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From the Editor-in-Chief's Desk

I am happy and proud to announce the release of the Volume 1, issue 10 of AgriTech Today Magazine.

As we usher in the new year, let's extend our heartfelt wishes to the resilient farmers who toil tirelessly to feed our nations. May the fields be bountiful, and may the harvests be abundant, bringing prosperity to every corner of the agricultural landscape. In the spirit of unity, let's cultivate stronger bonds within our farming communities, fostering collaboration and knowledge-sharing to overcome challenges that lie ahead. May the coming year bring innovation to the fields, sustainable practices to the forefront, and a renewed appreciation for the essential role agriculture plays in shaping our collective future. Happy New Year to the dedicated farmers and agricultural enthusiasts who nurture the roots of our sustenance!

It gives me great pleasure to inform you that we have curated and finalized 62 articles for publication in this issue. My sincerest hope is that this issue will provide readers with valuable insights into agricultural technologies and innovations.

I extend my heartfelt gratitude to the dedicated editorial team and the talented authors for their invaluable contributions in bringing this issue to fruition. Your efforts have played a pivotal role in making AgriTech Today Magazine a source of enlightenment and knowledge in the agricultural domain.

Editor-in-chief

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Global Status of Glutinous Rice

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Glutinous rice (GR) contains low (0-5%) amylose, making it very soft and sticky. It is also called as the Waxy rice as it appears like uncarved wax after cooking. Amylopectin component of starch is responsible for the stickiness of glutinous rice. Stickiness is not specific to japonica or *indica* or tropical *japonica* (*javanica*) ecotypes of rice. Rather sticky rice genotypes spread across all available ecotypes of rice are each group that have low or no amylose and hence, cooked to be served as sticky rice. In India, sticky rice is more popular in the North Eastern states where it is consumed as a staple food. While in rest of the country, non-sticky rice with 20-25% amylose content is more preferred. Some GR varieties are aromatic, colors include white, purple and black, and grain size varies. Glutinous rice is opaque when raw.

Countries	Area (mha)	Production (mt of paddy)	Yield (t/ha)
Thailand 1/	3.17	7.37	2.32
Laos PDR 2/	0.86	3.02	3.51
Myanmar 3/	0.036	0.11	3.06
Vietnam 4/	0.77	3.67	4.78
Cambodia	na	na	na
China	na	na	na
Total	4.836	14.17	2.93

Source: 1/ Obtained from OAE data available in 2013; 2/ Office of Foreign Trade Promotion, Viientian referred in OrawanSrisomphun, 2012. 3/ Myanmar Department of Agriculture 4/ Dao the Anh and Pham Cong Nghiep (2012) Report on rapid Assessment of Glutinous Rice Trade and Consumption in Vietnam. Na= data not available

Global production of milled white rice is about 476 mt where glutinous rice makes up 5% (23.8 mt) of it. Major growers of glutinous rice are, Laos, Thailand, Cambodia, Vietnam, Malaysia, Indonesia, Myanmar, Nepal, Bhutan, Northeast India, China, Japan, Korea, Taiwan, and the Philippines. Thailand and Laos PDR are two major sticky rice producing countries in Southeast Asia. An estimated 85% of Lao rice production is of this type (Delforge, 2001). Other countries in ASEAN have very little areas for sticky rice production. Laos PDR has been recognized as a center for glutinous rice biodiversity.

Major exporters and Importers in the International Market

Major exporters of glutinous rice are Thailand and Vietnam but major importers are Korea and Japan. Although Thailand produces 7.37 mt of glutinous rice, while its domestic consumption is 90%. The remaining 10% (0.74 mt) of GR of Thailand constitute nearly 90% export share of global GR export.

Export Countries	% share	Import Countries	%share
Thailand	89.60	**Korea**	33.03
Vietnam	9.82	**Japan**	15.93
Japan	0.22	**Hongkong**	10.78
Pakistan	0.18	**Liberia**	7.98
Others	0.17	**Others**	32.28
Total	100.0	**Total**	100.00
Total Value	(m.US$) 227.31	Total Value (m.US$)	273.47

Source: ETCN, 2556 referred by Orawan Srisomphun

However, the future market for GR shall not only be evaluated by its volume of consumption as cooked whole grain but also its application and utility in the up-surging food and beverage industries (CAGR of 7.5%). It has gained an important place in the beverage industry where it is used to produce *sake* in Japan, vinegar, *mirin* (sweet alcohol used in cooking) or crackers called *senbei* and many other beverages popular in many other countries. The steamed GR powder is also processed to different cuisines and desserts sold at high prices in the food outlets. Due to its gluten free nature, it is earning high popularity in the food industry.

