panel. GEF/C.24/Inf.10

REPORTS:

Some of the reports include:

- Options for enhanced cooperation among the five biodiversity-related Conventions. UNEP/CBD/WG-RI/1/7/Add.2
- Promoting CITES-CBD Cooperation and Synergy. Proceedings of the Workshop, 20-24 April 2004, Isle of Vilm, Germany
- Synergies and Cooperation:Status report on activities promoting synergies and cooperation between Multilateral Environmental Agreements, in particular biodiversity-related conventions, and related mechanisms. UNEP-WCMC. ***The Millenium Development Goals***
- The programme of work of the Convention and the Millenium Development Goals. UNEP/CBD/COP/7/20/ADD1
- Cooperation with the Global Biodiversity Information Facility (GBIF) and the Millenium Ecosystem Assessment. UNEP/CBD/COP/5/INF/19
- International Cooperation among Indigenous and Local Communities. UNEP/CBD/WG8J/1/4

DECISIONS:

Decisions pertaining to cooperation with other conventions, organizations and processes

In multiple decisions, the COP has requested the Executive Secretary to coordinate with Secretariats of other biodiversity-related conventions, institutions and processes with a view to, *inter alia*, facilitating exchange of information, exploring harmonization or efficiencies of reporting requirements, exploring the possibility of coordinating joint work programmes and exploring liaison arrangements for greater coherence in intergovernmental organizations and processes (decision II/13, paragraph 4; decision III/21, paragraph 3; decision IV/15, paragraph

5). Furthermore, the COP requested the Executive Secretary, on its behalf, to consider matters of liaison, cooperation and collaboration as a key responsibility (decision IV/15, paragraph 4).

At its sixth meeting, the COP reaffirmed the importance of cooperation and the need to design and implement mutually supportive activities with other conventions international organizations and initiatives (decision VI/20), and adopted the Strategic Plan by decision VI/26 that places significant importance on promoting cooperation. COP-7 underlined that enhanced cooperation and improved coordination at national level will be important in meeting the 2010 target of slowing the rate of biodiversity loss, and urged the Executive Secretary to further enhance cooperation between the Convention on Biological Diversity and all relevant international conventions, organizations and bodies, strengthening and building on existing cooperative arrangements to enhance synergies and reduce inefficiencies in a manner consistent with their respective mandates, governance arrangements and agreed programs, within existing resources (decision VII/26).

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RED AMARANTH (*Amaranthus cruentus*) GRAIN-A NUTRICIOUS PSEUDOCEREAL

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Introduction

Amaranthus cruentus (2n = 34), belonging to Amaranthaceae dicot family is a flowering plant species that yields the nutritious staple amaranth grain. It is one of three Amaranthus species cultivated as a grain source . It has several common names, including blood amaranth, red amaranth, purple amaranth, prince's feather, and Mexican grain amaranth. Among 60-70 species of Amaranthaceae, only three are grain-producing species and Amaranthus cruentus is one of them. It stands out for its significant chemical composition. The high protein content and amino acid composition give amaranth medicinal benefits such as cholesterol lowering, antioxidant, anticancer, anti-allergic, and antihypertensive activity.

BOTANICAL DISCRIPTION:

HABITAT: Amaranthus cruentus grows in Human Altered environments (yards, gardens, farms).

HABIT: Amaranthus cruentus grows as an annual or perennial to 2 m in height (usually shorter). The mostly glabrous leaves are arranged alternately, ovate-lanceolate, with an entire margin and acuminate leaf apex.

ROOT SYSTEM: It produces one dominant, large, central root (tap root), branching roots that spread out in the soil, providing stability to the plant and helping in nutrient and water absorption.

Fig.1. *Amaranthus cruentus* crop

Fig. 2. *Amaranthus cruentus*-Red Amaranth grain

LEAVES: Leaves are arranged spirally, simple, without stipules, and their shape varies from ovate to generally broad and lance-shaped.they are arranged alternately along the stem. Leaves: petiole 1/2 as long as to ± equaling blade; blade rhombic-ovate or ovate to broadly lanceolate, 3-15(-20) × 1.5-10(-15) cm, occasionally larger in robust plants, base cuneate to broadly cuneate, margins entire, plane, apex acute or subobtuse to slightly emarginate.

INFLORESCENCE : terminal and axillary, erect, reflexed, or nodding, usually dark red, purple, or deep beet-red, less commonly almost green or greenish red, leafless at least distally , large and robust. Bracts narrowly spathulate, 2-3 mm, equaling or slightly longer than tepals, apex short-spinescent . Pistillate flowers: tepals 5, oblong to lanceolate, not clawed, equal or subequal, 1.5-3 mm, apex acute; style branches erect or slightly reflexed; stigmas 3. Staminate flowers at tips of inflorescences; tepals 5; stamens (4-)5. Utricles obovoid to elongate-obovoid, 2-2.5 mm, smooth or slightly rugose distally, dehiscence regularly circumscissile.

FLOWER: Flowers are small, unisexual and monoecious. The pistillate flowers have 5 tepals, which are oblong to lanceolate.The style branches are erect or slightly reflexed, and there are 3 stigmas. Staminate flowers are found at the tips of the inflorescences. It have 5 tepals and (4-)5 stamens.

CALYX: The apex of the tepals is acute, meaning they come to a sharp point.The tepals are 1.5-3 mm in length. The calyx is usually dark red, purple, or deep beet-red, but sometimes almost green or greenish red.

COROLLA: It would be the outer whorl of floral organs, consisting of 2 to 5 segments, which may be free or united, and can be green or colored.

ANDROCEUIM: Stamens 5 or 3 (Amaranthus), free or united, staminodes sometimes present, introrse, dithecous or monothecous (Alternanthera). In Achyranthes 5 fimbriated scales alternate with 5 fertile stamens.

GYNOCEUIM : Bicarpellary, or tricarpellary; syncarpous, ovary superior, unilocular, usually one campylotropous ovule; basal placentation; style short or filiform; stigma 2 or 3.

SEEDS: Seeds usually white or ivory, with reddish or yellowish tint, sometimes dark brown to dark reddish brown, broadly lenticular to elliptic-lenticular, 1.2-1.6 mm diam., smooth or indistinctly punctate.

FRUIT: One-seeded nutlet: The mature ovary develops into a one-seeded fruit called a nutlet.

POLLINATION: Mostly anemophilous and in some plants entomophilous.

ORGIN : native to Mexico and Guatemala

RELATED SPECIES :

Amaranthus caudatus (Love-lies-bleeding or tassel flower)

Amaranthus hybridus (Smooth pigweed)

Amaranthus retroflexus (Redroot pigweed)

Amaranthus tricolor (Joseph's coat or edible amaranth)

Amaranthus dubius (Spleen amaranth)

Amaranthus blitum (Purple amaranth)

Amaranthus spinosus (Spiny amaranth)

USES:

Edible Leaves: The leaves of Amaranthus cruentus are often consumed as leafy greens. They can be cooked and used in a manner similar to spinach or added to salads.

Grain Harvest: The seeds of Amaranthus cruentus can be harvested and used as a grain. The seeds are tiny, nutritious, and gluten-free, making them suitable for various culinary purposes. They can be ground into flour or popped like popcorn.

Landscaping: Some varieties of Amaranthus cruentus, especially those with vibrant and distinctive inflorescences, are grown for ornamental purposes in gardens and landscapes.

Medicinal Uses: In some traditional medicinal practices, various parts of the plant, including the leaves and seeds, are believed to have medicinal properties. However, it's essential to note that the efficacy and safety of such uses should be validated through scientific research.

Natural Dye: The plant has been used historically to produce natural dyes. The pigments from the flowers can be used to create dyes for textiles.

Livestock Feed: The plant can be used as fodder for livestock due to its nutritional content. Both the leaves and the seeds can contribute to animal feed.

Soil Improvement: Amaranthus cruentus, are used as cover crops and green manure. They help improve soil fertility by fixing nitrogen and adding organic matter when incorporated into the soil.

Traditional Rituals: In some cultures, amaranth has cultural or ritual significance and may be used in ceremonies or rituals.

FODDER VALUE :

GREEN FODDER: *Amaranthus Cruentus* get well established after 60-70 days based on growing condition, when the plants are about 6-8 inches tall. They are still young and tender for the best flavour and nutritional content. Amaranth is a high-yielding plant that can produce 700 to 1 000 kg of grain per hectare and 4000 kg per hectare of leaves when planted in fertile, well-drained soils.

PALABILITY: Animals such as goats, sheep, and rabbits may find red amaranth palatable, particularly in its early growth stages. Poultry may also consume amaranth leaves. Animals with more selective eating habits, such as some horses, may not readily consume it.

NUTRITION VALUE:

Nutritional Composition (per 100 grams of raw leaves):

Energy: Approximately 23 calories

Protein: About 2.5 grams

Fat: Around 0.3 grams

Carbohydrates: About 4.2 grams

Dietary Fiber: Roughly 2.1 grams

Vitamins: Contains various vitamins, including vitamin A, vitamin C, vitamin K, and some B vitamins.

Minerals: Good source of minerals such as calcium, iron, magnesium, phosphorus, potassium, and manganese.

TOXICITY: Some plants, including certain varieties of amaranth, may contain oxalates, which can interfere with calcium absorption and lead to health issues, particularly in ruminants. However, the oxalate content in amaranth is generally lower than in some other plants known for high oxalate levels.

HEY AND SILAGE: Hey, a dried forage crafted, is cut, dried, and baled for storage, serving as a widespread preserved feed for livestock like cattle, and goats. Silage, a fermented forage derived from green crops, undergoes harvest and storage in airtight conditions, fostering fermentation by lactic acid bacteria; this preservation method retains more nutrients compared to traditional drying techniques. It contains essential nutrients like proteins, fibers, vitamins, and minerals

NUTRITIONAL BENEFITS :

1. **Lots of vitamins and minerals**: Amaranth leaves are a good source of vitamins, including vitamin A, vitamin C, vitamin K, and folic acid (vitamin B9). Vitamin A is essential for vision and immune system health, while vitamin K plays an important role in blood clotting and bone health. They also contain minerals such as calcium, iron, potassium, magnesium, and phosphorus. Calcium is important for bone health, iron for transporting oxygen in the body, and potassium for maintaining proper fluid balance and blood pressure.

2**. High in fiber**: Amaranth leaves contain a lot of fiber, which is good for digestive health. Fibers help regulate bowel function, prevent constipation and support a healthy gut microbiome.

3**. Antioxidant properties**: Amaranth leaves contain antioxidants including beta-carotene, flavonoids, and polyphenols that help protect cells from oxidative damage. Antioxidants play a role in reducing the risk of chronic diseases and promoting overall health.

4**. Protein content:** Amaranth leaves are a good source of vegetable protein, so they are a valuable addition to vegetarian and vegan diets. They provide essential amino acids, which are the building blocks of proteins.

5. **Low in calories**: Amaranth leaves are relatively low in calories, making them a suitable choice for those looking to maintain or lose weight while gaining essential nutrients.

6**. Potential health benefits**: Eating amaranth leaves may have potential health benefits, such as reducing inflammation, improving heart health and supporting the immune system. Some studies suggest that bioactive compounds in amaranth may contribute to these benefits.

7. Gluten Free: Amaranth is naturally gluten-free, which makes it a safe choice for people with gluten sensitivity or celiac disease.

8. Versatile and nutritious: Amaranth leaves can be used in various culinary preparations, such as salads, soups, stir-fries, and side dishes. They add a rich earthy flavor to foods while providing additional nutrients. It is worth noting that the exact nutritional content of *Amaranthus cruentus* can vary depending on factors such as growing conditions and maturity at harvest. Adding amaranth leaves to your diet can be a nutritious way to increase your intake of vitamins, minerals, and other important nutrients.

ADVANTAGES OF AMARANTHUS CRUENTUS, :

1. **Grain and Leafy Vegetable:** *Amaranthus cruentus* is versatile and can be used both as a grain and a leafy vegetable.The grain types have white seeds

2. **Culinary Uses**:The leaves and soft portions of the shoots are commonly boiled and used in various culinary applications. It is used as an African leafy vegetable and is part of traditional dishes in Nigeria, Mozambique, and West Africa.
3. **Dye Plant**: *Amaranthus cruentus* is widely grown as a dye plant. The red dye extracted from its leaves is used for colouring alcoholic beverages, maize dough, and other foods in different regions.
4. **Ornamental and Pot Herb**: The plant is cultivated for ornamental purposes, adding aesthetic value to gardens and landscapes. It is also used as a pot herb, likely indicating its use in culinary preparations.
5. **Traditional Medicine**: In Ethiopia, *Amaranthus cruentus* is used as a tapeworm expellant, and in Sudan, ash from the stems is used as a wound dressing.
6. **Nutritional Value**: The leaves are rich in vitamin A, calcium, and potassium. The seeds are valued for their high protein content, up to 15%.
7. **Cultural and Economic Importance**: *Amaranthus cruentus* is an important leaf vegetable crop cultivated throughout the tropics. It holds economic value and is popular in markets, ranking high among African leafy vegetables.
8. **Alegria in Mexico**: In Mexico, *Amaranthus cruentus* is used to produce sweets called Alegría, where the grains are toasted and mixed with honey or chocolate.
9. **Dietary Supplement**: Amaranth oil extracted from the seeds is high in squalene, a powerful antioxidant. The oil is used as a dietary supplement, particularly for diabetes and individuals with hypertension and metabolic disorders.
10. **Feed Ingredient**: *Amaranthus cruentus* forage meal and extruded grains are used as feed ingredients for broilers.
11. **Export and Consumption**: There is some unregistered export of *Amaranthus cruentus* from African countries and Latin America to Western Europe. It is noted as one of the main African leafy vegetables in terms of quantity and area.
12. **Functional Ingredient in Cereal Products**: Amaranth is high in protein, lysine, calcium, iron, and fiber, making it a valuable functional ingredient in cereal products.

LIMITATIONS:

1. **Agronomic Limitations**:

   Climate Sensitivity: *Amaranthus cruentus* is sensitive to frost and prefers warm temperatures. It is well-suited for tropical and subtropical climates.

- Water Requirements: While it can tolerate drought to some extent, consistent and adequate moisture is beneficial for optimal growth.
- Soil Preferences: It thrives in well-drained soils but may not perform well in waterlogged or compacted soils.

2. **Nutritional Limitations (if used as forage):**

- Oxalates: Some amaranth species, including *A. cruentus*, may contain oxalates, which can interfere with calcium absorption and potentially lead to health issues in livestock.
- Nitrate Accumulation: Like many other plants, excessive nitrogen fertilization can lead to nitrate accumulation, which can be harmful to animals.

3. **Market Limitations (if cultivated for seed production):**

- Market Demand: The market demand for *Amaranthus cruentus* seeds may vary, and finding a consistent market for the crop could be a limitation.
- Processing Challenges: The small size of the seeds may pose challenges in harvesting and processing, impacting commercial viability.

4. **Regional Adaptation**: The adaptability and performance of *A. cruentus* may vary by region, and more research may be needed to understand its regional adaptability.
   Cultural and Culinary Limitations:
5. **Limited Culinary Use**: While *Amaranthus cruentus* seeds are consumed in some regions, its culinary use may not be as widespread as other grains, limiting market potential.

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"REVEALING THE HIDDEN ANTINUTRIENTS IN VEGETABLE CROPS"

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Introduction

Vegetables are recognized for their nutritional and medicinal benefits, but some of them contain certain components that are undesirable for human consumption, known as anti-nutritional factors. Anti-nutritional factors are natural or synthetic compounds that interferes the absorption and metabolism of nutrients like minerals, vitamins and even protein that mostly found in fruits and vegetables. Anti-nutrients constitute of amino acids to proteins, simple amines to alkaloids, glycosides and phenolic compounds. In plants these anti-nutritional factors are also known as 'secondary metabolites', that are biologically active to a great extent, evolved as side products of procedure directing to synthesis of primary metabolites. Plant produced or synthesize antinutritional compounds for their self-defense, they are produced by plants to defend themselves in opposition to fungus, pathogen and harmful insects which ultimately offers a protective mechanism for the plant.

Many vegetables contain different kinds of anti-nutritional factors, few of them even neurotoxin. Vegetables like Lima beans (210–310 mg/100g), Cassava (110 mg/100g), Peas (2.3 mg/100g) contain a considerable high amount of HCN which is very toxic to the animal. On the other hand, Spinach (750 mg/100g, Beet greens (610 mg/100g), Okra (146 mg/100g), Parsley (100 mg/100g), Leeks (89 mg/100g) contains oxalate which is lethal in higher concentration. When a plant food is ingest as a nutritional source, along with this, anti-nutrients are consumed and create a health hazard to the consumer.

Antinutritional Compounds Present in Vegetable Crops

Antinutritional compounds	Name of vegetable
Tomatine	Tomato
Antitrypsin factors/ trypsin inhibitors	Legumes
Solanine	Potato
Saponine	Raw spinach, Asparagus, Tomato
Glucosinolates	Cabbage
Oxalates and Oxalic acid	Leafy vegetables, Elephant foot yam, Colocasia
Cyanoglucosides	Cassava
Dioscorine	Yam
Solasodine	Brinjal
Apiin	celery
Haemaglutine, Pisatin, Phaseottin	French bean
Vicine and Covicine	Broad bean
Serotonin	Watermelon
Carota-toxin	Carrot

Effects of Antinutritional factors

1. **Reduced Mineral Absorption**: Compounds like phytates and oxalates bind to essential minerals such as calcium, iron, and zinc, making them less available for absorption in the human body. This can lead to deficiencies over time, especially in populations reliant on plant-based diets.
2. **Protein Inhibition**: Protease inhibitors found in legumes and other vegetables can reduce protein digestion by inhibiting enzymes like trypsin and chymotrypsin, leading to poor protein utilization.
3. **Digestive Issues**: Lectins and tannins can cause gastrointestinal discomfort and interfere with nutrient digestion. High levels of these compounds may damage the gut lining or cause inflammation.
4. **Toxicity**: Some antinutrients, such as cyanogenic glycosides in cassava or solanine in potatoes, can release toxic substances when consumed in large amounts, leading to

symptoms like nausea, vomiting, or even more severe conditions.

5. **Reduced Bioavailability of Nutrients**: Antinutritional factors can reduce the bioavailability of vitamins and amino acids, affecting overall nutrition. This is especially important for those relying heavily on plant-based diets.
6. **Health Risks**: In extreme cases, prolonged consumption of vegetables high in antinutrients like oxalates can lead to health issues such as kidney stones (from oxalate buildup) or neurological disorders (from cyanogenic glycosides).

Detoxification of antinutritional factors

- ✓ Processing methods can significantly reduce the levels of cyanogenic glucosides.
- ✓ Partial detoxification is achieved through boiling, while traditional methods like soaking roots for extended periods, repeated boiling and frequent water changes further enhance detoxification.
- ✓ Fermentation, especially when combined with heat treatment, also modifies and reduces toxic compounds.
- ✓ Overnight soaking of beans and legumes improves their nutritional value, dissolving hydrophilic antinutrients like phytates, lectins and tannins.
- ✓ An efficient method involves pounding fresh tubers followed by sun-drying.
- ✓ Milling and grinding grains and legumes into flour can effectively reduce antinutrient concentrations, as certain compounds are more easily removed through these mechanical processes.
- ✓ Sprouting enhances nutrient bioavailability in legumes, seeds and grains, reducing phytate and protease inhibitors by 37-81%.

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CROP NUTRIENT OPTIMIZATION BY GREENSEEKER^{TM}: A NEW ERA IN FERTILIZATION PRACTICES

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Abstract

The most scarce nutrient for the production of cereal crops is nitrogen, which is also essential for the synthesis of enzymes, chlorophyll, nucleic acids, storage proteins, and cell walls. The energy-intensive and expensive process of producing nitrogenous fertilizers frequently results in a number of losses that have a negative impact on the environment's health as well as the profitability of the economy. Optimizing crop yields, raising profitability, and reducing nitrogen losses to the environment all depend on efficient nitrogen management. Modern nitrogen management strategies are worth considering in light of recent scientific discoveries and the growing emphasis on renewable energy, sustainability and environmental safety. The GreenSeeker^{TM} technology makes site-specific nitrogen management in agricultural fields easier by offering a non-destructive way to precisely estimate the necessary nitrogen quantities based on plant's requirement. GreenSeeker^{TM} is a highly effective tool for precisely managing nitrogenous fertiliser inputs, preventing fertiliser overuse, and providing accurate estimates of the amount of nitrogen to be applied during critical crop growth periods. Precision nutrient management can be utilised to improve fertiliser efficiency and reduce production costs.

Key words: Efficient nitrogen management, GreenSeeker^{TM}, Precision nutrient management.

Introduction

A plate of rice accompanied by a bowl of pulses and vegetables represents a wholesome and appetizing meal for us. Similarly, when discussing plant nutrition, the primary nutrients of concern are nitrogen, phosphorus, and potassium. However, a crucial question arises: if something is beneficial, how much should we consume? Whether in human nutrition or plant nutrition, achieving the right balance between the quantity and quality of a nutrient is vital. In the context of plant nutrition, the excessive application of nitrogenous fertilizers and the associated hazards are well-documented. It is imperative to consider the implications of such practices on both plant health and environmental sustainability.

The best way to reduce nitrogen fertilizer usage is to either increase crop Nitrogen Use Efficiency (NUE) or find more efficient ways to fertilize crops. Worldwide NUE for cereal grains is 33%, which indicates a bulk loss of 67%. This significant loss is in various forms, viz. denitrification, surface runoff, volatilization, leaching and from gaseous plant emissions. To increase crop NUE we need to develop a system approach that has varieties with a high harvest index and incorporates it with ammonium nitrogenous fertilizer which has to be applied at a prescribed rate consistently with in-field variability through the use of sensor- based systems. Following production practices (conservation tillage, rotation, forage production system) that counter conditions or environments which are the reason behind the nitrogen loss from the soil-plant system, will result in an increased NUE.

It has been a traditional practice among the farmers to apply nitrogen uniformly as a blanket application based on the recommendation for most of the crop. Such practices limit efficient use of nitrogen, as these recommendations are not based upon spatial and temporal variability of fields. This results in either the over or under application of nitrogenous fertilizer, which becomes a constraint to agricultural crop production. Addressing this issue is crucial for optimizing fertilizer use and enhancing overall crop yields.

What is GreenSeeker^{TM}?

GreenSeeker^{TM} is a state-of-the-art machine, which utilises a non-destructive method for exact estimation of the required amount of nitrogen based on plant conditions. It has a sophisticated sensor which utilises advanced optical technology to instantly measure plant health and vigour in terms of Normalized Difference Vegetation Index (NDVI). Reliability in yield potential can be predicted by estimating the amount of biomass produced daily using an optical sensor to measure the NDVI. Both pollution reduction and NUE are aided by it. When N fertilizer is administered at the right time, it will enhance plant uptake and reduce N_2O emissions while allowing for a reduction in fertilizer use without sacrificing production.

Principles:

Working of sensor:

The sensor of GreenSeeker^{TM} uses Light Emitting Diode (LED) to generate red (660 nm) and near infrared (NIR) (780 nm) light. Brief bursts of red and infrared light are emitted, and then the amount of each type of light reflected back from the plant is measured.

During the process of photosynthesis, red light is absorbed by chlorophyll and used as an energy source. When a plant is healthy, it will absorb more red light and reflect more near-infrared radiation (NIR), which indicates how green the plant is and that it does not now need nitrogen. But when plants lack nitrogen, the opposite phenomenon takes place, causing the plants to absorb more NIR and reflect more red light.

The field of view of Green Seeker's sensors is approximately 24 inches. Ten output readings per second are provided by each sensor.

The method developed by Raun et al. (2002), Raun et al. (2005), and Singh et al. (2011), which may be divided into multiple discrete components, was used to compute nitrogen doses using GreenSeeker®.

The following formula serves as the foundation for GreenSeeker's normalized differential vegetation index (NDVI) measurements:

$$\mathrm{NDVI} = \frac{\mathrm{NIR} - \mathrm{RED}}{\mathrm{NIR} + \mathrm{RED}}$$

In the electromagnetic spectrum, NIR and RED represent the near infrared and red regions, respectively of reflectance.

A formula known as the In-season Estimation of Yield (INSEY) was developed.

$$\mathrm{INSEY} = \frac{\mathrm{NDVI}}{\text{Days from planting to sensing}}$$

Using the following formula, the yield potential (YP_0) without additional fertilizer was determined:

$$YP_0 = a\,(\mathrm{INSEY})^b$$

Where, "a" and "b" are constants derived from the grain yield and INSEY relationship graph.

NDVI:

The ratio of energy incident on an item to energy reflected from it is known as reflectance.

In the visible red range (λ = 550–700 nm) and the near infrared area (λ = 700–1300 nm) of the electromagnetic spectrum, a crop's spectral reflectance varies significantly. Plants seem green to the human eye because chlorophyll absorbs red and blue light, which causes them to reflect less of these colors than green. The plant surface substantially reflects near-infrared radiant radiation, and the degree of this reflectance depends on the characteristics of the leaf tissues, their cellular structure, and the interfaces between the air-cell wall, protoplasm, and chloroplast. Thus, a variety of vegetative indices that are closely correlated with plant agronomic and biophysical factors pertaining to photosynthetic activity and plant productivity can be computed using spectral reflectance data. The near infrared and red light components of the NDVI make it a useful tool for predicting photosynthetic activity.

Plant photosynthetic activity is determined by the amount of chlorophyll present.

A number of variables, such as crop nutrient deficiencies, low grain yields at harvest, and prolonged water stress, have been linked to NDVI.

However, rather than only indicating the impact of a single component, NDVI must be understood as a measurement of aggregated plant development that takes into account a variety of plant growth characteristics. Physical attributes that the index finds are probably connected to a canopy density (leaf area or percent cover) or total biomass measurement. As a result, without understanding the main issue limiting growth, the fundamental cause of variability in a typical vegetation index cannot be arbitrarily attributed to a management input. For instance, NDVI may exhibit a strong correlation with soil N availability in a field where N is a growth-limiting element; on the other hand, in a different location where water is a growth-limiting factor, NDVI may exhibit a strong association with plant-available soil moisture.

Sensor Based Nitrogen Rate Calculator (SBNRC):

A free online tool for recommending nitrogen (N) based on sensors is the SBNRC. This web-based tool was created at Oklahoma State University and has been shown to boost winter wheat production profits by either increasing yields with more N fertilizer or reducing N fertilizer inputs without compromising yield. The method measures a high N strip (N Rich Strip) set in the field, pre-plant, and an adjacent patch representing the farmer's practice using the

GreenSeeker^{TM} sensor, which records the NDVI. These numbers are then fed into an algorithm that suggests a field-specific N rate by estimating both the potential yield and response to applied N.

How to use GreenSeeker^{TM} ?

1. Place the sensor from 24 and 48 inches above the crop canopy, then pull the trigger to start recording observations with the Green Seeker^{TM}.
2. Confirm the reading which is displayed on the tool.
3. The oval-shaped field of view of the sensor enlarges with increasing height; it is around 10 inches wide at 24 inches above the ground and 20 inches wide at 48 inches above the ground.
4. To obtain readings that cover a wider region, walk while holding the trigger pulled and stay consistently above the target. With a maximum measurement period of 60 seconds, the display refreshes continually, gathering many values and presenting an average when releasing the trigger.
5. Press the button to start a fresh measurement. The measurement is immediately ended by the unit turning off. Pull the trigger to start a fresh measurement at any moment and clear the screen.
6. With regard to the height of reading, it is important to note that the NDVI readings show consistency when taken at different elevations above the crop canopy. This consistency results from the normalized ratio calculation, which modifies proportionately even when the distance between the sensor and the crop varies. For best performance, the ideal sensing height is between 24 and 48 inches above the plants.
7. Algorithms for suitable crops have been developed, especially for maize, rice, and wheat. Developing algorithms specifically suited to other crops like potatoes, sugar beets, sugarcane, barley, cotton, and sunflowers is an important area of ongoing research.
8. In terms of the time of observation, data collection is flexible as NDVI assessments can be carried out at any time of day or night.
9. Another important feature is that the NDVI is applicable to different stages of plant development. This approach enables evaluation from emergence to physiological maturity at any stage of development. It is possible to adjust the particular observational stage to achieve the goals of the experiment.

10. With regard to the number of samples per plot, the usual method depends on the size of the plot and entails capturing one sample per plot within a set amount of time. For example, a 5-meter plot typically uses a length of about 5 seconds.

Taking NDVI value of paddy field (80 days after planting) at B.H.U., Varanasi

Uses of GreenSeeker^{TM}:

A more accurate and effective way to apply fertilizer right away is to use the GreenSeeker^{TM}, an integrated optical detection and application device. It is innovative and affordable diagnostic equipment that helps farmers to efficiently evaluate crop vigour. In order to function, the GreenSeeker^{TM} uses reflectance measurements in the electromagnetic spectrum's red and near-infrared areas. Whereas the near-infrared reflectance suggests the presence of living vegetation, the red reflectance is linked to the amount of chlorophyll. Through the use of these measures, the GreenSeeker^{TM} analyzes potential yield and early-season N uptake to estimate crops' nitrogen (N) requirements. Targeted nutrient management is made possible by this data-driven strategy, which eventually raises agricultural productivity and sustainability.

Conclusion

By applying only the necessary amount of nitrogen (N) fertilizer, farmers may maximize crop productivity and save money with the help of the GreenSeeker^{TM} technology. GreenSeeker^{TM} employs a sensor-based decision support management strategy to efficiently decrease the overall amount of nitrogen applied, improving Nitrogen Use Efficiency (NUE) while preserving yields that are on par with conventional methods and other contemporary instruments like the Soil-Plant Analysis Development (SPAD) meter and Leaf Color Chart (LCC). GreenSeeker^{TM} reduces nitrogen use without sacrificing crop output by precisely predicting the necessary nitrogen levels at pivotal points in crop development. GreenSeeker^{TM} continuously performs better than traditional fertilizer application techniques, which is especially advantageous for the development and yield of cereal crops. This focused strategy promotes more sustainable agricultural practices in addition to increasing efficiency. There is a lot of potential to achieve improved yields when a planned nitrogen dose is sown along with corrective doses directed by the Green Seeker optical sensor at different crop stages.

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INTEGRATION OF *CALOPHYLLUM INOPHYLLUM* INTO TRADITIONAL AGROFORESTRY SYSTEM FOR BIODIESEL PRODUCTION

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Introduction

Energy is a critical input for the socioeconomic development of India. The country's energy strategy aims at efficiency and security, and to provide access to an environment-friendly and optimum mix of primary energy resources. In India, energy is a critical factor for poverty alleviation and improvement in the quality of life of the rural people. The demand for diesel energy across the country is increasing, particularly in the transport sector. The transport and industrial sectors consume millions of tonnes of diesel energy every year. This results in depletion of fossil fuel resources and increased pollution.

The situation necessitates the search for alternate and renewable energy resources which are both productive and environment-friendly. The forests in India house more than a hundred different species of potential biofuel sources. Biofuel is an eco-friendly and alternative diesel fuel prepared from domestic renewable resources-i.e., vegetable oils (edible or non-edible oil) and animal fats. India has hundreds of species which could yield oilseeds for biodiesel production. Tree-borne oilseeds in particular could be rich sources of biofuel, especially if cultivated in marginal lands and/or wastelands. The potential species identified for biofuel production include: *Jatropha curcas, Pongamia pinnata, Madhuca latifolia, Garcinia indica, Azadirachta indica, Calophyllum inophyllum, Simarouba glauca*, etc. Besides Jatropha, *Calophyllum inophyllum* is another potential source of biodiesel to meet out energy demand in India and world level.

Distribution and Environmental Conditions

World distribution: The species is widely distributed throughout the tropics. As a native species it is found in Aruba, Cambodia, Cook Islands, Fiji, French Polynesia, India, Indonesia, Japan, Kiribati, Laos, Madagascar, Malaysia, Marshall Islands, Myanmar, New Caledonia, Norfolk Island, Papua New Guinea, Philippines, Reunion, Samoa, Solomon Islands, Sri Lanka, Taiwan, Province of China, Thailand, Tonga, Vanuatu and Vietnam. As an exotic, C. inophyllum occurs in Djibouti, Eritrea, Ethiopia, Kenya, Nigeria, Somalia, Tanzania, Uganda and United States of America (Allen, undated).

Distribution in India: It is essentially a littoral tree of the tropics occurring above the high tide mark along the sea coasts of the Indian Peninsula and the Andaman and Nicobar Islands. On the West Coast, it is found from Mumbai southwards to Southern Kerala and along the East Coast, from Orissa southwards. It is a characteristic species of the Littoral forest where it occurs in association with *Manilkara littoralis*, *Casuarina equisetifolia*, *Terminalia catappa*, *Heritiera littoralis*, *Pongamia pinnata*, *Barringtonia asiatica* and *Erythrina variegata* (Troup, 1921). *C.inophyllum* grows in areas with an annual rainfall ranging from about 750 to 5000 mm. The tree grows in a wide variety of soils, from nearly pure coastal sands to clay, and is capable of growth on degraded and poorly drained sites. It cannot withstand indefinite water logging. It is sensitive to frost and fire. Though the tree is a light demander planting in areas with light shade may improve success. It will not grow under dense forest canopies (Friday and Okano, 2006).

BIOPHYSICAL LIMITS

Altitude: 0-500 m, Mean annual temperature: 7-18 to 37-48 deg. C, Mean annual rainfall: 750-5000 mm. Soil type: C. inophyllum grows best on deep soil near the coast and will thrive on pure sand.

Species distribution recorded

Suggested that the species can be planted in every ecological zone within that country, nor that the species cannot be planted in other countries than those native ranges. Since some tree species are invasive, you need to follow biosafety procedures that apply to your planting site. Native range: Australia, Cambodia, Cook Islands, Fiji, French Polynesia, India, Indonesia, Japan, Kiribati, Laos, Madagascar, Malaysia, Marshall Islands, Myanmar, New Caledonia, Norfolk Island, Papua New Guinea, Philippines, Reunion, Samoa, Solomon Islands, Sri Lanka, Taiwan, Province of China, Thailand, Tonga, Vanuatu, Vietnam. Exotic range: Djibouti, Eritrea, Ethiopia, Kenya, Nigeria, Somalia, Tanzania, Uganda, United States of America

BOTANIC DESCRIPTION

It is a medium-sized evergreen, ornamental, submaritime tree with a broad spreading crown of irregular branches. Height is 8-20 m sometimes reaching upto 35 m and DBH is 0.5 - 1.5 m. This tree has sticky latex clear or opaque and white, cream or yellow; bole usually twisted or leaning, without buttresses. Outer bark often with characteristic diamond to boat- shaped fissures becoming confluent with age, smooth, often with yellowish or ochre tint, inner bark usually thick, soft, firm, fibrous and laminated, pink to red, darkening to brownish on exposure. Though the stem is reported to be short and often crooked, clear boles reaching upto 15 m and a girth of 7 m have been reported from Andaman. Its leaves are dark green and shining, 10 to 18 x 7.5 to 10 cm, broadly elliptic, rounded and often notched at the apex with wavy margins and very close lateral nerves giving a striate appearance to the blade, base acute; petioles 1 to 1.6 cm long stout, flat. The inflorescence is axillary racemose or paniculate consisting of 4 to 15 flowers. Flower is 1.9 to 2.5 cm in diameter, pure white, fragrant. Sepals 4, ovate-orbicular, concave reflexed, fringed with fine hairs; Petals 4, oblong, obtuse, spreading- The ball-shaped, light green fruits grow in clusters are 2.5 to 5.0 cm in diameter. The skin, which turns yellow and then brown and wrinkled when the fruit is ripe, covers the thin pulp, the shell, a corky inner layer, and a single seed kernel (Friday and Okano, 2006; Troup, l92l).

Reproductive biology

The flowering period is reported to vary depending on the area. In Tamil Nadu, the tree flowers during December-January and in Kerala, March-April. In some areas two flowering seasons have been observed as in the cases of Orissa (May-June and october-November). In Andaman profuse flowering occurs during the rainy season and to a smaller extent at other times of the year. Fruiting season also vary. Tamil Nadu: March; Kerala (May- June), Orissa (July-August and December-January) and Andaman (June-August). The bisexual flowers are pollinated by insects such as bees. It has been suggested that apomixis may occur in calophyllurn, resulting in polyembryony. Hybridization may occur with C. inophyllum as one of the parents (Troup, 192l). The fruit is dispersed by sea currents and by fruit bats.

Seedling production

Elite seeds can be collected from trees by picking individual fruits or lopping off branches with pruning poles, but it is generally more practical to collect them after the fruits fall to the ground. Ripe fruits (skin is yellow or brown and wrinkled) may be soaked overnight to remove skin. Just prior to planting, it is best to crack shells or shell seeds entirely using a mallet, pliers, or hammer. No additional treatments are required. Seed storage behaviour is recalcitrant the seeds are very oily, quickly losing their germinative power.

It is found to be desiccation and low temperature sensitive with high seed moisture during maturity. Seeds can be stored in sealed polythene bags within a temperature range of 10 to 20'C (Anandalakshmi and Sivakumar, 2008). The tree can usually be grown from seed without difficulty, provided the seed is sown soon after ripening. Complete removal of the seed shell is very effective in improving the germination to more than 90 per cent. Sowing seed directly into containers is the most efficient method. Small dibble tubes can be used when the seed is extracted from the shell or use of larger tubes (more than 6 cm diameter) or small pots or sowing in seedbeds followed by transplanting is recommended. Seedlings can be moved safely into full sunlight 1 to 2 months after germination. Seedlings should be hardened in full sunlight for 4 months before outplanting (Allen, Undated).

Agroforestry Practices

It is grown as part of the mixed garden agroforestry systems in many Pacific islands. In the Solomons, C. inophyllum has been traditionally retained or planted along with other trees such as breadfruit, sago palm, Terminalia, Burckella, Pometia, and Canarium in fallow yam and sweet potato fields (Yen, 1976). Indonesia has approximately 16.8 Mha of degraded lands. These lands have the potential to grow biofuel species to meet the need for energy security, income generation and land restoration. As a promising species Calophyllum inophyllum is suitable to grow in 5.7 Mha of degraded land in Indonesia and could contribute to green energy production and restoration of these degraded lands. Its seed provides high levels of non-edible oil, thus making it ideal for biodiesel production. In addition, during the biodiesel production process, its waste and by-products can be used as a raw material in pharmaceuticals and cosmetic industries, and as a compost for soil enrichment. Growing various cash crops with *Calophyllum inophyllum* as agroforestry can provide extra income to farmers, thus create added value of *Calophyllum inophyllum* for cultivation in different agroforestry systems.

Yield (Case study)

It is one of the important Tree Based Oilseeds species with an annual average nut yield of

12 kg/ tree (5 year old) and 100 kg in 20 year old tree. Fruiting starts at 4-5 yrs. A five year old tree yields 3 kg kernel, ie.2.1L oil per tree. A 5 year old plantation with just 35 trees can yield 75 L oil, provided superior clones are planted. Less than 0.25 acres is sufficient for annual requirement of 75L oil. In 1 acre at 4x4 m 250 trees can be accommodated.

If kernel collection and processing done by a farmer:

Cost price of crude oil as per market rate: Rs.55/L

Cost of 1 kg oilcake: Rs.20

Cost-Benefit

- 4 kg nuts give 1 kg kernel.
- 1 kg. kernel costs Rs.30/
- Extraction cost for oil Rs.5/- (Rs.30 - Rs 5)=Rs.25
- Cost price of oil from 1 kg kernel: Rs.39/- for 700 ml.
- Cost price of oilcake 400g: Rs.8
- Hence from 1 kg kernel or 4 kg nuts the earning is Rs.47
- Nut yield from one acre (250 trees): 3000 kg.
- Kernel yield from one acre (250 trees): 750 kg.

Annual income from one acre: Rs.47 x 750 = Rs.35250/- in the fifth year. The income gradually increases as the tree matures.

Conclusion

C. inophyllum grows in a wide range of environmental conditions. Young trees can grow up to 1 m/year for the first few years and slower in a later stage. The species is highly adaptable under varied soil conditions and it was found more than 60% survival when it is planted in marginal land. C. inophyllum very best suitable for agroforestry systems with various annual crops such as maize, cassava, peanuts, soybeans and fodder grass could increase farmers' income. In general paddy, peanut, and maize, as well as honey and horticultural production combined with C. inophyllum provides higher income. C. inophyllum is a potential bioenergy species that produce CCO and RCCO ranging 36–58.30 % and 17–33.8% respectively. Improved stands could increase oil content 11– 14% (CCO), 7–9% (RCCO) and 7–8% (biodiesel). Besides these benefits, the industrial waste and by-product from biodiesel processing could be utilized to produce various products, such as charcoal, briquettes, liquid smoke, animal feeds, compost, soaps, medicines, and cosmetics; these could also increase the economic from C. inophyllum cultivation, while at the same time reducing environmental pollution.

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REVOLUTIONIZING AGRICULTURE: HOW AI AND DEEP LEARNING ARE TRANSFORMING CROP DISEASE DETECTION

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Abstract

This article explores the revolutionary potential of artificial intelligence (AI) and deep learning (DL) in transforming crop disease detection, addressing the significant hurdles that farmers face due to limited expertise and high costs. Traditional methods of identifying plant diseases are often time-consuming and ineffective, leading farmers to rely heavily on pesticide dealers who exploit their lack of knowledge. The study uncovers prevalent misconceptions about plant diseases among farmers and emphasizes the urgent need for educational programs and innovative technology. By utilizing deep learning algorithms and automated image recognition, smartphone applications can empower farmers to diagnose diseases with precision and implement eco-friendly management practices. Nonetheless, the absence of standardized image repositories poses a challenge to progress. This article calls for enhanced research and the creation of comprehensive datasets to improve disease management in agriculture, paving the way for a more sustainable agricultural landscape.