It's also one of the components of miso paste, an essential ingredient in Japanese cuisine. Mochigome or glutinous rice is used for making mochi, traditional rice cakes. Rice flour, made from ground up white or glutinous rice, is used to make various Japanese sweets and rice crackers (senbei), as a thickening agent in cooking, or as substitute for wheat flour to make bread.

Status of glutinous rice germplasm in NRRI Gene Bank

The glutinous rice germplasm was collected from North-East states namely Sikkim, Assam, Arunachal Pradesh, Manipur, Nagaland and Tripura since last 6-7 decades. Total of 42 accessions of such germplasm were collected and conserved in NRRI medium Term Storage (MTS) gene bank.

Varieties

Kmj 3-292 (Bhogali) and Kmj 3-296-3 (Rongili) were developed at AAU, Titabar (Ahmed et al 1993). Lungnilaphou, glutinous rice variety is suitable for valley areas, ICAR-NEH, Umiam (https://icar.org.in/files/rice%20varieties%20for%20licensing%20from%20ICARNEH.pdf)

Few varieties with low amylose content have also been released through AICRIP specially for NEH regions. The varieteies RC Maniphou-6, RC Maniphou-10, RC Maniphou-12 and RC Maniphou-1 are low amylose content varieties are for the state of Manipur.

With the rapid growth of food and beverage industry worldwide, the demand for the sticky rice is predicted to increase due to its suitability to be processed into different types of snacks coatings as sweet dishes, beverages, vinegar, etc. For the preparation of Momos, thupka, desserts, sticky rice is more preferred. Considering these it may be concluded that the demand for glutinous rice may increase in future. The climate and soil of the North Eastern states of our country are very suitable for growing these glutinous. Therefore, it seems that there is high chance of increase in demand for glutinous in the coming years under the rapidly changing food habits, accelerated growth of food industries.

For Recent Status of Glutinous rice in global trade, its trends and prices 'TridgeMarket Intelligence'** (*https://www.tridge.com/pricing/data?next=%2Fproducts%2Fglutinous-rice*) **may be followed. (Paid site for market intelligence)

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CRISPR-Cas: Application in Crop Improvement

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CRISPR-Cas (Clustered Regularly Interspaced Short Palindromic Repeats and CRISPR-associated proteins) is a revolutionary genome editing tool that has garnered significant attention in the field of crop improvement. This technology allows for precise and targeted modification of genes within an organism's DNA, offering unprecedented control over genetic traits. The CRISPR system was originally discovered as part of the bacterial immune system. Bacteria use CRISPR-derived RNA and various Cas proteins, including Cas9, to fend off attacks by viruses and other foreign bodies. Cas9 is an RNA-guided endonuclease that can be programmed to target specific DNA sequences. The Cas9 protein acts as "molecular scissors" that can cut the DNA at precise locations.

This bacterial immune system was modified in a way to achieve targeted modifications in the genome. Researchers design a synthetic RNA molecule, known as guide RNA (gRNA), which is complementary to the target DNA sequence within the genome of the organism. The Cas9 protein is guided by the gRNA to the specific target site in the genome. Once it reaches the target, Cas9 induces a double-strand break in the DNA which will induce cell's natural repair machinery, such as NHEJ, may introduce small insertions or deletions during the repair process. This can result in gene knockout or disruption. Alternatively, researchers can provide a DNA template during the repair process to induce homology directed repair (HDR) mechanism, facilitating the introduction of specific changes or new genetic material.

Types of modifications

Many CRISPR-Cas9 tools have been developed which allows researchers to modify genes in various aspects given below.

Gene knockout

Gene knockout methods are crucial to verify or to know the gene function associated with the targeted sequence. Simultaneously, multiple genes could be targeted by designing multiple guide RNAs.

Gene knock-in

This method is useful to insert exogenous DNA fragment at a specific location where Cas protein makes double stranded break in the genome. CRISPR based knock-in strategy largely involves homology directed repair pathway (HDR targeted insertion events).