Keywords: Artificial intelligence, deep learning, crop disease detection, sustainable agriculture.

Introduction

The ability to think, imagine, create, memorize and understand, recognize patterns, make decisions, adapt to change, and learn from experience is intelligence. Artificial intelligence, on the other hand, is human intelligence displayed by machines (Helm *et al.*, 2020). In recent decades, artificial intelligence technology has made significant advancements and is now applied across various fields, including healthcare, marketing, the military, automotive industry, and agriculture. One of the challenges that artificial intelligence can address in agriculture is the identification of diseases. The world's need for food is growing daily, but countries all over the world are finding it difficult to deal with the reduction in crop productivity. One of the main biotic pressures preventing crops from being produced is plant disease. Traditionally, farmers and other professionals would use their unaided eyes to identify diseases and inspect crops. This required a thorough understanding of the symptoms of each disease as well as familiarity with the actual diagnosis of diseases. Automated image-based techniques for illness detection are necessary because expert identification is a tedious and time-consuming process (Mohanty et al. 2016). Deep learning in particular can be utilized to develop these models through artificial intelligence.

Challenges in Plant Disease Diagnosis/Identification

1. **Time-Consuming Process**: Identifying plant diseases requires significant time, effort, and hands-on field experience from experts.
2. **High Costs of Expertise**: Hiring a plant pathology expert to visit a farmer's field can be prohibitively expensive.
3. **Limited Availability of Experts**: There is a scarcity of specialists in plant pathology, making it difficult to find one at the village level.
4. **Monitoring Large Fields**: Manually monitoring and diagnosing diseases in large agricultural fields is extremely challenging and often impractical.
5. **Limited Scope**: Traditional methods of disease diagnosis are often restricted to small areas, leaving larger fields vulnerable to undetected diseases.

Farmer's perception of diseases

In a study done in 2015, Schreinemachers *et al*. sought to understand farmers' perceptions of viral diseases of vegetables in South Asian nations such as Thailand, Vietnam, and India. They discovered that 51% of tomato farmers and 42% of chili farmers were unaware that the disease symptoms were brought on by a plant virus. Few farmers believed that diseases caused by bacteria, viruses, or high temperatures were caused by nutrient deficits or fungal infections. This resulted in incorrect management techniques, such as applying fertilizers and fungicides. In 2020, Islam et al. conducted a follow-up survey to explore farmers' understanding of chilli anthracnose, a significant challenge in chilli cultivation. The results revealed that most farmers identified anthracnose as their main pest issue. However, only 25% recognized it as a fungal disease capable of spreading throughout their fields. This lack of awareness highlighted a critical gap in knowledge, as many farmers relied primarily on pesticides for control, with alternative methods rarely employed. The findings underscore the urgent need for education and training programs to equip farmers with effective strategies for managing this pervasive threat to their crops. By improving their understanding of the disease and its control, farmers could enhance their yields and sustain their livelihoods.

Exploitation of farmers by pesticide dealers

The exploitation of farmers by pesticide dealers is a pressing issue in agriculture. Many farmers, often lacking knowledge about pests and diseases, rely heavily on dealers for guidance. Unfortunately, some pesticide dealers take advantage of this dependence by promoting expensive or unnecessary products. This can lead to increased costs for farmers, who may already be struggling to make ends meet.

In many cases, these dealers prioritize profit over the well-being of the farmers, pushing chemical solutions rather than sustainable practices. This not only impacts the farmers' financial stability but also poses risks to their health and the environment. Ultimately, the cycle of dependency on pesticides can undermine the long-term viability of farming practices and threaten food security.

To address these challenges, a smartphone app that identifies plant diseases and offers tailored control measures could serve as an effective solution. By utilizing Deep learning and automated image recognition, such an app could empower farmers to diagnose issues accurately and access expert advice at their fingertips. This technology would enable farmers to make informed decisions, reducing dependency on unscrupulous vendors and fostering more sustainable agricultural practices.

With the ability to analyse images of crops and provide immediate feedback, the app could help in early detection of diseases, allowing for timely interventions that could prevent further spread. Additionally, by recommending eco-friendly control measures, the app could support farmers in maintaining healthy ecosystems while optimizing their yields. Ultimately, this innovative tool could enhance productivity, lower costs, and improve the overall resilience of farming communities.

Artificial intelligence (AI), Machine learning (ML) and Deep learning (DL)

Artificial intelligence is large field and it has many subfields like narrow AI, expert systems, machine learning, generative AI, Deep learning etc. Machine learning is a subfield of Artificial intelligence which is based on experiential learning which is exhibited by humans and Deep learning is a subset of machine learning which is based on neural networks.

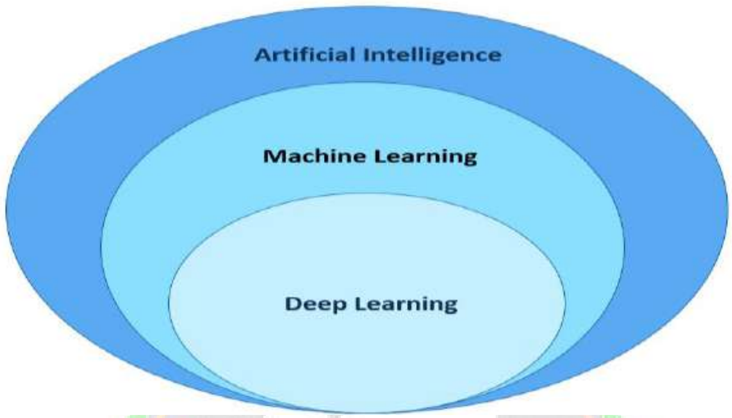

Fig 1: Difference between AI, ML and DL, ML as a subfield of AI and DL as a subfield of ML

Deep Learning: Neural networks are utilized in deep learning; it is a subdivision of machine learning which is based on these networks. It is made up of multiple layers (input, hidden, output) which consists of many units called as perceptrons or neurons. The image perception by these neurons is similar to the process of image perception by humans that is each neuron will become expert in a specific task or the neurons will divide the image into various parts and analyse it.

Training a deep learning model

A significant number of images are necessary to train a deep learning model, particularly for plant disease identification, which relies on thousands of images. The dataset must be organized into disease categories and healthy samples, allowing the algorithm to detect patterns and details in the images. When a new image is uploaded for identification, the model can classify it into a specific disease category or label it as healthy. For image acquisition, we can utilize publicly available datasets such as PlantVillage and PlantClef.

The next step in training the model involves image pre-processing, which focuses on emphasizing the area of interest (the infected region). This process includes noise removal, image enhancement, image segmentation, and standardizing images to account for variations in size and lighting. Afterward, features are extracted from the images to create feature vectors.

Finally, the model identifies the disease using classification techniques like Convolutional Neural Networks (CNN) or Support Vector Machines (SVM).

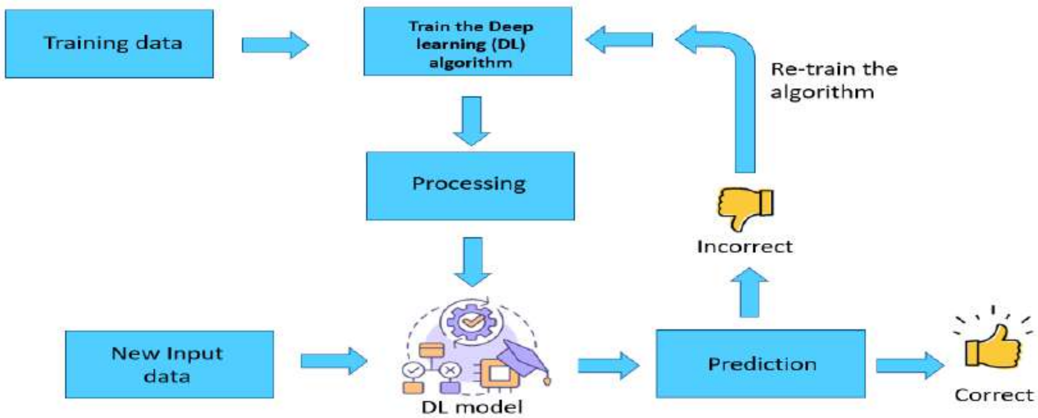

Fig 2: How a Deep learning (DL) or Machine learning (ML) model works

Limitations of AI-Based Plant Disease Identification Models

- **Inadequate Training Data**: Training exclusively on images of plant diseases is insufficient, as symptoms from nutritional disorders, nematode infestations, and insect damage can resemble disease symptoms.
- **Lack of Image Libraries**: The absence of comprehensive image libraries, particularly for cereal crops, poses a challenge for model development.
- **Multiple Diseases in One Image**: Many diseases can coexist in a single image, challenging the assumption that each image only contains one disease. Current models have not been developed to identify multiple diseases on a single leaf.
- **Dependence on Visible Symptoms**: Models trained solely on RGB images will only detect pathogen attacks after symptoms are visible, limiting their effectiveness for early diagnosis.

Future prospects

Deep learning algorithms are poised to revolutionize plant disease identification, demonstrating higher accuracy by directly utilizing photographs for automatic feature extraction and outperforming traditional methods like machine learning and image processing. However, the lack of standardized benchmarking photos remains a significant barrier to progress, emphasizing the need for agricultural experts to collaborate in developing a comprehensive image repository of plant diseases. Currently, many studies rely on datasets from platforms like

Kaggle or create their own, which are often not publicly accessible, limiting innovation. Most research focuses on horticultural crops, with only 27.3% and 22.7% addressing cereals and other crops, respectively, highlighting the urgent need for more research in cereal disease identification, particularly in countries like India. Additionally, creating image repositories for various crop categories will facilitate machine learning and deep learning research. The use of infrared spectral bands may help differentiate similar diseases, despite its added complexity and cost, while models utilizing hyperspectral images offer exciting potential for early disease detection. By harnessing these advancements, we can enhance our ability to manage plant diseases and promote more sustainable agricultural practices.

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PLANTS VS. INSECTS: EXPLORING THE MECHANISMS BEHIND RESISTANCE

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Abstract

Plant resistance to insect pests is a complex, multifaceted phenomenon. Not all plants are susceptible to the same phytophagous (plant-feeding) insects and no insect species is a pest to all plant species. The host range of insects can vary widely; while some, like locusts, are generalists feeding on a broad spectrum of plants, others are more specialized. Insect interactions with plants are categorized into host plants those which are fed upon and non-host plants, which remain unaffected due to a phenomenon known as immunity. Immunity reflects the inability of certain insects to attack non-host plants. Resistance in plants is governed by several key characteristics: it is heritable, controlled by one or more genes; relative, measurable only in comparison to a susceptible cultivar of the same species; measurable in terms of insect establishment, either qualitatively or quantitatively and variable, influenced by both biotic (e.g., other organisms) and abiotic (e.g., environmental) factors. Understanding these mechanisms offers critical insights into improving plant resilience and developing sustainable pest management strategies.

Keywords: Plant resistance, phytophagous insects, Insect immunity

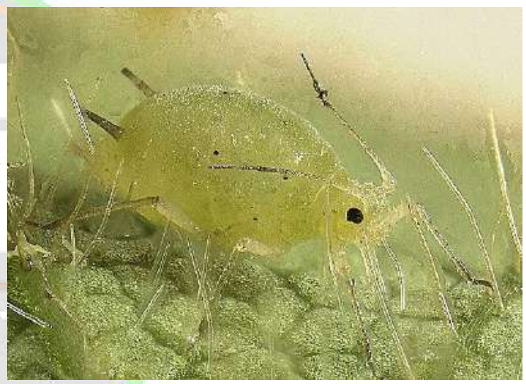
Introduction

Plants and insects have coexisted for millions of years, evolving intricate relationships based on feeding and defense. While many insects rely on plants for sustenance, plants have developed various defense mechanisms to reduce damage from phytophagous (plant-eating) insects. These defense mechanisms are critical for plant survival and have given rise to a complex interplay between plants and insect pests. Not all plants are equally vulnerable to insect attack, nor are all insects capable of feeding on every plant species. The relationship between plants and insects is governed by host range, which can vary widely. Some insects specialize in feeding on a few plant species (narrow host range), while others, like locusts, consume a variety of plants (broad host range). However, insects with such a broad diet are generally not considered in detailed host-plant interactions.

Plant resistance to insects plays a significant role in determining which plants insects feed on. Host plants are those that provide sustenance to a particular insect, while non-host plants remain immune to attack. Understanding the mechanisms behind plant resistance to insects is key to advancing agricultural practices and developing pest-resistant crops (Kogan and Orthe 1982).

A. MECHANISMS OF PLANT RESISTANCE

I. Non-preference (Antixenosis)



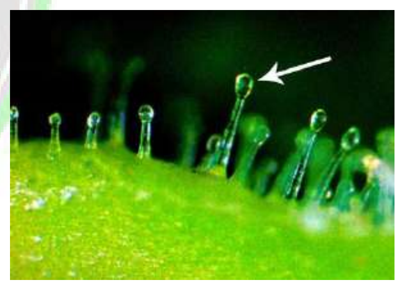
Non-preference refers as antixenosis to the response of the insect to the characteristics of the host plant, which make it unattractive to the insect for feeding, oviposition or shelter. Antixenosis may result from certain morphological characteristics or the presence of allelochemicals in the host plant. Under field conditions, non-preferred varieties frequently escape infestation and even when insects are caged on nonpreferred hosts, they lay fewer eggs and thereby develop smaller populations than those caged on susceptible varieties. Kogan and Ortman (1982) proposed the term 'antixenosis' to describe the host plantproperties responsible for non-preference. Thus antixenosis resistance mechanism employed by the host plant to deter or reduce colonization by insects.

The plants may check the insects from feeding, oviposition and or seeking shelter and the insects are unable to colonize. It signifies that the plant is considered as a bad host. Antixenosis may results from certain morphological characteristics or the presence of allelochemicals in the host plant. The antixenosis may lead to break in the chain of responses leading to oviposition or feeding. These breaks may be due to

- i) The absence of an arrestant or attractant.
- ii) The presence of a repellent.
- iii) An unfavourable balance between an attractant and a repellent.

Antixenosis can be quite important, especially when light infestation cause severe damage. Infestation by insect vectors of plant diseases or peduncle of the plants such as stem borer infestation resulting in white heads. In fields plantings, antixenotic varieties frequently escape infestation and even when insect are caged on non-preferred hosts, they lay fewer eggs and thereby smaller populations than those caged on susceptible varieties (Pathak, 1970). A crop variety may not be preferred when plants possess character that increases the response of pests to use these varieties less for oviposition, shelter food or any combination of three. Resistance mechanism in plants may be attributed to the effect of chemical on host selection or may be due to morphological or structural plant features.

Chemical antixenosis: When offered a choice of two or more alternative foods, phytophagous insects usually display a consistent pattern of preferences. Inadequate hosts are often totally rejected that lacks the proper stimuli. Similarly, oviposition preferences are observed in females selecting oviposition sites. The oviposition preference of the ovipositing females usually measured by counting the number of eggs oviposited by the females on susceptible and resistant plants offered. The rice stem borer (*Chilo suppressalis*) deposited 10- 15 times more eggs on susceptible than on resistant rice varieties (Pathak, 1970).



Morphological antixenosis: Resistance mechanism under this category is related to morphological or structural plant features that impair feeding or oviposition by the insect. Many leafhoppers fail to feed on plants whose epidermis is covered with a thick layer of cellulose hairs. Normal and dense pubescent types are highly resistant to potato leafhopper.

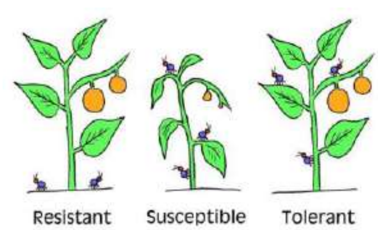
II. Antibiosis

Antibiosis refers to the adverse effect of the host plant on the biology (survival, development or reproduction) of the insects and their progeny infesting it. All these adverse physiological effects of permanent or temporary nature following ingestion of a plant by an insect are attributed to antibiosis. The insects feeding on resistant plants may manifest antibiotic symptoms varying from acute or lethal to subchronic or very mild. The most commonly observed symptoms in insects include larval death in first few instars, abnormal growth rates, disruption in conversion of ingested food, failure to pupate, failure of adults to emerge from pupae, abnormal adults, inability to concentrate food reserves followed by failure to hibernate, decreased fecundity, reduction in fertility, restlessness and abnormal behaviour. These symptoms may appear due to various physiological processes, *viz*., presence of toxic substances, absence or insufficient amount of essential nutrients, nutrient imbalances, presence of antimetabolites and enzymes adversely affecting food digestion and utilization of nutrients.

III. Tolerance

The tolerance refers to the recovery or the ability of the host plant to withstand an insect population sufficient to damage severely the susceptible plants. It is generally attributable to plant vigour, re-growth of damaged tissues, resistance to lodging, ability to produce additional branches, utilization of non-vital parts by insects and compensation by growth of neighbouring plants. However, tolerance has no adverse effect on the insect pest. The ability of tolerant varieties to support insect infestation for longer periods without loss in yield or quality than the susceptible varieties enables them to frequently escape insect damage through compensation by the plants. As tolerance is not likely to provide a high level of resistance, it could be useful in combination with other mechanisms of resistance. Moreover, tolerant varieties do not depress insect populations nor do they provide any selection pressure on the insects. Thus, these can prove very useful to prevent the development of insect biotypes. Working on corn Wiseman *et al* (1972) studied the response of corn earworm to resistant and susceptible corn hybrids and observed that number of earworm obtained from resistant and susceptible hybrids were same but damage to the resistant hybrids was much lesser than the susceptible ones.

A tolerant variety offers an opportunity to use several alternative methods of pest control like: a. Pesticides at a reduced rate. b. Parasites or predators c. Cultural control (*eg*. Early planting) d. Insect pathogens. Utilization of non-vital parts by insect and compensation by growth of neighbouring plants. However, tolerance has no adverse effect on the insect infestation for longer periods without loss in yield or quality than the susceptible varieties and enables them to frequently escape insect damage through compensation by the plants.



Tolerance is useful in pest management programs due to certain distinct advantages (Panda and Khush, 1995).

i. Tolerant varieties have a higher ET level than the susceptible varieties and hence requires less insecticide application and promote biocontrol.

ii. Tolerance varieties do not depress insect population nor do they provide any selection pressure on the insect and thus are useful in preventing the development of insect biotype.

iii. In varieties with a combination of three mechanisms of resistance, tolerance increases yield stability by providing at least a moderate level of resistance.

Although the above widely recognized classification of mechanisms appear to provide a generally acceptable breakdown of the phenomenon of host plant resistance, however, under certain circumstances some overlap may occur between antixenosis and antibiosis and these may not be clearly separated from each other due to the presence of extreme deterrent chemicals and /or physical factors in the plant cultivar. There are often overlap between the morphological and biochemical bases of resistance. Antixenosis refer to undesirability i.e., avoidance by insects whereas antibiosis refers to unsuitability, *i.e.* adverse effects on the insects after feeding on the host plant. However, sometimes it become difficult to separate the two mechanisms unless the insect-plant relationships is fully examined. For e.g. *Eruca sativa* Lam. (Taramira) is not a preferred host of mustard aphid (*Lipaphis erysimi*). The growth and development of the insect was slower on *E. sativa* as compared to that on *Brassica* sp. The mechanism appeared to be antibiosis, but it has been found that the poor development was due to reduced food uptake because of presence of certain allelochemicals in *E. sativa*, indicating antixenosis (Dhaliwal *et al*., 1993).

B. BASES OF PLANT RESISTANCE

I. Morphological Resistance: The morphological characteristics of a plant which confer resistance to insect pests are trichomes on plant surface, surface waxes, hardness of plant tissues, thickening of cell walls and cuticle, anatomical modifications, silica content, colour, shape and size. Resistance mechanism under this category is related to morphological or structural plant features that impair feeding or oviposition by the insect. The leafhopper fail to feed on cotton plants whose epidermis is covered with a thick layer of cellulose hairs. Normal and dense pubescent types are highly resistant to cotton leafhopper (Panda and Khush 1995).

II. Biochemical Resistance: The role of biochemical molecules in host plant resistance has been critically elucidated and chemicals such as glucosinolates, cyanogenic glucosides, alkaloids,

terpenoids, flavonoids, phenolics and Proteinase Inhibitors (PIs), function as toxins, repellents, antifeedants, sterilants, etc. are reported to be toxic to the insects and so influence the biology of the insects. In the recent past cotton genotypes with-in built resistance due to nutritional factors have been evolved for insects such as the leafhopper, *Amrasca biguttula* (Ishida); whitefly, *Bemisia tabaci* (Gennadius) and thrips complex. The cotton resistant genotypes to whitefly showed higher contents of K, P and Mg and lower of N and Fe as compared to susceptible ones. But the other parameters like sugars, proteins, Ca and Cu did not show significant relationship with whitefly build up. Total sugar content of cotton cultivars was positively correlated with whitefly incidence during the vegetative phase but negatively correlated with it during the reproductive phase of the crop. Similarly, the role of biochemical constituents of resistant and susceptible genotypes of cotton in ovipositional preference of cotton leafhopper. As highly susceptible genotype, Acala 4-42 had higher amount of reducing sugars (2.55%), proteins (18.49%) and free amino acids (10.15 mg/g) as compared to highly resistant BJR 741 containing 1.63 per cent reducing sugar, 13.45 per cent proteins and 6 mg/g free amino acids.