Gene regulation

This includes regulation of gene transcript at genetic level (DNA) as well as epigenetic level. To regulate gene at epigenetic level, modified Cas protein, dCas is utilized which lacks nuclease activity. dCas protein along with transcriptor activators/inactivators will be targeted at specific site (promoter/transcription start site) to modulate gene expression. Epigenetic regulation can be achieved by binding dCas9 with epi-effectors or by altering chromatin structure or by modulating interaction between enhancer and promoter to regulate gene expression.

Base editing

Base editing comprises editing at one or two nucleotides called as single base editors (cytosine base editors and adenine base editors) and double-base editors, respectively. These editors utilize nickase cas9 (nCas9) protein which cleaves single stranded sequence, cytocine deaminase and uracil glycosylase inhibitor. Introduction of such editors increased precise editing without introducing double stranded break in DNA.

Prime editing

In prime editing, a modified form of the Cas9 protein (nCas9) is fused to a reverse transcriptase enzyme. The Cas9 protein is guided to the target DNA sequence by a guide RNA, similar to traditional CRISPR-Cas9. However, instead of inducing breaks, the reverse transcriptase enzyme writes the desired genetic information directly into the DNA. CRISPR prime editing has several potential advantages over traditional CRISPR-Cas9, including increased accuracy and reduced likelihood of unintended off-

target mutations. It allows for the insertion, deletion, or replacement of specific DNA sequences with a higher degree of precision.

Applications in crop improvement

The fundamental objective of research in plant genetics and breeding is to uncover the connection between genotype and phenotype. Traditional crossbreeding relies heavily on the breeder's experience and phenotypic observations to select improved varieties. Many crucial agronomic traits are typically influenced by multiple quantitative loci, and there is often correlation among different agronomic traits, with modular gene regulation being common. This intricate nature poses a significant challenge to conventional breeding methods. The advent of high-throughput sequencing technology has increased the availability of sequenced crop genomes, greatly advancing the understanding of gene functions and the identification of genes that regulate vital traits like yield, quality, stress tolerance, and disease resistance. Key regulatory genes and their associated networks, governing complex crop traits, have been pinpointed through research into gene functions. Additionally, some of these genes have been precisely edited to enhance germplasm resources, progressively establishing accurate molecular breeding systems. In this context, CRISPR/Cas9 proves valuable in enhancing various crop traits, including yield, quality, stress tolerance, disease resistance, and herbicide resistance, thereby generating a significant abundance of new germplasm.

- **Trait Modification:** CRISPR-Cas can be used to modify specific traits in crops, such as enhancing yield, improving nutritional content, and increasing resistance to diseases and pests.
- **Accelerated Breeding:** Traditional breeding methods can take many years to achieve desired traits. CRISPR-Cas accelerates this process by directly modifying the relevant genes, reducing the breeding timeline.
- **Reduced Environmental Impact:** By creating crops with improved resistance to pests and diseases, farmers may reduce their reliance on chemical pesticides, leading to a more sustainable and environmentally friendly agriculture.

Conclusion

In summary, CRISPR-Cas technology has immense potential for crop improvement, offering a precise and efficient way to edit the genetic makeup of crops. Its applications extend to addressing global challenges such as food security, climate change, and sustainable agriculture. However, ongoing discussions about regulatory frameworks and ethical considerations continue to shape the responsible and transparent use of this powerful tool in crop research and development.

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Herbicidal Selectivity and Phytotoxicity

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Herbicides play a pivotal role in modern agriculture by aiding in weed control, a critical aspect of successful crop management. However, the indiscriminate use of herbicides can lead to unintended consequences, causing damage to non-target plants and the environment. Herbicide selectivity, therefore, emerges as a fundamental concept in agricultural practices. It refers to the ability of a herbicide to effectively control target weeds while minimizing harm to the desired crops. Achieving selectivity is a delicate balance, requiring an understanding of the biochemical, physiological, and genetic factors that differentiate crops from weeds.

In the pursuit of sustainable and environmentally conscious agriculture, herbicide selectivity has gained prominence. Farmers and researchers alike seek herbicides that exhibit a high degree of selectivity to optimize weed management without compromising the health and yield of the cultivated crops. This introduction explores the significance of herbicide selectivity, the challenges associated with achieving it, and the advancements in research and technology driving the development of more selective herbicides. As we delve into this crucial aspect of weed management, we uncover the intricate mechanisms that make herbicide selectivity both a challenge and an opportunity in modern agricultural practices.