Non-reducing sugars had significant negative correlation with leafhopper eggs in cotton (- 0.72). The allelochemcial compounds known to exert adverse effects on pests in cotton include gossypol, gossypurin, heliocides and related terpenoids, p-hemigossypolone, tannins, anthocyanins, flavonoids and phenolics. The high gossypol cotton cultivars (No. 6482, 6501 and Termez-14) have detrimental effects on insect development, *viz.* increasing incubation period, causing greater mortality among young larvae and lowering larval weight compared with low gossypol cultivar, Tashkent-1. The antibiotic effect of high gossypol reduces the fecundity of *H. armigera* by more than 50 per cent. Gossypol in known to adversely affect the nutritional quality of bolls by forming complexes with amino acids, proteins and enzymes. The *Gossypium arboreum* L. genotypes with high gossypol-gland density on ovary surface showed low incidence of bollworms.

Key Characteristics of Plant Resistance

The effectiveness of plant resistance can be assessed based on the following characteristics:

Heritability: Resistance is genetically controlled and passed down through generations. It can be governed by one or multiple genes, which influence the plant's ability to defend itself against insect attacks.

Relative Nature of Resistance: Resistance is not an absolute trait; it is measured in comparison to a susceptible cultivar of the same species. This relative nature of resistance highlights the differences in response to insect attack within a plant species.

Measurability: Resistance can be qualitatively or quantitatively measured. Standard screening systems can be used to evaluate resistance based on observable traits, such as reduced insect population or damage. Quantitative measurements often involve studying insect establishment rates on resistant versus susceptible plants.

Variability: Plant resistance is not fixed; it can be influenced by biotic factors (such as interactions with other organisms, including pathogens and beneficial insects) and abiotic factors (like temperature, soil conditions and water availability). These environmental influences can enhance or suppress the plant's resistance to insect pests (Hwang *et al*., 2023).

Conclusion

Plant resistance to insects is a critical factor in the ongoing evolutionary battle between plants and their insect pests. By understanding the mechanisms behind this resistance to whether through antibiosis, antixenosis, or tolerance to farmers and scientists can develop more effective and sustainable pest management strategies. The heritable, relative, measurable and variable nature of plant resistance offers a valuable tool for breeding pest-resistant crops, reducing pesticide use and minimizing agricultural losses. As research continues, the potential for enhancing plant resistance and improving food security becomes increasingly promising, ensuring that plants can continue to thrive despite the constant pressure from insect pests.

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THE ROLE OF SMART SENSORS IN MODERNIZING AGRICULTURE AND ENHANCING CROP YIELDS

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Introduction

Over the past several decades, technological breakthroughs have led to enormous shifts in the agricultural sector. In particular, the integration of smart sensors has revolutionized how farmers maximize yields by managing their crops. The integration of Smart sensors with the Internet of Things (IoT), big data, and artificial intelligence, are now playing a pivotal role in precision agriculture. These technologies enable farmer community to have data which is more accurate and real-time about their crops, soil, and environmental conditions, bringing forth more informed decisions and efficient farming practices. In this article, we explore the various ways smart sensors are modernizing agriculture and enhancing crop yields.

1. What Are Smart Sensors?

Smart sensors are devices capable of collecting data from the physical environment and processing that information to make it usable for various applications. These sensors can measure a range of factors such as:

- Soil moisture and temperature
- Humidity levels
- Light intensity
- pH levels
- Nutrient content in the soil
- Crop growth patterns
- Weather conditions

- The sensors gather the data and is sent to centralized systems, such as cloud-based platforms, where further analysis takes place and is used to improve agricultural practices. The application of smart sensors in agriculture enables the concept of precision farming, which focuses on optimizing inputs like water, fertilizers, and pesticides to meet the specific needs of crops.

Fig.1: Smart agriculture sensors

2. Types of Smart Sensors and their roles in Precision Agriculture

Smart sensors are essential in precision agriculture, gathering data that helps farmers make well-informed decisions about their crops. These sensors gather information on various environmental, soil, and crop health factors that directly impact farm productivity. Below, we explore various types of smart sensors commonly used in agriculture, each with a unique function that contributes to enhancing crop yields and optimizing farm inputs.

2.1 Weather and Environmental Sensors

Weather and environmental sensors monitor climatic factors such as temperature, humidity, solar radiation, wind speed, and rainfall. This data helps farmers anticipate weather changes and adjust their operations accordingly, ensuring that crops are exposed to optimal growing conditions.

- Temperature Sensors: Measure air temperature, which is crucial for determining when to plant crops and how to manage heat-sensitive crops. For example, temperature sensors can signal when frost is likely to occur, prompting protective measures.

- Humidity Sensors: Monitor the moisture in the air, which is essential for determining irrigation needs and preventing diseases caused by high humidity.
- Rainfall Sensors: Help farmers measure precipitation and adjust irrigation schedules accordingly, reducing unnecessary water use.

By integrating this information with predictive weather models, farmers can better plan planting, irrigation, and harvesting activities, ultimately improving efficiency and reducing the risks associated with weather variability.

Weather sensors

2.2 Soil Sensors (Moisture, Temperature, Nutrient Levels)

Soil sensors are critical for understanding the physical and chemical properties of the soil, enabling precise management of irrigation, fertilization, and other agronomic practices.

- Soil Moisture Sensors: These sensors measure the volumetric water content in the soil, providing real-time data on soil moisture levels. This data allows farmers to fine-tune their irrigation practices, avoiding over- or under-watering, both of which can harm crop health and reduce yields.

- Soil Temperature Sensors: These sensors measure the temperature at different soil depths, which influences seed germination and root growth. Knowing the soil temperature helps farmers determine the best time for planting crops.
- Nutrient Sensors: Measure levels of essential nutrients such as nitrogen (N), phosphorus (P), and potassium (K) in the soil. This data allows farmers to apply fertilizers more effectively, ensuring that crops receive the right nutrients at the right time.

By leveraging soil sensors, farmers can tailor their input management to match the exact needs of their crops, resulting in healthier plants and higher yields.

Soil moisture sensors	soil temperature sensors

2.3 Crop Health Sensors (NDVI Cameras, Chlorophyll Meters)

Crop health sensors assess the physiological status of plants by detecting signs of stress, nutrient deficiencies, or pest infestations. These sensors include:

- NDVI Cameras: The Normalized Difference Vegetation Index (NDVI) is a widely used measure of crop health, derived from satellite or drone imagery. NDVI cameras detect variations in plant greenness, which can indicate early signs of stress, disease, or nutrient deficiencies. The index is based on the reflection of near-infrared light from plant leaves, providing a real-time assessment of plant vitality.
- Chlorophyll Meters: Chlorophyll content is a strong indicator of a plant's nutritional status. Chlorophyll meters assess the chlorophyll concentration in leaves, which can be correlated with nitrogen levels. This allows farmers to determine if crops require additional nitrogen fertilizer, optimizing nutrient use and improving yields.

These sensors allow farmers to monitor crop health at a granular level, making timely interventions to ensure maximum productivity.

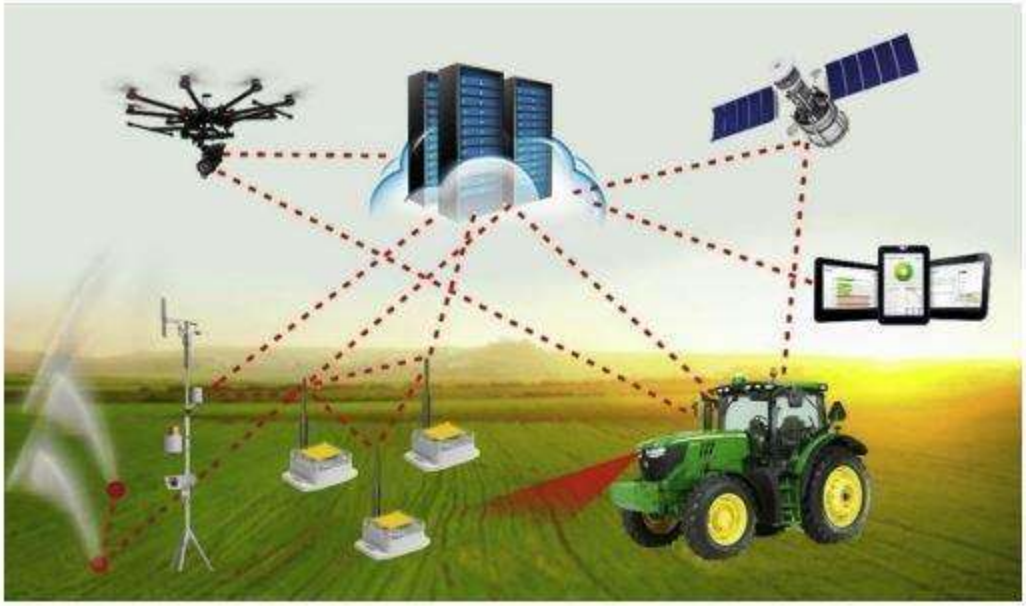
Crop health sensors

2.4 GPS and Remote Sensing Technologies

Global Positioning System (GPS) and remote sensing technologies are essential for spatial data collection in precision agriculture. These technologies allow farmers to map fields, monitor crop conditions over large areas, and apply inputs precisely.

- GPS Sensors: These sensors provide accurate location data, enabling precision farming techniques such as variable-rate application (VRA) of fertilizers, pesticides, and water. GPS-guided machinery ensures that these inputs are applied only where needed, reducing waste and environmental impact.
- Remote Sensing: Through the use of satellites, drones, and aerial vehicles, remote sensing provides high-resolution imagery of fields. This imagery can reveal patterns in crop growth, soil variation, and moisture levels, allowing farmers to manage their fields more effectively.

The combination of GPS and remote sensing technologies ensures that farmers can optimize field operations, resulting in increased productivity and reduced input costs.



Remote sensing in agriculture

2.5 Water Quality Sensors

Water quality sensors measure parameters such as pH, salinity, dissolved oxygen, and contaminant levels in irrigation water. Maintaining high-quality water is crucial for ensuring healthy crop growth.

- pH Sensors: Measure the acidity or alkalinity of water, which can affect plant nutrient uptake. Crops are highly sensitive to pH imbalances, and maintaining optimal water pH ensures efficient nutrient absorption.
- Salinity Sensors: Detect salt concentration in irrigation water, which is essential in regions with high levels of salinity in water sources. High salinity can reduce crop yields, and monitoring it helps prevent damage.

By monitoring water quality, farmers can ensure that crops receive the necessary nutrients and are not harmed by unsuitable irrigation conditions.

2.6 Pest and Disease Detection Sensors

Early screening of pests and the resulting diseases is crucial for preventing widespread damage to crops. Smart sensors are now being developed to identify pest and disease outbreaks before they become a serious threat.

- Optical Sensors: These sensors detect changes in leaf colour or texture that could indicate disease or pest infestation. For instance, infrared sensors can identify areas of crop stress that are invisible to the naked eye, enabling farmers to intervene early.
- Trap Sensors: Used in conjunction with pheromone traps, these sensors monitor pest activity by counting the number of pests caught in traps. This data can help farmers predict the likelihood of infestations and apply targeted treatments.

By integrating pest and disease detection sensors into their operations, farmers can reduce crop losses, lower pesticide usage, and maintain healthier crops throughout the growing season.

3. The Future of Smart Sensors in Agriculture

The future of smart sensors in agriculture is bright, with ongoing research and technological advancements making these tools more affordable and accessible to farmers worldwide. Key developments expected in the near future include:

- AI Integration: Advanced AI algorithms can analyse and interpret the enormous amount of data collected by smart sensors, providing even more precise recommendations for crop management.
- Automation: The combination of smart sensors and autonomous machines, such as drones and robots, will further reduce the need for manual labour in farming operations.
- Expansion to Small-Scale Farmers: As the cost of smart sensor technology decreases, it will become increasingly accessible to small-scale farmers, who make up a significant portion of the agricultural sector in developing countries.

4. Conclusion

Smart sensors are revolutionizing agriculture by providing farmers with detailed, real-time data that allows for precise, efficient, and sustainable farming practices. Through better irrigation, optimized fertilizer use, and timely pest management, these technologies are enhancing crop yields and contributing to a more resilient agricultural industry. As advancements in AI and IoT continue, the role of smart sensors in modern agriculture will only grow, offering even greater opportunities to improve food security and reduce the environmental impact of farming.

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WOMEN-FRIENDLY TOOLS IN AGRICULTURE: EMPOWERING FEMALE FARMERS

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Introduction

Agriculture is the main economic activity carried out in India. Women play a major role in agriculture and allied activities and their role is often unrecognized. Women have a significant role in the activities ranging from planting to post harvest process in the agriculture. They also play an important role in the allied activities also such as cleaning and maintaining the farm sheds, preparing feed to the animals etc. It is believed that women were the first who started the art of agriculture in India. While men went out to hunt and gather food, women were used to collect the seed and planting materials and grown in the outdoor spaces of their homes. Men's role is confined to only land preparation and the sowing, weeding, harvesting, threshing and post harvest processes are carried by women only

The agricultural sector is the largest employer of women. Majority of the female workforce (84 per cent) works in rural India. A very large share (73 per cent) of this female workforce toils in the agricultural sector, mostly (96 per cent) in rural areas.

Challenges Faced by Women in Agriculture

Women in agriculture face numerous challenges, ranging from limited access to resources, land ownership, wage differences to heavy physical labor and restricted access to modern farming technologies. Most farm technologies are designed keeping in view of men's body posture and their requirements. So the tools available for farming are often too heavy or not ergonomically suitable for women, leading to discomfort, health issues, and reduced productivity. According to a study by the Food and Agriculture Organization (FAO), Indian women are often involved in manual tasks like weeding, transplanting, and harvesting, which require long hours of repetitive movements, putting them at risk for musculoskeletal disorders. Moreover, lack of training in handling modern machinery further limits their efficiency. Recognizing these challenges, women-friendly tools have been introduced to improve their experience and reduce the physical burden of agricultural work.

Key Women-Friendly Tools in Indian Agriculture

Several innovative tools have been designed with the unique needs of female farmers in mind. These tools are lighter, easier to handle, and ergonomically designed to reduce physical strain. But awareness and access to these technologies is being limited. Several research institutions are conducting demonstrations and field trail to create awareness and enhance the adoption of women friendly technologies among farm women. So an attempt is made through this article to familiarize the common women friendly tools used in agriculture.

1. Naveen dibbler:

It is a type of sowing equipment used to sow the seeds of various crops such as soybean, maize, pea and sorghum. Seed wastage can be reduced by employing this technique. It differs from the traditional method by avoiding bending posture while sowing the seeds.

Drudgery reduction aspect: About 13 per cent saving in cardiac cost of workers per unit of output with the dibbler as compared to traditional one

Naveen dibbler

2. Two row rice planter

This equipment is used to transplant the 20-25 days of rice seedlings on to the field. It prevents the adoption of bent posture employed in traditional method and thus reduces the drudgery caused due to back pain. The use of machine will reduce the need of manual labour and thus reduces the labour cost and save time.

Two row rice planter

Drudgery reduction aspect: 16 per cent saving in cardiac cost of workers per unit area. Workers productivity is increased by 79 per cent as compared to traditional method

3. Four row paddy drum seeder

It is used to sow the sprouted paddy seeds for growing into seedlings. It ensures the uniformity and reduced wastage of seeds. It reduces the labour cost during weeding.

Drudgery reduction aspect: About 61 per cent saving in Cardiac cost of workers per unit area. Productivity of workers is increased by more than 6 times as compared to traditional method.

Four row paddy seed drum

4. Sugarcane bud chipper:

It is used for chipping of sugarcane crop. It requires low maintenance and improves the efficiency of sugarcane chipping. It reduces the pain caused in fingers and wrist due to the use of traditional and manual chipping.

Drudgery reduction aspects: Due to this technology, the sugarcane buds can be pretested before sowing. It reduces cost of plantation by over 90 per cent

Sugarcane bud chipper

5. Grubber weeder/Single wheel hoe/Twin wheel hoe

All these technologies serve similar function but the structure and operation differs. They are light weight manually operated weeding equipment usually employed row crops such as soybean, pigeon pea, rapeseed and chick pea. They eliminate the pain caused in wrist due to force applied for weeding and waist pain in due to bending and squatting posture.

Grubber weeder

Drudgery reduction aspect of Grubber weeder: Output of this weeder was 94 per cent more than the traditional khurpi

Drudgery reduction aspect of Single wheel hoe: The heart rate is reduced by 11 beats/minutes. Resting period is reduced from 33.33 min to 20.63 min.

Single wheel hoe

Drudgery reduction aspect of Twin wheel hoe: About 43 per cent saving in cardiac cost of workers per unit of output. It saves 59 per cent labour and operating time

Twin wheel hoe

6. Cono weeder:

It is similar to other weeders which reduce drudgery and pain caused in wrists and waist but it is mainly used in rice crop

Cono weeder

7. Improved sickle:

It is used for harvesting crops such as wheat, rice, soybean, chick pea and cutting for grasses and fodder crops. It is in lightweight, doesn't require sharping because of serrated edges and increases the efficiency. It eliminates the pain caused in shoulder, waist and wrist due to constant changing postures employed in traditional method.

Improved sickle

Drudgery reduction aspect: About 15 per cent saving in cardiac cost of workers per unit of output with Serrated Sickle as compared to local sickle.

8. Cotton stalk puller (wheel type and jaw type):

It helps in uprooting the cotton plants from soil after cotton harvesting. It reduces the back aches caused due to the bending postures employed in traditional manual pulling.

Cotton stalk puller

9. Fruit harvester:

It helps to pluck the fruits from high rise trees and thus reduce the injuries caused due to climbing up and down of the trees for fruit plucking. It also reduces the damage caused to fruits.

Fruit harvester

10. Bhindi plucker:

Lady's finger consists of thorn which causes discomfort when directly picked with bare hands. So this bhindi plucker helps to pick the lady's finger and reduces the wrist pain, itching and discomfort caused to the skin.

Bhindi plucker

11. Hand operated maize thresher:

It is employed for threshing maize. It reduces the pain caused in wrist and fingers due to manual shelling and saves time and energy.

Drudgery reduction aspects: About 68.80 per cent saving in cardiac cost of workers. Saving in energy expenditure is 47.36 per cent. Reduction in Right hand grip fatigue is 15 per cent. Reduction in Left hand grip fatigue is 13 per cent.

Hand operated maize thresher

12. Sunflower threshing bunch

It is used for threshing/picking the seeds from sunflower bunch. It reduces the pain caused on wrists and fingers due to manual threshing.

Drudgery reduction aspects: Saves 60 per cent of conventional cost per ha

Sunflower threshing bunch

13. Tubular maize sheller:

It is used for shelling the maize from dehusked cob. It eliminates the sufferings of wrist and fingers due to manual shelling.

Tubular maize sheller

Drudgery reduction aspect: About 15 per cent saving in cardiac cost of workers per unit of output in comparison to the traditional practice. The productivity of workers increased 1.6 times than traditional practice i.e. shelling with the help of sickle.

14. Groundnut decorticator (sitting and standing type):

It is used to separate the kernals from ground nut pods. The both serve similar function and differ in operation. It decreases the back pain caused due to bending posture.

Drudgery reduction aspects: The reduction of drudgery with the equipment per kg of pods decorticated is to the tune of 74 and 79 per cent in case of standing and sitting type decorticator respectively

Groundnut decorticator

15. Ground nut stripper:

It aids in stripping groundnut pods. It eliminates the squatting and bending posture and thus reduces the drudgery caused by traditional method.

Drudgery reduction aspects: About 79 per cent saving in cardiac cost of workers per unit of output with the groundnut stripper as compared to conventional practice

Groundnut stripper

16. Sugarcane stripper:

It is used for stripping of sugarcane crop. It prevents the employment of bending position and thereby reduces discomfort and drudgery.

Sugarcane stripper

17. Seed treating drum:

It will be helpful in mixing the seeds with chemicals uniformly for sowing. It eliminates the direct exposure or contact with chemicals and reduces discomfort.

Seed treating drum

18. Fertilizer broadcaster:

It is used for uniform applying of fertilizer to the agriculture field. It avoids the exposure to chemicals and reduces the health hazards.

Fertilizer broadcaster

Benefits of Women-Friendly Tools

The introduction of women-friendly tools in Indian agriculture has multiple benefits:

- **Increased Productivity**: With access to these tools, women can complete tasks more efficiently and with greater accuracy, leading to improved crop yields and reduced labor time.
- **Reduced Physical Strain**: Ergonomically designed tools reduce the physical burden of agricultural tasks, lowering the risk of musculoskeletal disorders and chronic pain.
- **Empowerment and Economic Independence**: By enhancing the productivity and efficiency of women in agriculture, these tools empower them to contribute more significantly to household income, leading to greater financial independence.