What is herbicide selectivity?

Selectivity refers to the phenomenon by which in a mixed stand of plants, some plant species (e.g. weeds) are preferentially controlled or killed, while other (e.g. crop plants) remain unaffected when a herbicide is applied to them. When one plant species is more tolerant to the herbicide than another plant species, the herbicide is considered to be selective

Selectivity results from the differential response of plant species to herbicides and is a complex phenomenon achieved by complex interaction between plant, herbicide and environment (climate and soil). Selectivity is a relative property of a herbicide and is dependent largely on the time, method, rate and formulation of herbicide application, environmental conditions (e.g. soil moisture, temperature, texture, humidity, rainfall etc.), plant species and the stage of growth of crop and weeds. A herbicide is selective to a particular crop only within certain limits. It is more herbicide rate-dependent, environment dependent and crop-specific.

Selectivity index (SI)

SI is the ratio of maximum dose of herbicide tolerated by the crop to the minimum dose of herbicide required to control weeds. The higher the selectivity index, the greater is the safety to a crop. If SI is greater than 2, the herbicide is safer for use without much fear of crop damage.

Kinds of selectivity

Four major types of selectivity

1. Physical
2. Chemical
3. Biological
4. Chronological

Physical selectivity

It could be achieved due to manipulation of a number of factors, e.g. sowing depth of crops, modifying application devices, etc.

- Depth protection selectivity of pre-emergence herbicides
- Externally-working antidote-mediated selectivity

- Application device protection selectivity of non-selective herbicides
- Selectivity to non-selective herbicides achieved due to other means

Chemical selectivity

Selectivity achieved due to structural changes of herbicides is called chemical selectivity. Chlortoluron has -CH_3 group, while diuron has –Cl group on the fourth carbon position of the phenyl ring. Otherwise, they both have similar structures and belong to phenylurea group. Due to this difference, diuron is selective to cotton, while chlortoluron is selective to wheat.

Biological selectivity

Selectivity achieved due to metabolism/reverse metabolism of herbicides inside plants is called biological selectivity. Differential physiology across plants is exploited to attain this kind of selectivity. For example, propanil is selective to rice, but not to the grassweed *Echinochloacolona*.

Chronological selectivity

Selectivity achieved due to manipulation of the time of application of a herbicide is called Chronological selectivity. The selectivity results from the application of same herbicide as pre-planting, preemergence or post-emergence are chronological selectivity. For example, pendimethalin is selective to most crops, when applied as pre-emergence, but not as post-emergence.

Factors affecting selectivity

plant factors

It includes anatomy, morphology and physiology of plants. Varying plant architecture, growth behaviour, bio-chemical and bio-physical processes across plants are highly responsible for imparting herbicide selectivity to plants.

Morphology of plants

- Location of growing points of plants
- Leaf/canopy
- Root system
- Age/stage of the plants

Physiology of plants

- Uptake
- Translocation
- Metabolism of herbicide

Herbicide factors

- Class of a herbicide
- Formulation of herbicide
- Time of herbicide application
- Dosage of herbicide
- Method of herbicide application

Environmental factors

- Climatic factors
- Temperature
- Relative humidity
- Sunlight
- Rainfall

Soil factors

- Organic matter content
- Texture and structure of soil
- Soil temperature
- Soil moisture
- Soil pH

What is phytotoxicity?

Phytotoxicity is a toxic effect by a compound on plant growth.

Phytotoxic means harmful or lethal to plants

Phytotoxicity is the degree to which a chemical or other compound is toxic to plants

Phytotoxic effects can be from spray droplets, soil residues or vapours contacting sensitive plants. Plants can also be harmed by herbicides which move off target in water or soil or when sensitive crops are planted in fields too soon after a herbicide treatment was applied.