- **Improved Work-Life Balance**: With reduced labor time and physical strain, women can better balance their agricultural responsibilities with household chores and care giving duties.

Initiatives Promoting Women-Friendly Tools

Several government and non-government initiatives in India are promoting the use of women-friendly tools in agriculture. The Indian Council of Agricultural Research (ICAR) and various state agricultural universities have been instrumental in developing and disseminating these tools to female farmers.

One notable initiative is the **All India Coordinated Research Project (AICRP)** on Home Science, which works on developing and promoting agricultural tools that reduce drudgery for women. Training programs and demonstrations are conducted across rural India to raise awareness about these tools and provide hands-on experience to female farmers.

The **National Rural Livelihood Mission (NRLM)** has also been working with self-help groups (SHGs) to provide women with access to modern agricultural tools and equipment, thereby improving their agricultural productivity and livelihoods.

Conclusion

The integration of women-friendly tools in Indian agriculture is a crucial step toward gender equality in the sector. By addressing the unique challenges faced by female farmers, these tools not only increase productivity but also improve the quality of life for women in rural areas. With continued support from the government and private organizations, these innovations can help transform Indian agriculture and empower women to play a more prominent role in shaping the future of farming.

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THE STRATEGIES OF *SALMONELLA* CONTAMINATION IN FISHERY PRODUCTS AND ITS IMPACTS

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Abstract

In seafood trades, *Salmonella* bacteria are the most portend foodborne pathogen and the incidence of *Salmonella*-associated foodborne disease is highest in imported fishery products and consumption of fish from local markets. This emphasizes the need to improve the quality control system for seafood. The bacterium adopts several virulence factors specifically *S*. Typhi which has an SPI effector protein that interacts with the host's epithelial layer, causing severe health issues for the consumer. *Salmonella* also adopts antimicrobial resistance, making it a "superbug" and an emerging issue in microbial safety management for seafood industries.

Keywords; *Salmonella,* Seafood, Outbreak, Virulence, Transmission and resistance

Introduction

Globally, seafood-related pathogens and outbreaks of foodborne disease were the most pressing concern among consumers, industries and regulatory bodies. According to the World Health Organization (2018), around 33 million people each year suffer from severe foodborne illness caused by consuming contaminated food. The incidence of seafood outbreaks has also increased, leading to deaths and becoming a public health burden. Despite this, the consumption and trade of fish and shellfish continue to rise annually due to their functional compounds and health benefits (Hosomi et al., 2012).

Salmonella is one of the most threatening food-borne pathogens and triggers a series of foodborne diseases. It is a bacterium that is facultatively anaerobic, nonsporulating, Gram-negative motile bacterium that lives in a mesophilic environment. This pathogen can enter the fish production chain by improper handling, poor hygiene or contact with polluted water and also that will occur by cross-contamination with zoonotic and anthropogenic activities in aquatic environments. The bacterial contamination was recorded in various fish and shellfish-associated products from harvest to consumption of seafood. The two primary species of Salmonella bacteria, *Salmonella enterica* and *Salmonella bongori*, each of which has six subspecies, are members of the Enterobacteriaceae family.

Based on serotypes, there are over 2500 subspecies in these bacteria. Typhoid fever and gastroenteritis are two different illness syndromes that are commonly referred to as systemic typhoidal or Nontyphoidal foodborne disease. Another known as paratyphoid fever is brought on by different strains of the salmonella bacterium(Amagliani et al., 2012). As same as salmonellosis leads to major health hazards and huge losses in seafood industries because of the refusal of export shipments. An estimated 1.9 million cases and 388,000 fatalities of invasive nontyphoidal Salmonella (iNTS) sickness occur each year, with *invasive nontyphoidal Salmonella (iNTS) disease* being a significant source of bloodstream infections. Among the most common NTS serovars in seafood are *S*. Weltevreden, *S*. Rissen, *S*. Typhimurium, and *S*. Derby (Stephen et al., 2022).

In recent years, antibiotic resistance has emerged, making the condition more difficult to treat. The virulent *inv*A and *stn* genes in *Salmonella* which had the level of pathogenicity of the organism remained high and active in seafood which poses a risk for the treatment and health of the human. Development of resistance in *Salmonella* serovars shows multidrug tolerance capacity to make a complicated situation in medication (Hall, 2010)

Prevalence of Salmonella in seafood

USFDA recorded that high level of Salmonella incidence in imported raw seafood compared to other products during 1990 – 1998 (Heinitz et al., 2000) .In the 20th century, Japan reported that incidence of *Salmonella enterica* serotype Weltevreden in imported black tiger prawn. Thirty per cent of Salmonella was found by (Kumar et al., 2003)in finfish that were obtained from the fish market and processing industries. The confirmation of Salmonella presence in the US state from farmed-raised tilapia imported from China(Wang et al., 2011).

Bakr et al., 2011 recorded that 10 % prevalence of Salmonella in the market of Alexandria(Bakr et al., 2011). The study showed that Salmonella was present in fish and shrimp compared with other seafood in the Persian Gulf of Iran. The notable prevalence of S. enterica (16%) in RTE sushi and sashimi was reported in Malaysia(Puah et al., 2017).

In India, eight Salmonella species from the retail seafood market were identified as resistant to antibiotics in 2014(Adesiji et al., 2014). Salmonella pathogen-led seafood-borne disease outbreaks of 41,681 cases were identified and reported from 2010 to 2022 specifically the United States had a major outburst and responsible prime seafood product for the outburst are shrimp, fish and crab, followed by European countries reported 10 outbreaks in fish and fishery product. Each year in the USA, *Salmonella* causes 1.2 million illnesses and 450 fatalities, according to the CDC, with June, July, and August seeing the highest prevalence. In 2012 raw scraped ground tuna products associated with Salmonella strains of *Salmonella* Bareilly and *Salmonella* Nchanga outbreaks were reported in a multistate of United States and a total of 425 people were infected and hospitalized.

Table 1: outbreaks of Salmonella from seafood occurred during 2010-2022 as follows

Period	***Country***	***Outbreaks/ cases***	***Attribute food***	***Data source***
Salmonella				
2019	Chile	80 cases	Sushi	Popa et al., 2021
2021	USA (Colorado & out of state)	1 outbreak/115 cases	Sushi& cooked seafood	CDC 2021
2022	USA (California, Arizona)	39 cases	Fish (salmon)	Narayanan et al., 2020
2006-2019	Netherland	1 outbreak	fish	Friesema et al., 2022
2006-2019	Netherland	2 outbreak2	shellfish	Friesema et al., 2022
2017-2021	EU states	10 outbreaks	Fish and fishery product	EFSA and ECDC, 2022
2010-2021	US state	11 outbreaks/ 230 illness	Fish	CDC
		1,592 Outbreaks 41,023 Illnesses	shrimp	
		6 outbreaks/85 illness	Crab	

As follows the again *Salmonella* Paratyphi B Variant L (+) tartrate (+) and *Salmonella* Weltevreden Infections linked to the consumption of frozen yellowfin tuna resulted in 65 cases reported in 2015. After a long year, on May 22, 2019 outbreaks of *Salmonella* Newport (5 cases) were reported by the consumption of raw tuna products. In 2021 there was 124 people got illnesses and 23 of got hospitalised due to consumption of seafood and frozen cooked shrimp as a followed year in 2022, 39 people got infected and 15 were hospitalised and the survey reported 72% of people got infected by consumption of raw fish and sushi and 83% consume raw salmon from another restaurant.

Transmission and virulence strategies of Salmonella

Salmonella bacterium enters the consumer from seafood through the gastrointestinal tract and migrates to deeper tissues by a multiple mechanism. Most incidents of seafood poisoning worldwide are caused by Salmonella enterica Typhimurium (ST). The bacterium is classified as a non-specific zoonotic bacterium that can infect humans and animals. While the majority of infections caused by this microbe result in self-limiting gastroenteritis, certain strains of ST have been demonstrated to be invasive, meaning they can penetrate the intestinal wall and enter the bloodstream(dos Santos et al., 2019). After translocating into intestinal tissue, the bacterium niche replicates in macrophages and counters the adaptive immune response. Even though Salmonella is a significant human pathogen, causes long-term systemic infections by affecting the host immune system or their virulence mechanisms. Infected individuals act as reservoirs of a source of bacterium because of the periodically shed and transferred to another host (Oludairo et al.,2023)

Salmonella Typhimurium (S. Typhimurium), Salmonella Enteritidis (S. Enteritidis), and Salmonella Senftenberg firmly adhere to vectors as food through the use of AgfD-regulated adhesin, biofilms, and flagella. Pathogenicity of Salmonella Typhimurium has several encoded virulence properties that influence to cause of severe disease by virulence plasmid that encompasses of virulence gene(dos Santos et al., 2019)

Severe sporadic salmonellosis caused by non-Typhoidal Salmonella bacterium. Host-specific factors, travel, environmental, animal and food exposures as significant risk factors for salmonellosis transmission (Guillier et al., 2021). Salmonellosis is the second most reported bacterium transmission linked with zoonosis in European countries (EFSA and ECDC, 2018). S. Typhimurium-caused bovine enteritis is mostly an intestinal infection that can be fatal due to dehydration and intestinal ulcers (Tsolis et al., 1999)

Salmonella has several virulence factors that cause disease such as virulence plasmid, lipopolysaccharide biosynthesis and capsular polysaccharide. Antimicrobial resistance genes also had a significant virulence by plasmid or transposon exchange. The IncHI1 plasmid, which has a composite transposon that may carry several resistance genes, is typically linked to the AMR genes. Specifically, S. Typhi have a Salmonella pathogenicity island (SPI) site of a chromosome that has been responsible for virulence factors such as adhesion, invasin (protein)and toxin genes (Khafaji et al., 2021)

Antimicrobial resistance strategies of Salmonella

Antimicrobial resistance of bacteria was the most important facing issue in public health in the 20th century, latterly multidrug resistance has become a challenging one in treatment and public health significance. The pathogenic bacterium of Salmonella adopts the mechanisms of drug efflux pump system, alteration of target site, inactivation of antibiotic through enzyme and prohibition the drug entry by porin channel. *Salmonella* has a complex multi-structured cell wall with encompasses of efflux pump and multiplex protein. Bacteria detect and expel dangerous compounds through the efflux pumps (Alenazy, 2022). Salmonella resists the first generations antibiotic (chloramphenicol, amoxicillin, and co-trimoxazole) in the 19th century and the second generations antibiotics (fluoroquinolone) from the early 20th century, recently reported that Salmonella resists the third generations antibiotics such as cephalosporins and azithromycin (Karkey et al., 2018).

Conclusion

Seafood is one of the vectors that carry *Salmonella* which causes the disease of Salmonellosis and typhoid fever. Consumption of live cell or typhoidal toxin (Salmonella cytolethal distending toxin) of the *Salmonella* bacterium leads the DNA damage in human cells and more than 40 nontyphoidal Salmonella (NTS) serotypes found the S-CDT toxin. The evolution of resistance to *Salmonella* provokes a major risk in clinical treatment worldwide exclusively in industrial countries.

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DISEASES OF SILKWORMS

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Introduction

Many silkworm diseases are caused due to the infection of various bacteria, virus, fungus, microsporidia, etc., in the silkworm colonies and this is a major limiting factor in the successful cocoon production. Diseases such as grasserie, flacherie, muscardine and pebrine are caused due to these pathogens. Here's a detailed overview of some common diseases that affect silkworms.

Silkworm is infected by

Viral diseases

Fungal diseases

Bacterial and

Protozoans

I. Viral diseases of silkworm:

1. Grasserie: Halu hula

Also referred as Jaundice or hanging disease. It is caused by *Borrelina bombycis*, Borrelina virus, it is NPV Nuclear Polyhedrosis Virus.They infect the nuclei of midgut epithelial cells, adipose tissue, fat body and blood cells.This is a viral disease which may appear in any stage of rearing but usually occurs just when the worms are due to ripen. It is also known as "Jaundice" in view of yellowish color assumed by the affected worms.

Symptoms: Intersegmental swelling is peculiar symptom of this disease, the swelling first appears at the first abdominal segment of the affected worm and gradually extends over the whole body, stretched skin begins to shine and finally bursts in places yellowish or white spores escapes from ruptured places. If this disease occurs just before moult, the worms will not go into moult but crawl aimlessly along the ridges of the rims of the rearing trays subsequently falling on the ground and dies. Usually death takes place 4-5 days after NPV infection. Sometime, they die by hanging to the rim of the trays. If ripe worm is attacked with grasserie, it may spit and waste its silk or may just spin thin melted cocoon and die within it before becoming pupa. Damage caused by the disease-If this disease occurs in early instars, worms fail to spin the cocoon and dies. If ripe worm attacked they may just spin melted cocoon and die within it before becoming pupa.

Preventive measures:

1. Rearing the silkworms under hygienic conditions
2. Provide good quality leaves depending on the stage of worms
3. Give proper ventilation to the rooms without any wide fluctuations in temperature
4. Avoid causing injuries to the silkworms while handling since the virus has access to enter through injured parts
5. Egg card disinfection should be followed
6. Remove and destroy infected worms

Curative measure:

- Grassarie can be controlled by dusting 'Resham keet oushad" (developed by CSR & TI, Mysore) as bed disinfectant which has got antimicrobial activity.
- Constituents of Resham keet oushad (RKO): 1% Captan + 1% Parafarmaldehyde + 2% Benzoic acid + 96% Lime powder.
- This should be dusted with the help of thin cloth on the larva and bed during IV & V instars.
- Dusting should be done only after moult and not during preparation for moult or during moult.
- Oral administration of nalidixic acid is effective: it is the first of the synthetic quinolone antibiotics.

2. Cytoplasmic polyhedrosis virus (CPV)

Caused by the organism *smithia virus*, the site of infection and multiplication of virus is cytoplasm of midgut cells.Symptoms caused by this is Loss of appetite, Mid gut become whitish, Head sometime disproportionately large. Control method is Similar to NPV

3. Infectious fletcheri virus (IFV)

Caused by the organism *Morator virus*, the site of infection and multiplication of virus is goblet and columnar midgut cells. Symptoms caused by this is Loss of appetite, larva become whitish. Control method is Similar to NPV

II. Fungal diseases of silkworm

The fungal pathogens causing disease in insects are called muscardine disease or calcino disease. Three types of muscardine diseases are noticed on silkworm.

1. White muscardine: *Beauveria bassiana*
2. Green muscardine: *Metarrhizium anisopliae*
3. *Brown muscardine: Aspergillus flavus, A. oryzae etc*

Depending on the colour of the mycelium, the body colour of the silkworm becomes, green, white, yellow, red etc. The white muscardine (*B. bassiana*) is very common.They also differ from each other also in the tissues they infect. But modes of infection, the symptoms as well as the control measures are same for all the muscardine infections.

Infection:

Takes place through skin due to body contamination, Conidia adhering to the skin readily germinate if temperature and humidity conditions are suitable to them.The germinating tube penetrates through the skin into the body, grows into a mycelium, fungus continuous its development with in the body cavity, blood becomes scanty, blood cells are destroyed and during advanced stages of infection, circulation slows down and finally circulation stops and the worms dies. Dead caterpillar is a dangerous source of infection. The mycelia from infected worms come out and acts source of infection for further spread, the larvae are more susceptible to the attacks during moults. Life cycle from spore to spore hardly takes ten days in cloudy weather and about four days in hot weather.

Symptoms caused by the organism shows infected larvae loose appetite and become inactive, Specks of oil markings may appear on the skin, the larvae may also have diarrhoea and vomit fluid, Body becomes weak and loses its elasticity. larvae ceases to move and generally dies, body generally hardens and becomes stiff. White muscardine caused by *Beauveria bassiana* infection, within a day or two days of death, the entire body is covered with numerous conidia giving mealy white powdery appearance covering the worm. At ripening if there is incidence caterpillars may spin the cocoons but moth will not emerge.

Green muscardine caused by *Metarrhizium anisopliae* infection, within 3 to 5 days of death, the entire body is covered with numerous conidia white mycela, white mycelia turns to olive-green later, hence called green-muscardine.

Prevention and control of fungal diseases:

In recent times, muscardine disease has shown tendencies to break out in epidemic forms especially in Karnataka. Hence, following steps are recommended.

1. Disinfection of rearing room and appliances with 2% formalin and room should be closed for 24 h to effectively kill the spores.
2. Disinfection of eggs with 2% formalin on the larval body and bed. It acts as disinfectant
3. Rearing bed should be kept as dry as possible in order to overcome the germination of conidia and spread of fungus.
4. Keeping anhydrated lime in the corners of trays during rainy seasons absorbs excess moisture and reduces the humidity.
5. Free aeration will reduce the humidity.
6. Separation of diseased worms either picking or by use of nets, litter should be removed as frequently as possible
7. Application of formalin chaff should be used here formalin is mixed with burnt paddy husk and sprinkled

III Bacterial diseases:

1. **Flacherie**- The main causative pathogens are different are bacteria viz., *Streptococcus sp*., *Staphylococcus sp*., *Bacillus thuringiensis* and *Serratia marcescence* and non-occluded viruses such as infectious flacherie virus (BmIFV) and densonucleosis virus (BmDNV).

   (will be discussed under viral diseases). Flacherie is also caused by the combined infection of bacteria and viruses.

   Flacherie is classified into several types depending on the causal agent and symptoms.

The principal categories are:

1. **Bacterial diseases of digestive system/gastric injury flatcherie** *Bacillus bombycis*, *B. bombycoides* etc.

2. **Specticaemia** caused by *Streptococci*, *Staphylococci etc*

3. **Sotto disease** caused by *Bacillus sotto, B. thuringiensis var. sotto*

4. **Court disease** caused by *Serratia marcescens*

The main causes for incidence of flacherie are high temperature, high humidity and bad ventilation, bad leaves namely dirty, coarse leaf, leaf not suited to the age of the larvae, wet and fermented leaf etc. over feeding, decreased alkalinity of the gut, overcrowding etc.

General Symptoms of bacterial diseases are loss of appetite, Sluggishness, slow growth, Inelasticity of the skin and softening of the body are also observed, In certain cases and especially in V age larvae diarrhoea can be noticed and worms pass out soft excreta. In some cases, the disease is accompanied by vomiting of fluid, In most cases, the body putrefies and becomes black, emits bad odour.

Prevention and control of bacterial diseases:

1. Select a sturdy race which can normally resist adverse seasonal conditions
2. Incubate the eggs properly so that the worms which hatch out are healthy and robust
3. Proper disinfection
4. Feed appropriate type of good quality leaves in adequate quantities.It is very important that feeding with over mature or withered leaves is avoided as lechery is a disease mainly arising from wrong type of feeding
5. Diseased worms must be removed from healthy ones and destroyed by burning or deep burying in soil

2. Kenchu disease of silkworm

This is a multiple syndrome disease caused by bacteria such as *Streptococci*, *Staphylococci* and virus such as kenchu virus. This is common disease in Karnataka. Symptoms observed is larvae become dull and turns to pale colour, Infected larvae when dead develop brownish specks and emit foul smell, Control measures are similar to other viral and bacterial diseases

iv. Protozoans diseases

Pebrine disease is caused by *Nosema bombycis* (Nosematidae : Protozoa Microsporidia) is also called as Ganturoga. The name pebrine was given to the disease because of pepper like spots that appears on the body of silkworms infected by this disease. The entire silk industry of France would have been wiped out, if not for the timely intervention of Pasteur, who discovered the cause and remedy for the disease.

Different Sources of infection are Contact, Oral and Transovarial- The main source of infection is food contaminated with spores later this infection begins in the gut regions and spread to other parts of the body. Finally reaches the reproductive system and infects the eggs through transovarial transfer.

Symptoms of the disease are Eggs lack adhesive gum, hence they can be easily detached from egg cards, also laid in lumps, one over the other, instead of side by side. In worms, On larvae, Symptoms appear only when the diseases is for advanced, In India the appearance of blacks pots on the body is not quite common, diseases takes an acute form with the early age larvae than the grown up larvae, When the disease has advanced the larvae become sluggish and dull, have poor appetite and generally cease to feed resulting in irregular moulting and growth irregular development in most striking symptoms, a tray of pebrinised larvae shows various sizes of worms, worms appear paler and more translucent than healthy worms, When the larvae rest, their heads instead of being held up, hang down, infected larvae may die before spinning often the ripened worms spits the silk and wastes it.

In the pupa, the abdominal part swells and gets unusually soft, colour gets dark, movement of pupa gets dull on the sides especially where the wings are forming black spots may appear. In moths, the scales fall off easily, leaving the body bare in patches, wings do not strech fully and antennae are distorted, belly swells and moths does not move freely, egg laying capacity of infected moths will become poor. However, some of the infected moths do not show any symptoms.

Prevention and disease elimination

1. Mother moth examination – Louis Pasteur method of pebrine elimination
2. Surface sterilization of egg cards
3. Destruction of diseased life stages and disinfection of rearing room and appliances

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LATERAL FLOW ASSAY: A NEXT-GENERATION POINT-OF-CARE SENSORS AGAINST PLANT PATHOGENS

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Introduction

Plant diseases caused by fungi, bacteria, viruses, and other virus-like particles have a significant impact on crop production quality and quantity. Currently, it is imperative to incorporate early prediction and detection technologies on a regular basis to mitigate crop output loss and prevent the spread of diseases. Well-established techniques for the detection of diseases, including microscopy, serology, and molecular techniques, are available. Despite their high precision and sensitivity, these techniques are complex to operate, necessitate skilled personnel, and involve intricate sample preparation, limiting their suitability for on-site rapid detection. Hence, there is an increasing demand for efficient and accessible detection methods which underscores the need to explore new ways that are simple, reproducible, and cost-effective.

In this regard, immunoassays are adaptable methodologies for point-of-need applications that rely on specific antibody-antigen interactions to qualify and quantify analytes. Out of these, the lateral flow immunoassay (LFIA) is a potent analytical platform for point-of-need testing because it aligns with the ASSURED criteria set forth by the World Health Organization (Naseri *et al*., 2021). LFIA is a paper-based (bio) analytical method that enables on-site detection of target substances, with findings delivered within 5–10 minutes from a standalone device with limits of detection ranging from 0.1 to 10 ng/mL for both competitive and non-competitive formats (Soh *et al*., 2020). Nanoparticles like gold, silver, fluorescence, and magnetic markers have been used in recent studies to try to improve detection. This is because other methods aren't as sensitive or accurate as these.

General Principles and Fundamental Components of LFIAs

The LFIA is a composite strip comprised of various components, including a porous nitrocellulose membrane, cellulose or glass fiber pads, and conjugate pads. These components work together to make it easier to analyze the target molecules. The LFIA is designed with a plastic backing that links the sample pad and absorbent pad to each end of the strip, providing the necessary components required for liquid sample pre-treatment and absorption. Here, the conjugate pad, which sits between the sample pad and the nitrocellulose membrane, includes dried, labeled immune-reagents such as gold nanoparticles or latex-tagged antibodies. The Test lines and Control lines on the nitrocellulose membrane offer the necessary data for the analysis. The completed strip is housed in a plastic cassette with a reading window above the reactive regions and a sample well above the sample pad to ensure the correct flow of the sample and labeled conjugate solution. To use the LFIA, apply the liquid sample to the sample pad, which rehydrates the labeled immunoreagents on the conjugate pad. The analytes and labeled probe flow along the membrane by capillary forces, enabling immunoreactions to produce quick and easy-to-interpret without the need for extra equipment (Bahadır and Sezgintürk, 2016).

Bio-specific molecules for the LFIA

The most frequently employed method for identifying bio-specific molecules in LFIA is the use of antibodies, particularly monoclonal antibodies (Guliy *et al*., 2023). However, polyclonal antibodies and immunoglobulin fragments are also applicable. In addition, artificial structures such as aptamers, lectins, molecular beacons, and DARPins are currently being investigated for their exceptional properties (Pruksaphon *et al*., 2021). Furthermore, oligonucleotides combined with GNPs have been also utilized for the selective visual detection of viral and bacterial DNA. These LFIA labels encompass magnetic particles, fluorescent and luminescent materials, enzymes, various nanoparticles, and many more (Mirica *et al*., 2022).

Also, these GNPs are the most commonly used LFIA labels, with conjugation typically involving adsorption or chemisorption using alkanethiol linkers (Mirica *et al*., 2022), while affinity conjugation improves their functionalization (Lou *et al*., 2012). GNPs' plasmonic properties enable optical resonance tuning from visible to near-infrared, hence further boosting their LFIA utility. Spherical GNPs of a diameter of 20–40 nm are optimal for LFIA with larger sizes and enhancements are also used (Babaei-Afrapoli *et al*., 2021). In recent years, researchers have investigated several GNP morphologies such as nanorods, nanoshells, and multi-branched nanostructures to lower detection limits, particularly for instrumental analysis methods like surface-enhanced Raman spectroscopy (SERS) (Chen *et al*., 2022).

Types of LFIAs

According to Sajid et al. (2015) and Bahadır and Sezgintürk (2016), LFIAs are categorized into three types: sandwich, competitive, and multiplex detection assays. In the sandwich assay, labeled antibodies on a conjugate pad temporarily bind to the target analyte in the sample, which then moves to the test line where it binds to another antibody, forming a labeled antibody-analyte-primary antibody complex. The excess-labeled antibody is captured at the control line, ensuring the test is functioning correctly. In contrast, the competitive assay is capable of detecting low-molecular-weight compounds that cannot bind two antibodies simultaneously. It involves competition between the target analyte and a pre-immobilized antigen for binding to a labeled antibody at the test line. Moreover, in the multiplex assay, multiple target analytes are detected on a single strip with multiple test lines, allowing simultaneous analysis under the same conditions. This format is particularly beneficial for clinical diagnoses requiring the detection of multiple interdependent analytes.

Isothermal nucleic acid amplification-based lateral flow testing (INAA-LFT)

INAA-LFT is an innovative method that amplifies genetic material (DNA or RNA) through isothermal amplification and detects it via a lateral flow strip (LFS). This approach provides greater sensitivity than traditional lateral flow immunoassays by amplifying the pathogen's nucleic acid within the assay.

The high-sensitivity detection of target nucleic acid fragments in INAA-LFTs is contingent upon the efficient amplification of these fragments. Isothermal techniques like LAMP, RPA, and RAA are often employed for DNA or RNA amplification (Ivanov *et al*., 2023), followed by labeling the target nucleic acid fragments from pathogens with markers such as biotin, fluorescein isothiocyanate (FITC), tetramethyl rhodamine (TAMRA), or digoxigenin (DIG). The specific detection of biotin is made possible by its intense affinity for avidin or streptavidin. In contrast, the rapid and sensitive detection of FITC is facilitated by the emission of a robust green fluorescence upon excitation. Similarly, TAMRA enhances sensitivity by producing intense red fluorescence. Digoxin also offers a distinctive labeling option that facilitates a variety of detection methods. Furthermore, the choice of label depends on factors such as detection sensitivity, ease of use, equipment availability, and specific assay requirements.

Type of amplification	Virus	Testing duration	Sensitivity	References
LAMP	Tobacco rattle virus	<50 min	78 pg template/ µL RNA	Edgu *et al.*, 2020
	Chinaberry tree badnavirus 1	45 min	0.5 pg/ reaction	Lu *et al.*, 2021
	Rice stripe virus	50 min	3 copies per reaction	Zhu *et al.*, 2022
	Xanthomonas oryzae pv. *oryzae*	<90 min	0.2 ng/µl of gDNA and 2.5×10^5 cfu/ml of bacterial cell.	Buddhachat *et al.*, 2024
	Xanthomonas oryzae pv. *oryzicola*	<90 min	0.2 ng/µl of gDNA and 2.5×10^5 cfu/ml of bacterial cell.	Buddhachat *et al.*, 2024
RPA	Citrus tristeza virus	15–20 min	141 fg of RNA when cDNA used as a template	Ghosh *et al.*, 2020
	Tomato spotted wilt virus	15 min	10 fg TSWV CP transcripts	Lee *et al.*, 2021
	Potato virus Y (PVY)	30 min	4 ng of PVY per g of plant leaves	Ivanov *et al.*, 2021
	Potato virus S (PVS)	30 min	0.04 ng of PVS per g of plant leaves	Ivanov *et al.*, 2021
	Potato leaf roll virus (PLRV)	30 min	0.04 ng of PVS per g of plant leaves	Ivanov *et al.*, 2021
	Tobacco mosaic virus	40 min	-	Marques *et al.*, 2022
	Peronophythora litchii	15-25 min	1pg/µL	Wang *et al.*, 2024
RAA	Rice stripe mosaic virus	30 min	10^7 dilution	Wang *et al.*, 2023
	Tomato brown rugose fruit virus	20 min	10^1 copies /reaction	Cao *et al.*, 2023
	Pepper mild mottle virus	<1h	-	Zhao *et al.*, 2023

Table 1: Detection of plant pathogens using INAA-LFT.

After labeling, the target nucleic acid fragments are detected using a paper-based strip. This strip has specific zones with immobilized proteins that bind the labeled target nucleic acid fragments. If pathogen-derived nucleic acid fragments are present, they bind to the immobilized labels in the detection zone, forming a visible line indicating a positive result (Sang *et al*., 2021). A control line is also present to verify the test's functionality, capturing excess labeled markers to ensure test validity.

CRISPR-CAS System-Integrated LFT Detection of Plant Viruses

CRISPR-Cas technology, which is widely known for its genome editing capabilities, is now being utilized in INAA-LFT to detect plant viruses with remarkable specificity and sensitivity. This technology relies on guide RNA to target and bind to specific sequences that are amplified through PCR, LAMP, or RPA/RAA. Once bound, Cas proteins such as Cas12 or Cas13 activate and cleave the target, creating a detectable signal, typically in the form of fluorescence.

Marques *et al*. (2022) employed CRISPR-Cas12a and Cas13a/d to identify viral RNA amplicons from tobacco mosaic virus (TMV), tobacco etch virus (TEV), and potato virus X (PVX) without the need for costly RNA purification. Similarly, Zhu *et al*. (2022) developed a CRISPR/Cas12a-assisted LAMP-LFT system for detecting rice viruses RSV and RBSDV, as well as the bacterial pathogen *Xanthomonas oryzae* pv. *oryzae* (Xoo), with sensitivity down to three or nine copies. Many researchers have also accomplished quick diagnosis using lateral flow strips in under 30 minutes.

Conclusion

The Point-of-Care Testing (POCT) has completely revolutionized the approach to diagnostic strategies in contemporary times. The advancement of LFAs with improved specificity and sensitivity has facilitated the rapid detection of numerous plant pathogens, making them highly cost-effective technologies. Simultaneously, nucleic acid-based LFAs, such as INAA-LFT, enhance both the specificity and duration of detection for NCDs, hence broadening the application of POCT in many domains as a substitute for labor-intensive conventional approaches.

Although POCT devices, particularly LFAs, have several advantages, they also have certain drawbacks. These include the need for confirmatory independent testing for certain conditions, higher costs for qualitative analysis, and the occurrence of technological errors.

Nevertheless, the recent and anticipated advancements focused on Point-of-Care Testing (POCT) and Lateral Flow Assays (LFA) have the potential to enhance the efficiency of this technology and render it essential for the future.

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GENE PYRAMIDING - CONCEPTS, STEPS INVOLVED AND BENEFITS IN AGRICULTURE PERSPECTIVES

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Introduction

"Gene pyramiding involves the combination of multiple genes (typically resistance genes) into a single genotype". The aim is to create a plant variety with enhanced or durable resistance to diseases or pests, combining the effects of multiple genes to achieve a cumulative or synergistic effect.

Key concepts of gene pyramiding

1. **Multiple gene integration:**
   - Resistance genes: Typically involves integrating multiple resistance genes (R-genes) that confer resistance to various pathogens or pests.
   - Trait enhancement: Can also be used to combine genes for other desirable traits such as drought tolerance, improved yield, or nutritional quality.
2. **Durability of resistance:**
   - Cumulative effect: The combined effect of multiple resistance genes can provide a more robust and long-lasting defense against diseases and pests.
   - Reduced breakdown: Pathogens and pests find it more challenging to overcome multiple resistance mechanisms simultaneously, thus delaying resistance breakdown.
3. **Breeding Techniques:**
   - Conventional breeding: Traditional methods of cross-breeding plants with desirable traits over successive generations.

   - Marker - Assisted Selection (MAS): Use of molecular markers to identify and select plants carrying the desired genes, speeding up the breeding process.
   - Genetic engineering: Direct insertion of multiple genes into a plant's genome using biotechnological methods.
4. **Challenges:**
   - Gene interaction: Ensuring that the combined genes do not negatively interfere with each other or with other important traits.
   - Complexity: The process can be complex and time-consuming, requiring detailed knowledge of the genes involved and their interactions.
   - Cost: Development and deployment of pyramided varieties can be expensive due to the need for advanced technology and extensive field testing.

Steps in gene pyramiding

1. **Identification of genes:**
   - Identify and isolate the genes that confer resistance or other desirable traits.
2. **Marker development:**
   - Develop molecular markers linked to the desired genes to facilitate selection in breeding programs.
3. **Crossing and selection:**
   - Cross plants with different resistance genes.
   - Use markers to select offspring that carry the desired combination of genes.
4. **Backcrossing and testing:**
   - Backcross selected plants with high-performing varieties to retain desirable agronomic traits.
   - Conduct extensive field testing to evaluate the performance and stability of the pyramided traits.
5. **Release and deployment:**
   - Once a stable and high-performing pyramided variety is developed, it is released for commercial cultivation.

Applications of gene pyramiding

1. **Disease resistance:** Developing crop varieties that are resistant to multiple strains of a pathogen, such as various races of rust in wheat or late blight in potatoes.

2. **Pest resistance:** Creating plants that can resist multiple pests, such as insects and nematodes, by combining genes that target different pests.
3. **Abiotic stress tolerance:** Combining genes for tolerance to different abiotic stresses like drought, salinity and extreme temperatures.
4. **Improved nutritional content:** Developing biofortified crops with enhanced levels of vitamins, minerals and other nutrients by pyramiding genes involved in nutrient biosynthesis.

Key strategies used in gene pyramiding

Gene pyramiding involves combining multiple genes, particularly those conferring resistance to pests and diseases, into a single plant variety to create durable and broad-spectrum resistance. Implementing gene pyramiding requires careful planning and a variety of strategies. Here are some key strategies used in gene pyramiding:

1. Marker-Assisted Selection (MAS)

Description:

- MAS uses molecular markers linked to specific genes to track the presence of these genes during the breeding process.

Steps:

1. Marker development: Identify and develop molecular markers associated with the desired resistance genes.
2. Genotyping: Screen the parent plants and progeny using these markers to identify individuals carrying the target genes.
3. Selection: Select individuals that carry all desired resistance genes for further breeding.

Benefits:

- Increases the efficiency and accuracy of selecting plants with multiple resistance genes.
- Reduces the time and cost compared to traditional phenotypic selection.

2. Genetic engineering and transgenic approaches

Description:

- Directly inserting multiple resistance genes into a plant's genome using biotechnological methods.

Steps:

1. Gene identification: Isolate the genes conferring resistance.
2. Vector construction: Construct a suitable vector to carry multiple resistance genes.

3. Transformation: Introduce the vector into the plant genome using techniques like *Agrobacterium* - mediated transformation or gene gun.
4. Selection and regeneration: Select transformed plants and regenerate them to develop stable lines.

Benefits:

- Allows precise insertion of multiple genes.
- Can incorporate genes from different species.

3. Conventional breeding

Description:

- Traditional cross-breeding techniques are used to combine multiple resistance genes from different parent lines.

Steps:

1. Selection of parents: Choose parent plants that each carry one or more desired resistance genes.
2. Crossing: Perform crosses between these parents.
3. Segregation and selection: In subsequent generations, select progeny that carry all desired resistance genes.
4. Backcrossing: Backcross selected progeny with elite, high-yielding varieties to combine resistance with desirable agronomic traits.

Benefits:

- No regulatory hurdles associated with genetically modified organisms (GMOs).
- Can use naturally occurring resistance genes.

4. Pyramiding through backcross breeding

Description:

- Incorporate resistance genes into an elite variety by repeated backcrossing while selecting for the presence of the resistance genes.

Steps:

1. Initial cross: Cross a donor plant carrying the resistance gene with an elite variety.
2. Backcrossing: Backcross the F1 progeny with the elite parent while selecting for the resistance gene using molecular markers or phenotypic assays.

3. Repetition: Repeat the backcrossing and selection process for several generations until the resistance gene is incorporated into the elite genetic background.

Benefits:

- Combines resistance with high agronomic performance.
- Retains most of the elite variety's desirable traits.

5. Stacking genes using bi-parental crosses

Description:

- Cross two plants, each carrying different resistance genes, to combine these genes in the progeny.

Steps:

1. Crossing: Perform an initial cross between two parent plants, each with different resistance genes.
2. F1 selection: Select F1 plants that carry both resistance genes.
3. Selfing: Self-pollinate the selected F1 plants to produce F2 generation.
4. Segregation and selection: Screen the F2 generation to identify individuals carrying all desired resistance genes.
5. Stabilization: Further selfing or backcrossing to stabilize the desired genotype.

Benefits:

- Simple and straightforward approach.
- Can be used with natural genetic variation.

Case Studies of Successful Gene Pyramiding

The success of gene pyramiding in plant breeding can be evaluated through various case studies and practical outcomes where this approach has been implemented. Key factors contributing to this success include advanced breeding techniques, rigorous field testing and integration with broader pest management strategies. These successes highlight the potential of gene pyramiding to enhance crop resilience, improve yields and promote sustainable agriculture. Here are several examples and factors that illustrate the successful application and benefits of gene pyramiding:

1. **Rice (*Oryza sativa*)**
   - Disease resistance: Researchers have successfully pyramided genes for resistance to bacterial blight (Xa4, Xa21, and Xa27) into rice varieties. These pyramided varieties

show enhanced resistance to multiple strains of the pathogen compared to those with a single resistance gene.

- Example: The variety "IRBB66," developed by the International Rice Research Institute (IRRI), combines multiple bacterial blight resistance genes, resulting in durable resistance across different environments.

2. **Wheat (*Triticum aestivum*)**
   - Rust resistance: Wheat varieties with pyramided rust resistance genes (e.g., Lr34, Lr46, Sr2 and Yr18) have shown significant resistance to leaf rust, stripe rust and stem rust. These pyramided varieties have delayed the emergence of rust strains that can overcome single resistance genes.
   - Example: The variety "Mace" in Australia incorporates multiple rust resistance genes and has provided durable resistance against rust pathogens for over a decade.
3. **Potato (*Solanum tuberosum*)**
   - Late blight resistance: Pyramiding resistance genes Rpi-blb1, Rpi-blb2, and Rpi-blb3 in potatoes has led to varieties with broad-spectrum resistance to late blight, a devastating disease caused by *Phytophthora infestans*.
   - Example: The variety "Fortuna" contains multiple late blight resistance genes and demonstrates high resistance under various field conditions.
4. **Tomato (*Solanum lycopersicum*)**
   - Nematode resistance: Combining resistance genes Mi-1, Mi-2, and Mi-3 has produced tomato varieties with durable resistance to root-knot nematodes.
   - Example: Varieties like "Celebrity" and "Better Boy" incorporate multiple nematode resistance genes and are widely used in nematode-infested areas.

Factors Contributing to the Success of Gene Pyramiding

1. **Identification of effective genes:**
   - Success depends on accurately identifying and isolating genes that confer strong and complementary resistance to target pests and diseases.
2. **Advanced breeding techniques:**
   - Marker-assisted selection (MAS) and genomic selection have significantly enhanced the efficiency and accuracy of pyramiding multiple genes.

- Genetic engineering allows precise insertion of multiple resistance genes, accelerating the development process.

3. **Field testing and validation:**
   - Extensive field testing in diverse environments ensures that pyramided varieties perform well under different conditions and resist various strains of pathogens or pests.
4. **Integrated Pest Management (IPM):**
   - Incorporating pyramided varieties into broader IPM strategies enhances their effectiveness and sustainability.
5. **Monitoring and adaptation:**
   - Continuous monitoring of pest and pathogen populations helps in adapting and updating pyramiding strategies to address emerging threats.

Benefits of successful gene PYRAMIDING

- **Durable resistance:** Combining multiple genes provides a more robust and long-lasting defense against pests and diseases, reducing the likelihood of resistance breakdown.
- **Broad - spectrum resistance:** Pyramided varieties often exhibit resistance to multiple strains or species of pathogens and pests, providing comprehensive protection.
- **Reduced chemical inputs:** Enhanced genetic resistance reduces the need for chemical pesticides, lowering production costs and minimizing environmental impact.
- **Increased yield and stability:** Improved resistance leads to higher and more stable yields, contributing to food security and farmer livelihoods.
- **Sustainable agriculture:** Gene pyramiding supports sustainable agricultural practices by integrating genetic resistance into crop management systems, reducing reliance on external inputs.

Conclusion

Gene pyramiding strategies aim to combine multiple resistance genes into a single variety to enhance durability and breadth of resistance. Techniques such as marker-assisted selection, genetic engineering, conventional breeding, backcross breeding, and bi-parental crosses each offer unique advantages and can be used alone or in combination to achieve successful gene pyramiding. These strategies help create crop varieties that are more resilient to pests and diseases, contributing to sustainable agricultural practices and improved food security.

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CLIMATE-RESILIENT HORTICULTURE PRACTICES: A TECHNICAL OVERVIEW

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Introduction

Climate-resilient horticulture focuses on practices that enable crops to withstand climate-induced stresses such as temperature fluctuations, drought, flooding, and changing pest and disease patterns. The increasing volatility in climate conditions due to global warming has heightened the importance of building resilient agricultural systems, including horticultural crops. This article provides a comprehensive overview of technical strategies and innovations that promote climate resilience in horticulture.

1. Climate Change and Horticulture: A Growing Challenge

1.1. Impact of Climate Change on Horticulture

Horticulture, involving the cultivation of fruits, vegetables, flowers, and other plants, is highly sensitive to climate conditions. A changing climate introduces several challenges:

Temperature Extremes: Many horticultural crops are sensitive to temperature variations. For instance, fruit trees such as apples and cherries require a certain number of chill hours to break dormancy. Warming temperatures can disrupt this cycle.

Water Stress: Drought and erratic rainfall patterns can result in water shortages or flooding, affecting crop growth, yield, and quality.

Pest and Disease Pressure: Warmer temperatures and changing precipitation patterns can expand the range and life cycles of pests and diseases, increasing pressure on horticultural crops.

A 2021 study by the **Intergovernmental Panel on Climate Change (IPCC)** highlighted that crop yields of temperature-sensitive fruits and vegetables could decrease by 20-40% in certain regions by 2050 due to increased climate stress.

1.2. Key Challenges to Overcome

1. Decreasing water availability
2. Shifts in growing seasons
3. Reduced pollinator efficiency
4. Emerging pests and diseases

2. Climate-Resilient Horticulture Practices

Several strategies can be employed to mitigate climate-related risks and enhance the resilience of horticultural systems.

2.1. Climate-Smart Crop Varieties

Breeding Climate-Resilient Varieties

Developing and promoting crop varieties that are more tolerant to climate stressors such as heat, drought, and flooding is crucial.

Heat-Resistant Varieties: Breeding programs have introduced heat-tolerant tomato varieties like **'Heinz 1706 and Solar Fire'**, which can withstand high temperatures and maintain fruit set even in hot conditions.

Drought-Resistant Crops: Drought-resistant varieties like the drought-tolerant watermelon (Sugar Baby) are now available, using advances in molecular breeding and conventional techniques.

Biotechnology in Climate Resilience

Biotechnology tools such as CRISPR and transgenic approaches are being utilized to develop crops with enhanced climate resilience. Researchers are working on improving traits like **salt tolerance** in spinach and tomatoes and enhancing **drought tolerance** in crops like cucumber through genetic modifications.

2.2. Water Management Techniques

Efficient Irrigation Systems

Water management is crucial for horticultural resilience.

Drip Irrigation: According to FAO data, drip irrigation systems use up to 50% less water than traditional methods and ensure that water is delivered directly to the plant's root zone. This practice is particularly beneficial for high-value crops like grapes, tomatoes, and lettuce.

-Rainwater Harvesting: Capturing and storing rainwater for irrigation during dry periods ensures an additional water source for crops. A case study in Kenya showed that farms adopting rainwater harvesting techniques increased vegetable production by 30%.

Mulching

Mulching with organic materials like straw, leaves, or compost reduces water evaporation from the soil, keeping the root zone moist and moderating soil temperature. Mulching also suppresses weed growth and adds organic matter to the soil, enhancing its structure.

2.3. Crop Diversification and Agroforestry

Diversification of Crops

Growing a diversity of crops rather than relying on monocultures improves resilience by reducing the risk of total crop failure. For example, combining heat-tolerant vegetables with drought-resistant fruits (e.g., pomegranate) can hedge against climate variability. Intercropping legumes with fruit trees can improve nitrogen fixation in the soil and support overall plant health.

Agroforestry

Agroforestry integrates trees and shrubs with crops to create more diverse and productive ecosystems. The trees provide shade, reduce evapotranspiration, and improve the microclimate for horticultural crops. Fruit orchards interspersed with nitrogen-fixing trees such as acacia or gliricidia are examples of successful agroforestry systems. According to the **International Centre for Research in Agroforestry (ICRAF)**, agroforestry can reduce temperature extremes and boost yields by 10-30% under climate stress conditions.

3. Integrated Pest and Disease Management (IPDM)

3.1. Monitoring and Early Warning Systems

Climate change can exacerbate pest outbreaks, which is why early pest detection and forecasting systems are vital. The use of remote sensing technologies and mobile apps to monitor pest population trends can help growers take proactive measures.

Example: FAO's **Plant Village Nuru app** uses AI to help farmers identify plant diseases through smartphone images and provides real-time advice.

3.2. Biological Control and Ecological Pest Management

Natural Predators

Promoting natural predators, such as ladybugs for aphids or parasitic wasps for caterpillar pests, is an eco-friendly and effective way to manage pest populations. Creating **habitat strips** with flowering plants like marigolds or lavender can attract beneficial insects.

Bio-Pesticides

Bio-pesticides, derived from natural materials like plants, bacteria, and minerals, are gaining importance in climate-resilient horticulture. For example, neem oil is widely used to control a variety of pests while minimizing harm to beneficial organisms.

4. Climate-Resilient Infrastructure

4.1. Protected Cultivation Systems

Greenhouses and Shade Nets

Protecting crops from climate extremes such as excessive heat, cold, or rain can greatly improve yields. In areas with high solar radiation, **shade nets** (blocking 30-40% of sunlight) reduce heat stress on plants while allowing adequate light for photosynthesis. Greenhouse structures equipped with temperature control can extend the growing season and protect against weather variability.

Low-Cost Polytunnels

Polytunnels are cost-effective alternatives to greenhouses that offer climate control at a fraction of the cost. Polytunnels can raise temperatures by 2-4°C, which is critical for horticultural crops in cooler climates.

5. Climate-Resilient Soil and Fertility Management

5.1. Organic Matter Enrichment

Soil health is fundamental to climate-resilient horticulture. Soils rich in organic matter can retain more water and nutrients, helping plants survive during periods of drought. Practices like composting and the use of cover crops such as clover or rye can boost soil fertility and enhance carbon sequestration.

Data Point: Research from the University of California indicates that soils high in organic matter can retain 20-30% more water, improving plant resilience to drought.

5.2. Reduced Tillage

Minimizing soil disturbance through reduced tillage helps preserve soil structure and prevent erosion. Reduced tillage also promotes the buildup of organic matter, leading to better water retention and improved soil biodiversity.

6. Policy and Institutional Support for Climate-Resilient Horticulture

6.1. Government and Policy Interventions

Governments are increasingly recognizing the need for climate adaptation in horticulture. Policies promoting climate-resilient practices such as crop insurance, subsidies for drip irrigation, and financial incentives for adopting organic fertilizers are becoming more common.

Case Study: India's National Mission for Sustainable Agriculture (NMSA) promotes climate-resilient agriculture by providing subsidies for micro-irrigation, improved seeds, and climate-smart farming equipment.

6.2. Knowledge Dissemination

Extension services play a critical role in disseminating climate-resilient practices to farmers. Investment in research and development, combined with farmer training programs, helps bridge the knowledge gap between scientific innovations and practical implementation on the ground.

Conclusion

Climate-resilient horticulture is key to ensuring the sustainability and productivity of crops in the face of increasing climate variability. By adopting climate-smart crop varieties, efficient water management, integrated pest control, and resilient infrastructure, horticultural systems can continue to thrive. The future of horticulture will depend on the integration of scientific advancements with localized farming knowledge to create adaptable and sustainable food systems for a changing climate.

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ANIMAL WELFARE PRACTICES FOR GOOD DAIRY MANAGEMENT

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Introduction

The concept of Good Dairy Management Practices which aims at improving the animal productivity by enveloping scientific with humane management practices gains the importance. The intensification of animal husbandry practices, though needed for meeting the food needs of our burgeoning population, in the process, it also exerts varied type of stresses on animals, compromise their welfare. This indeed calls for a balanced production management practices which would consider both scientific management and animal welfare issues.

Concept of Animal Welfare:

According to OIE (World Organization for Animal Health) Animal Welfare 'means how an animal is coping with the conditions in which it lives. An animal is in a good state of welfare if (as indicated by scientific evidence) it is healthy, comfortable, well nourished, safe, able to express innate behaviour, and if it is not suffering from unpleasant states such as pain, fear, and distress. Good animal welfare requires disease prevention and veterinary treatment, appropriate shelter, management, nutrition and humane handling. Animal welfare refers to the state of the animal; the treatment that an animal receives is covered by other terms such as animal care, animal husbandry, and humane treatment.' Animal welfare is the **physical**, **psychological** and **natural** state of an animal as regard to its attempt to cope with its environment (Rollin *et al.*, 1993).

The major animal welfare indicators are; (FAWC, UK, 1992)

1) Freedom to express normal behaviour,

2) Freedom from hunger and thirst,

3) Freedom from fear and distress,

4) Freedom from pain, injury & diseases and

5) Freedom from discomfort

The five freedoms have been widely accepted as a statement of fundamental principles of animal welfare. Although they do not provide detailed guidance on the treatment and care of animals, they still serve as a useful framework for the assessment of whether animals' basic welfare needs are being met on farms, in markets, during transport, in lairages (holding pens for animals awaiting slaughter) and during slaughter.

The Welfare Quality Protocol for dairy animal welfare practices, formulated by European Union consists of four major welfare principles which includes; good feeding, good health, good housing and expression of appropriate behaviour. Under these four principles, twelve welfare criteria's were included viz., absence of prolonged hunger and thirst criteria under good feeding, comfort around resting, thermal comfort and ease of movement criteria under good housing, absence of injuries, diseases and pain induced management practices criteria under good health and expression of social behaviour, good animal-human relationship criteria under expression of appropriate behaviour principle.

Importance of Animal Welfare

Cow is considered sacred by a majority of the population in India. Animal welfare in India has gained a huge significance with respect to cow's welfare and protection. The population of indigenous cattle of the country has been decreasing over the years. But due to introduction of mechanized farming operations and indiscriminate cross breeding programmes for increasing milk production, many farmers are forced to abandon such indigenous unproductive cattle. This has led to extra burden on the farmers' to take care of feeding, breeding and healthcare needs of the cattle. All these events have led to serious problem of stray cattle in India. The cause may be the fodder and feed which they want to save for productive cattle or young heifers and calves.

In India, cow slaughter is prohibited in many states owing to religious reasons. Both the slaughter of cows and the sale of beef are punishable and non-bailable offenses in some states that demand rigorous fine and imprisonment for five to ten years. The factors such as abandoning unproductive cattle, prohibiting beef and rigorous penalties on transportation cattle outside could lead to increase in stray cattle population. Currently there are 52,87,767 stray cattle in India (DAH&DF, 2012). They hinder people's ordinary life by causing traffic jams and being one of the main causes of road accidents. They are also occupying parks and residential areas, defecating on the highways and clogging dung sewers. They also lead to crop losses by grazing farmers' fields. Farmers therefore incur huge fencing costs. The main reasons are due to in adequate space and funds with the Gaushalas and lack of public cooperation.

There are certain amendments, laws and institution developed to address cow welfare and protection. The Animal Welfare Board of India (AWBI), established in 1962 under Section 4 of the Prevention of Cruelty to Animals Act, 1960 is an apex and statutory advisory body under *Ministry* of Environment and Forests for formulating animal welfare laws and policies that promotes animal welfare in the country. It also provides financial grants to Gaushalas registered under AWBI and provide advice to the Government of India on animal welfare issues. Gaushala being the State subject mostly is governed by their respective State Goseva Ayogs. The Gaushalas in the State acquire registration under different provisions viz., Societies Registration Act, Gaushala Act etc., thus confirming to the animal welfare bylaws of their respective State. According to, The Indigenous Cow Protection Board Bill, 2017 it provides legal constitutional rights for the protection of indigenous cow and its progeny. To safeguard the interest of different communities, the Supreme Court had included the laws against cow slaughter as Directive Principle of State Policy. This means that States have the power to enforce independent policy for the matter which will be valid within the State only. All these have led to the empowerment of animal welfare boards both in Centre and State to take action against illegal smuggling and slaughtering of cows, thereby protecting our cows from the vagaries of external threat in our country.

Animal Welfare Vs Animal Productivity:

- It is well known fact that animal productivity and animal welfare are closely related.
- Protecting animal welfare involves 'meeting the most basic animal needs, ensuring good feeding, good housing, good healthcare and good behavior and consequently good animal productivity.
- However, high productivity is no guarantee of good welfare.
- On the contrary, striving to attain very high levels of productivity puts physiological stress on the animal with resultant impaired health, reproduction and longevity.

- Welfare is a multidimensional concept.
- In essence, animal welfare is the application of sensible and sensitive animal husbandry practices to the livestock on the farm. Animal welfare is primarily concerned with the wellbeing of the animal.
- In general, consumers perceive high animal welfare standards as an indicator that food is safe, healthy and of high quality.
- Animal welfare standards have been incorporated into most on-farm food quality and food safety schemes.

Animal welfare Indicators as specified in GDMPs: (FAO and IDF 2011):

S. No	Welfare principles	Welfare criteria	Measures
1	Good feeding	1. Absence of prolonged hunger 2. Absence of prolonged thirst	• Body condition score • Water provision, cleanliness of water points, water flow, functioning of water points
2	Good housing	3. Comfort around resting 4. Thermal comfort 5. Ease of movement	• Animal lying down area, cleanliness of udders, • cleanliness of flank/upper legs, cleanliness of lower legs, access to outdoor loafing area or pasture
3	Good health	6. Absence of injuries 7. Absence of disease 8. Absence of pain induced by management procedures	• Lameness, nasal discharge, • hampered respiration, • diarrhoea, vulvar discharge, milk somatic cell count, mortality, dystocia • Disbudding/dehorning, tail docking
4	Appropriate behaviour	9. Expression of social behaviours 10. Expression of other behaviours 11. Good human-animal relationship 12. Positive emotional state	• Agonistic behaviours • Access to pasture • Avoidance distance • Qualitative behavior assessment • (Source: Welfare Quality Protocol, EU)

1. **Ensure animals are free from thirst, hunger and malnutrition:**
   - Provide sufficient feed and water for all animals every day
   - Adjust stocking rates and/or supplementary feeding to ensure adequate water, feed and fodder supply
   - Protect animals from toxic plants and other harmful substances
   - Provide water supplies of good quality that are regularly checked and maintained

2. **Ensure animals are free from discomfort:**
   - Design and construct buildings and handling facilities to be free of obstructions and hazards
   - Provide adequate space allowances and clean bedding
   - Protect animals from adverse weather conditions and the consequences thereof
   - Provide housed animals with adequate ventilation
   - Provide suitable flooring and footing in housing and animal traffic areas
   - Protect animals from injury and distress during loading and unloading and provide appropriate conditions for transport.

3. **Ensure animals are free from pain, injury and disease:**
   - Have an effective herd health management programme in place and inspect animals regularly
   - Do not use procedures and practices that cause unnecessary pain
   - Follow appropriate birthing and weaning practices
   - Have appropriate procedures for marketing young dairy animals
   - Protect against lameness
   - Milk lactating animals regularly
   - Avoid poor milking practices as they may injure dairy animals
   - When animals have to be euthanized on-farm, avoid unnecessary stress or pain

4. **Ensure animals are free from fear:**
   - Consider animal behaviour when developing farm infrastructure and herd management routines
   - Provide competent stock handling and husbandry skills and appropriate training
   - Use facilities and equipment that are suitable for stock handling

5. **Ensure animals can engage in Normal behavior:**
   - Have herd management and husbandry procedures that do not unnecessarily compromise the animals' resting and social behaviours.

Factors influencing its adoption:

- The importance attributed to different aspects of animal welfare may vary between different people.
- Animal welfare is an important attribute of an overall 'food quality concept' and consumers expect their animal-related products, especially food, to be produced with respect for the welfare of the animals
- Consumers' concern and the apparent demand for information on animal welfare was the starting point for reliable science based systems for assessing the animals' welfare status.

Organizations promoting animal welfare:

- World Society for the Protection of Animals (WSPA), London
- Farm Animal Welfare Council (FAWC), UK
- Animal Welfare Board of India
- Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA)
- National Institute of Animal Welfare, Faridabad, Haryana
- Animal Ethics Committee –Research Organizations

Suggested strategies to promote animal welfare in India:

- Extension workers/veterinarians needs to be sensitized and trained adequately regarding Animal Welfare Protocol.
- Extension efforts needs to be strengthen in order to educate the farmers about GDMP/Animal Welfare Protocol.
- Government initiative to provide policy support to promote GDMP and Animal welfare practices among the farmers level.

Conclusion

In essence, animal welfare is the application of sensible and sensitive animal husbandry practices to the livestock on the farm. Animal welfare is primarily concerned with the wellbeing of the animal. In general, consumers perceive high animal welfare standards as an indicator that food is safe, healthy and of high quality. Animal welfare standards have been incorporated into most on-farm food quality and food safety schemes. Many animal welfare codes list ‘five freedoms’ that should underpin best farm practice in relation to animal welfare. These five freedoms provide a comprehensive overall concept of animal welfare. There is strong need develop and disseminate region and species-specific animal welfare protocols which could be easily adoptable by the farmers. Further, extension support system of state animal husbandry department needs to be strengthened, by training the extension personnel/veterinarians for effective dissemination of Animal Welfare Protocol (AWP) among the farmers.

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DAIRY VALUE CHAIN MANAGEMENT: CRITICAL ISSUES AND STRATEGIES

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Introduction

Milk is the single largest agricultural commodity contributing 5 percent to our national economy valued at Rs.8.4 lakh crore in 2019-20. India continues to be the largest milk producer in the world with annual production of 209.96 million MT (2020-21), contributing around 23 percent of global milk production. Surprisingly, Indian Dairy Sector is largely unorganised and only around 34 percent is organized sector, which is expected to grow at faster rate due to improved purchasing power, health consciousness leading changed consumer preference towards hygiene milk and milk products. And hence the demand for milk and milk products is expected to grow at a rapid rate due to population growth, urbanization, increase in income levels and changes in food habits at global level. This increase in demand for dairy products will put increasing pressure on dairy production systems;

However, the prospects of India being able to meet fully this demand from domestic output appears to be limited due to the factors such as traditional dairy farming methods, shortage of grazing land & water resources, constraints in increasing feed and fodder production, overstocking of livestock due to large proportion of non-productive animals and lack of efficient supply chain management would limit India's capacity to expand milk production. As a result, India’s contribution to global dairy exports is less than 1 percent. Hence greater attention needs to be paid in creating of smart and efficient dairy value chain besides improving the cattle milk productivity. As a result, it is expected that there will be investments made in this sector which will aid the introduction of technological advancements both in logistics and farm management.

With increased investments, dairies will be enabled to automate processes, reduce major costs and improve the quality of milk.

Dairy value chains

Dairy value chain analysis refers to different stages where the dairy products pass from farm to consumer. This encompasses the various stages of value chains like production, transportation, processing, marketing and distribution to the consumers. Value chain is the overall activities which are necessary to create produce and add value to end products or services. Supply chain is the network of establishments which involves, through upward and downward stream, the linkage of various process and actions in the form of products and services of customers. Moreover, it is concerned with harmonizing flow of materials and services from producers up to consumers in a way which improves value and profit. Dairy value chain is important to understand markets and their relationship, participation of different players and activities & critical constraints associated with delivering milk and milk products to the final consumer. To increase the product value practically, dairy chain would involve production, transport, processing, packaging and storage & distribution. Activities require inputs – such as finance and raw materials – which are employed to add value and to deliver dairy products to consumers. Every player in the chain should give the product the maximum added value at the minimum possible cost.

Establishing an efficient and effective dairy chain is a serious challenge in countries, like India. The prominent reasons encompass, difficulties in establishing a viable milk collection and transport system because of the small quantities of milk produced per farm and the remoteness of production sites; seasonality of the milk supply; poor transport infrastructure; deficiency of technology and knowledge in milk collection and processing; poor quality of the raw milk; distances from production sites to processing units and on to consumers; difficulties in establishing cooling facilities.

Supply Chain Management

Supply Chain Management (SCM) is the process of planning, implementing and controlling the operations of the supply chain with the purpose to satisfy customer requirements as efficiently as possible. Supply chain management spans all movement and storage of raw materials, work-in-process inventory and finished goods from point-of-origin to point-of-consumption. Supply chain management involves an organizational or institutional perspective involving collaboration, business environment, power and trust; a performance perspective involving performance measurements and consumer behaviour; and a process perspective involving process management issues such as costing, organizing supply chain, targets and decision making. A supply chain refers to different players being linked from farm to fork to achieve more effective, efficient, customer focused and market oriented flow of products.

The supply chain may include growers, packers, processors, storage and transport facilitators/providers, marketers, exporters, importers, distributors, wholesaler and retailers. The concept of supply chain has many connotations such as commodity chain, value system, value chain, production network and value network. A value system is a set of interlinked complete firms, which have all the business functions. Alternatively, a commodity chain is a network of labour and production processes whose end result is a finished commodity. It is the series of relations through which a produce passes i.e. extraction, conversion, exchange, transport, distribution and final use. The participants in a value chain can be integrated firms, retailers, lead firms, turn key suppliers, and component suppliers.

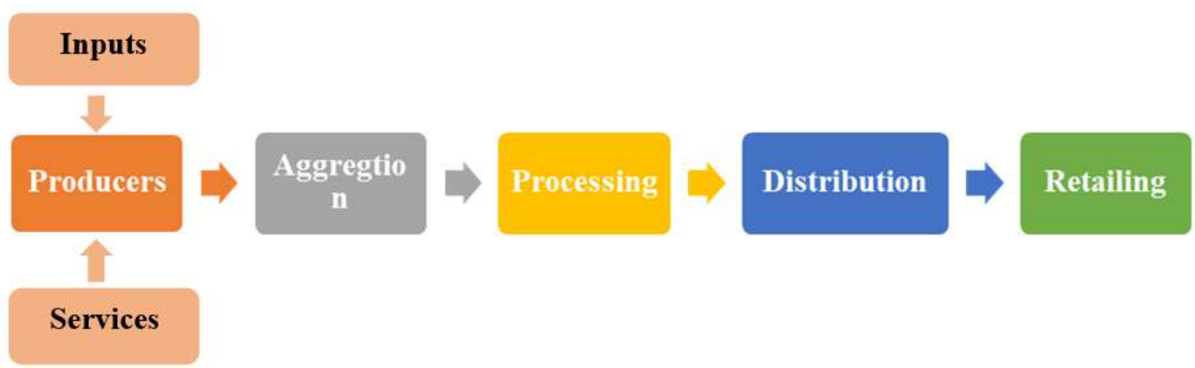
The development of supply chain requires knowledge and expertise about the functioning of the complete chain including strategic aspects i.e. framing strategies pertaining to chain design, chain formulation, chain organization, chain management and partnership and the functioning aspects i.e. chain marketing, chain logistic, quality assurance, material flow, information flow, value addition, technology and interaction. Managing supply chains warrants an integrated approach in which chain partners jointly plan and control the flow of goods, information technology and capital from farm to fork and vice versa. Supply Chain Management must ensure efficient integration of the entities involved so that merchandise is produced and distributed in the right quantity, to the right locations and at the right time.

Supply chain of Indian Dairy Industry

The major activities carried out in dairy supply chain includes;

- Producers-Dairy farmers/entrepreneurs involved in cattle rearing and milk production process.
- Inputs and Services- Supply of inputs and services for dairying in form of milching animal, cattle feed and fodder, supplements, veterinary aids for the animal, breeding & health care services etc.,

- Aggregation – Milking and its collection by collection centres, collection agents, chillers, firms milk trader and transportation.
- Primary and secondary processing - Milk collected are sent to the dairy plants where chilling of milk, processing and packaging of milk and milk product, transportation of milk and milk product is carried out.
- Distribution -Transportation of chilled milk and milk products through refrigerated vans, insulated milk tankers/vans of private, government and cooperatives societies.
- Retailing and Export- Final processed milk and milk products are transported to various retails outlets, supermarkets, and to retails markets of other countries from where the processed milk and milk products finally reaches to their end customers.



Dairy Production System

The Indian dairying is characterized as 'production by masses' rather than 'mass production'. The dairy production system in India can largely be classified in to four major productions systems which includes; Pastoral system, small holder production system, commercial dairy farm and urban/peri-urban dairy production systems. With more than 80 percent of the milk produced in developing countries including India is coming from small-scale dairy producers, dairying improves food security and represents a source of employment and income to millions of smallholder families. Smallholder dairy production relies heavily on family labour, with occasional use of hired labour. Small-scale dairying provides jobs along the dairy chain, for example, for small-scale processors and intermediaries. The strengths of smallholder dairying are low production costs, high profit margins, low liabilities, limited liquidity risk, and relative resilience to rising feed prices. Weaknesses include limited access to services such as breeding and healthcare services, training & awareness; poor access to markets and inputs, especially feed; scarce capital; and village level milk collection centers. The viability and profitability of small-scale milk production depend greatly on production costs and the efficiency of the dairy chain. Organized small-scale dairy systems (i.e., with improved productivity and market access) can compete successfully with large-scale, specialized, capital intensive "high-tech" dairies.

Dairy Processing Scenario

Of the total milk produced in rural areas around 46 percent consumed by the rural masses and the rest 54 percent is the marketable surplus. Of this surplus less than half of the milk sold (around 34%) is handled by the organized sector comprising of dairy cooperatives and private dairy companies and the rest by the unorganized sector. Based on the product type, the dairy industry in India can be segregated into liquid milk, UHT milk, flavoured milk, curd, frozen yoghurts, probiotic dairy products, lassi, buttermilk, table butter, ghee, paneer, cheese, khova, cream, skimmed milk powder, dairy whiteners, sweet condensed milk, ice cream, whey, milk shake, and dairy sweets. Among these, liquid milk currently holds the majority of the total market share which accounts for 65 percent of the market, is likely to remain stable. The majority of value-added dairy products (VADSPs) such as ghee, panner, butter, ice cream and curd are estimated to grow particularly in metropolitan areas. The dairy sector valued at around INR 7.5 trillion is expected to witness a further growth in the forecast period of 2022-2027, growing at a CAGR of 15.4%.

The performance of dairy value chains is primarily evaluated in terms of;

Efficiency

Flexibility

Responsiveness

Food quality

Critical Issues and Challenges in Dairy Value Chain Analysis:

- Policy environment: Lack of coherent livestock development policy coupled with lack of clarity of roles amongst the various concerned developmental departments
- Services: Inadequate coverage of veterinarian, breeding, health care and extension services. Added impetus required for NGOs and private players.

- Inputs: Inadequate availability of quality inputs at reasonable prices, Ineffective management of common property resources. Poor access to formal credit agencies at the farm level. High rates of interest charged by informal credit agencies besides compelled milk pouring.
- Production: Low genetic potential of animals, poor management of animals and feeding practices, disease incidence, inadequate quality milk production practices, food safety and public health issues, high milk production cost and low milk production per household.
- Procurement: Smallholder production system, unorganized milk vendors and too many intermediaries, milk quality issues, lack of infrastructure, seasonality of milk production, complex milk pricing and traceability.
- Marketing & processing: Inadequate coverage of co-operatives / private players, lack of transparent milk pricing system, lack of effective transportation facilities, inadequate cold chain and processing facilities.
- Record keeping: Poor record keeping leading memory biased data and analytical problems.

Strategies for efficient Dairy supply chain:

- Propagation of Good Dairy Management Practices among milk producers for improved quality milk production through institutional interventions.
- Improved access to quality feed inputs and green and dry fodder resources in the rural areas
- Promotion of women dairy farmers in milk production business through their active participation and decision making in organised milk marketing system.
- Increased share of organized milk marketing through establishment of Milk collection centres and BMCs at rural areas and improved infrastructure for bulk milk transport
- Investments in technologies like Bulk Milk Coolers (BMCs), immersion coolers and advanced milk testing kits.
- Adoption of Quality milk production practices at each level of dairy supply chain to ensure quality milk for domestic use as well for export.
- Expansion of organized milk collection centers and modernization of milk processing units and improved transport services

- Sensitization of local milk vendors – the important stakeholder of unorganised milk marketing, to actively participate in the dairy value chain and thereby building their capacities in quality milk handling.
- Leveraging the benefits of digital technological advancements like, IoT, Sensors and other mobile applications for efficient herd and cattle management for informed data driven decision making.
- Deployment of high-end technologies like block chain technologies and RFID for ensuring the efficient production, quality and traceability solutions facilitating smart dairy value chain.
- Tech-enabled transportation and packaging are traceable and can be utilized for real-time supply chain tracking and management.

Conclusions

An increasing population and higher consumption are combining to boost the demand for milk in India. The rise in consumption of milk and milk products is attributed to an increase in consumer purchasing power and health consciousness. There are different levels of value chains identified like input supply, production, marketing, processing, transportation and consumption. For efficient dairy value chain concerted efforts are needed for institutional interventions to empower dairy farmers with adequate knowledge and access to quality inputs and services and assured organized marketing services. Mostly, small holder dairy production system and processing is practiced at rural areas results in low milk production and hygiene. Hence, all concerned organizations (dairy value chain enablers) should focus on adoption of good dairy farming practices and quality milk production practices at their levels so as to increase the share of organised milk marketing and thereby ensuring managing efficient dairy value chain in our country.

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MULCHING: A BOON TO INDIAN AGRICULTURE

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Introduction

Agriculture in India, which forms the backbone of the economy, is constantly grappling with challenges such as water scarcity, soil degradation, and fluctuating weather patterns. Mulching, an age-old agricultural practice, has emerged as a powerful tool to address these issues. By providing multiple benefits, mulching is increasingly seen as a boon to Indian agriculture, particularly in the context of sustainable farming.

What is Mulching?

Mulching involves covering the soil around plants with various materials to create a protective layer. This can be done with organic matter such as straw, leaves, and grass clippings, or with inorganic materials like plastic, gravel, or stones. The practice helps to regulate soil temperature, retain moisture, control weeds, and improve soil health.

Benefits of Mulching in Indian Agriculture

1. **Water Conservation:** Water scarcity is a pressing issue in many regions of India, especially in arid and semi-arid areas. Mulching significantly reduces water evaporation from the soil, which in turn minimizes the need for frequent irrigation. This is particularly beneficial in states like Rajasthan and Maharashtra, where agriculture is largely rain-fed and water resources are limited.
2. **Weed Control:** Weeds compete with crops for water, nutrients, and sunlight, often leading to reduced yields. By covering the soil with mulch, the growth of weeds is suppressed as it

blocks sunlight, preventing weed seeds from germinating. Organic mulches decompose over time, further improving the soil's fertility, while plastic mulches can be reused season after season for effective weed control.

3. **Soil Health Improvement:** Organic mulches gradually decompose, adding organic matter back into the soil. This improves soil structure, enhances microbial activity, and increases nutrient availability. Improved soil health leads to better plant growth and resilience against pests and diseases. In states like Punjab and Haryana, where soil health has been compromised due to overuse of chemical fertilizers, mulching can help restore balance.
4. **Temperature Regulation:** In a country like India, where summer temperatures can soar to extreme levels, mulching helps regulate soil temperature by keeping it cooler during hot days and warmer during cooler nights. This is particularly beneficial for crops sensitive to temperature fluctuations, such as vegetables and fruits.
5. **Reduction of Soil Erosion:** Mulching provides a protective layer over the soil, reducing the impact of heavy rains and strong winds that can lead to soil erosion. This is especially important in regions with hilly terrains like Himachal Pradesh and Uttarakhand, where soil erosion poses a major challenge to agriculture.
6. **Cost-effectiveness:** While organic mulches can be sourced from farm residues like crop straw, leaves, and grass, inorganic mulches like plastic can be an investment that pays off over multiple cropping cycles. For small and marginal farmers, adopting mulching can reduce the costs associated with weeding, irrigation, and fertilizers, thereby improving farm profitability.

Types of Mulching in India

1. **Organic Mulches:** These include crop residues, straw, leaves, and green manure. Organic mulches not only conserve moisture but also enrich the soil as they decompose. They are commonly used in organic farming practices, which are gaining popularity across India.

2. **Plastic Mulching:** Plastic mulching has gained traction in modern farming systems, especially in horticulture. It offers efficient weed control, reduces water loss, and improves crop yields. The government of India has promoted plastic mulching under schemes like the *Pradhan Mantri Krishi Sinchai Yojana* to encourage farmers to adopt water-efficient technologies.

3. **Agro-textile Mulching:** Agro-textile mulching is a relatively new concept in India, where biodegradable materials or synthetic fabrics are used as a protective layer. These materials provide enhanced weed control and moisture retention while allowing air and water penetration, making them suitable for crops that need both protection and ventilation.

Challenges in Adopting Mulching in India

Despite its benefits, the adoption of mulching faces several challenges:

- **Cost of Materials:** For small farmers, the cost of inorganic mulching materials, particularly plastic, can be prohibitive. While organic mulches are cheaper, they require labor for collection and application.
- **Awareness and Training:** Many farmers, especially in rural areas, are not fully aware of the long-term benefits of mulching. Training and extension services are essential to educate them about its application and advantages.
- **Environmental Concerns:** While plastic mulching is effective, it poses environmental concerns related to plastic waste. The need for proper disposal and the promotion of biodegradable alternatives are crucial for sustainable use.

Government Initiatives Promoting Mulching

The Indian government, recognizing the importance of sustainable agricultural practices, has launched several initiatives that encourage the use of mulching:

- **Pradhan Mantri Krishi Sinchai Yojana (PMKSY):** This scheme promotes efficient irrigation practices, including mulching, to increase water-use efficiency in agriculture.
- **National Mission on Sustainable Agriculture (NMSA):** Under this mission, mulching is promoted as part of the broader aim to conserve soil moisture and improve soil health in rain-fed areas.
- **Subsidies and Training Programs:** Several state governments offer subsidies on mulching materials and conduct training programs to educate farmers on the benefits and techniques of mulching.

Conclusion

Mulching is a game-changer for Indian agriculture, especially in the context of climate change, water scarcity, and soil degradation. By conserving water, improving soil health, and enhancing crop yields, mulching can significantly contribute to sustainable farming practices. With proper awareness, training, and support from the government, mulching can help Indian farmers not only cope with the challenges they face but also enhance their productivity and income, securing a brighter future for agriculture in India.

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TERMITE: POTENT UNDERESTIMATED INSECT!

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Introduction

Termites stand out as the paramount arthropod decomposers within tropical forests, boasting remarkable diversity and abundance. Their pivotal role in reshaping both biotic and abiotic environments within these ecosystems cannot be overstated. However, their distribution in India faces constraints imposed by higher altitudes and extreme temperatures. Notably, the northeastern regions of India harbor a richer diversity of termite species compared to other parts of the country. Out of the 337 species documented in India, approximately 35 have been implicated in causing damage to agricultural crops and man-made structures. The impact of termite infestation is particularly pronounced in rain-fed crops, where damage rates range from 20% to 25%, contrasting with a lower incidence of 10% in irrigated crops. Perennial crops often fall victim to termite attacks during dry seasons, while annual crops become susceptible towards harvest time. Termites have earned the ominous moniker of "silent killers" due to their voracious appetite for cellulose-based plant materials, coupled with their ability to swiftly devour wood without leaving discernible traces of their presence. Their insidious nature underscores the need for vigilant monitoring and proactive measures to mitigate potential damage.

The major mound-building species in India are *Odontotermes obesus* (Rambur), *Odontotermes wallonensis (*Wasmann), and *Odontotermes redemanni* (Wasmann) and the subterranean species are *Coptotermes ceylonicus* Holmgren, *Heterotermes indicola* (Wasmann), *Coptotermes heimi* (Wasmann), *Microtermes obesi* Holmgren, *Odontotermes horni (*Wasmann), *Microcerotermes beesoni* Snyder and *Trinervitermes biformis* (Wasmann).

Damage Symptoms

Wilting serves as the initial telltale sign of termite infestation in the roots of seedlings or mature plants. Subsequently, affected plants may succumb to death or collapse. To confirm live termite activity, one can extract the affected plants and inspect their roots and lower stems. Over time, roots and stems, such as sugarcane setts, may become completely hollowed out and filled with soil. In orchards, termite damage frequently commences in areas with dead wood resulting from pruning or other injuries. Attacks on trees and bushes often commence with the exploitation of small cracks or tunnels created by other insects, providing entry points for winged termites in their reproductive stage. These invaders may ascend through the roots into the trunk and branches, ultimately disrupting the plant's vascular system's ability to transport nutrients and water, leading to the demise of the plant.

Sugarcane sett damaged by termite

Termites

Termite Mound

Some of the crucial practices inadvertently leading to termite attack are as follows:

- Unsuitable climatic conditions and cropping site; the crops would be and weakened and stressed and are more susceptible to termite infestations.
- Failure to remove damaged bark provides an opportunity for termites to colonize the pruned dead ends
- Root damage resulted from intercultural practices in field/horticultural crops, leads to termite infestation. The exudates from roots serve as attractants for termites.
- Collection and storing of crop residue, viz. stubbles, straw, uprooted dry weeds, etc., serves as additional food supple for termites.

- Improper nursery raising practices in horticultural, vegetable and silvicultural plants, resulting in poor-quality seedling and crops.
- Root infection arises from nematodes and soilborne diseases sick the plants and attracts termites.
- Any abiotic stress caused by poorly drained soil, drought, etc. favours termite infestation

Table 1. Termite infestation in diverse crops in India.

Crop	Species	Damage (%)	Reference (s)
Wheat	*C. heimi, O. obesus, O. redemanni, M obesi, O. feae, T. biformis*	13-100	Parween *et al.,* (2016); Roonwal (1979); Sharma (1967)
Maize	*O. obesus, M. obesi*	2-25	Joshi *et al.,* (2005); Reddy *et al.,* (2008)
Pulses	*O. obesus, O. parviden*	5-30	Paul *et al.,* (2018)
Groundnut	*Microtermes spp., Odontotermes spp., Amitermes spp.* India	10-30	Paul *et al.,* (2018)
Castor	*M. mycophagus, O. obesus, C. hemi*	19.8-80.2	Parween *et al.,* (2016)
Cotton	*M. mycophagus, O. obesi, O. obesus, T. biformis*	27-100	Parween *et al.,* (2016)
Sugarcane	*C. heimi, R. flavipes*	10-76	Pardeshi *et al.,* (2010); Bhattacharyya *et al.,* (2007)
Tea	*M. beesoni* and other termites	11-90	Roy *et al.,* (2020); Gurusubramanian et al., (2008);
Coconut	*Microtermes* spp., *Microcerotermes* spp., *Coptotermes* spp., *Neotermes* spp.	20-40	Mahapatro and Kumar (2015)
Mango	Different termite species	32 (Approx.)	Tomar (2003)

Management

Cultural practices:

- **Deep ploughing:** Deep ploughing serves as a proactive measure by exposing termites to desiccation and natural predators, thereby contributing to a reduction in their population. Additionally, harvesting crops at the appropriate time and promptly removing harvested plant materials from the field are beneficial practices in termite management.
- **Clean Cultivation:** Clean cultivation practices entail maintaining fields or orchards free from debris to deter infestations. This involves regular irrigation of cropped areas and diligent removal of dead, decaying plants, trees, and weeds from both the cropped areas and their immediate surroundings.
- **Intercropping and Crop Rotation:** Farmers can mitigate termite infestations by implementing crop rotation, particularly incorporating non-preferred crops, and adopting cropping systems that include fallow periods. This not only allows the soil to replenish its fertility but also promotes the healthy growth of subsequent crops, fostering some level of tolerance to attacks. Intercropping maize with soybean or groundnut has demonstrated efficacy in reducing termite activity while simultaneously enhancing predatory ant activity, further contributing to pest management efforts.
- **Soil Management:** Regular intercultural operations and pre-planting tillage play a crucial role in disrupting the tunnels and galleries constructed by termites. These operations effectively limit their foraging activities and significantly minimize crop damage. Additionally, in vertisols, termite infestations are less of a concern owing to the frequent occurrence of small cracks and crevices, which inhibit the maintenance of runways, galleries, and mounds by termites.
- **Water Stress:** Sustaining healthy plant growth is essential for preventing termite damage, as these pests tend to target sickly or water-stressed plants more frequently than healthy ones. Implementing frequent irrigation practices has been observed to reduce attacks by *M. obesi* in various field crops such as maize, wheat, sugarcane, and groundnut.

Chemical Control:

Non- agricultural use

- Bifenthrin 02.50 % EC 1. Pre and post construction: Bifenthrin 2.5% EC shall be applied at 0.05% a.i. conc. i.e. 20.0 ml formulated product diluted in 1 liter of water for the control of termites in building during pre and post construction. Treatment should be as per IS 6313 (Part 2):2001 for pre-construction chemical treatment and IS 6313 (Part3): 2001 for post construction treatment of the existing building

- For protecting building from termite attack at pre and posts construction stages, apply Chlorpyriphos 50% EC @ 0.5% and 1.0% concentration.
- For protecting building from termite attack at pre and post construction stages, apply Imidacloprid 30.5% m/m SC @ 0.075% a.i. concentration

Agricultural use

Used for drenching (Dose per ha.)				
Sr. No.	**Chemical**	**Dose of a.i.**	**Dose of formulation**	**Water**
1	Bifenthrin 10 % EC	100	1000	500
2	Chlorantraniliprole 18.50 % SC	100 – 125	500 – 625	1000
3	Clothianidin 50 % WDG	125	250	1000
4	Bifenthrin 8% + Clothianidin 10% SC	80 + 100	1000	1000
5	Imidacloprid 17.80 % SL	70	350	1875
6	Thiamethoxam 75 % w/w SG	120	160	500 – 1000

Used for Granular Application (Dose per ha.)			
Sr. No.	**Chemical**	**Dose of a.i.**	**Dose of formulation**
1	Fipronil 00.60 % w/w GR	75	12.5
2	Thiamethoxam 0.4% + Bifenthrin 0.8% GR	48+96	12

References

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