Phytotoxicity of herbicides

Sr. No.	Herbicide type	Symptoms
1.	Pre-emergence	Reduce germination
		Suppressed crop growth
		Produces deformility in crop plants
2.	Post-emergence	Leaf injury
		Wilting
		Vein clearing
		Necrosis
		Epinasty

- Phytotoxicity is not necessarily caused by the active ingredient.
- Plant damage can also be caused by: the solvents in a formulation, impurities in spray water, using more pesticide than listed on the label, or poorly mixing of the spray solutions.
- Condition of the plant at the time of treatment can affect phytotoxicity; stressed plants may be more susceptible.
- The variability of the weather is a major cause of unreliable herbicide performance resulting in either inadequate control of weeds or crop damage.
- In order to meet the most economic use of herbicides, with minimal adverse effect on the environment, it is important to know how light, temperature, humidity and rain affect herbicide performance

Minimize the risk of phytotoxic effects by

- Reading and following label directions, especially the correct rates and timing, and being aware of potential weather effects
- Avoiding application when drift is likely to happen waiting for the correct planting times if unsure, conduct a simple field bioassay by treating only a few plants, before the treating whole block to check for phytotoxic effects, especially when growing new cultivars
- Incorporating organic matter, such as compost or manure helps adsorb the herbicides into the organic matter rendering it unavailable or inactive.

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Pink Bollworm-A Serious Insect Pest of Cotton Crop

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Cotton (*Gossypium hirsutum L.*) is most important commercial crop known as "King of natural fiber" and world over commonly referred as "White Gold". Cotton belongs to family Malvaceae and genus Gossypium. India has the sole distinction of growing all the four cultivated species of cotton and their intra- and inter-specific hybrids. In India, cotton is grown in three distinct agro-ecological zones, viz., Northern (Punjab, Haryana and Rajasthan), Central (Gujarat, Maharashtra and Madhya Pradesh) and Southern zone (Andhra Pradesh, Tamil Nadu and Karnataka).

Among cotton pests, the pink bollworm *(Pectinophora gossypiella* saunders) is the most important worldwide. The name "pink bollworm" refers to the pinkish hue of its larvae, which are caterpillars responsible for the most significant damage to cotton plants. It primarily infests the buds, flowers and bolls, causing substantial economic losses for cotton farmers. In India, the incidence of pink bollworm on cotton in Maharashtra has been reported to exceed the Economic Threshold Level (ETL) and caused a 33 percent crop loss during 2017-18.

Major states affected: Maharashtra, Gujarat, Andrapradesh, Telangana and Karnataka

Life Cycle of Pink Bollworm

The pink bollworm undergoes a life cycle consisting of the following stages:



- **Egg:** The pearly iridescent white eggs are flattened and oval, measuring approximately 0.5 mm long and 0.25 mm wide. They have longitudinal lines and are laid singly or in groups of four to five.
- **Larva:** The larvae of the pink bollworm undergo color changes as they mature. The first two instars are white, while the third instar and beyond develop a pink color. The larvae have a dark brown head due to the sclerotized prothoracic shield.
- **Pupa:** The pink bollworm pupates within a thin silken cocoon in the cotton lint, soil, or kapas. The pupae start as light brown and gradually become dark brown as pupation progresses. They measure up to 7 mm in length.
- **Adult:** The adult pink bollworm moth is grayish brown with blackish bands on the forewings, while the hind wings are silvery gray. Moths emerge from pupae in the morning or evening and are nocturnal, hiding among soil debris or cracks during the day.

Nature of Damage by Pink Bollworm

The pink bollworm larvae cause significant damage to cotton plants and bolls. Here are some characteristics of their damage:

- **Square, Flower, and Boll Infestation**: The larvae enter squares, flowers, or bolls shortly after hatching. They penetrate the developing bolls through the tip, and the entrance hole closes as the boll matures.
- **Feeding on Seeds and Fiber**: The larvae feed on the seeds and fiber-forming tissues inside the boll, resulting in the retardation of lint development.
- **Movement and Seed Destruction:** The larvae feed on seeds and move to adjacent seeds and locules by creating holes through the septum.

Damage Symptoms of Pink Bollworm in cotton

The presence of pink bollworm infestation in cotton crops leads to the following symptoms:

- **Bud Shedding:** Infestation of flower buds causes them to shed prematurely.
- **Rosette Flower Formation:** Flower infestation can lead to the formation of rosette flowers.
- **Reduction in Lint Development:** The feeding activities of larvae result in reduced lint development and weakened lint quality.

- **Premature Boll Opening:** Infested bolls may open prematurely, exposing them to saprophytic fungi growth.
- **Reduced Germination:** If infested seeds are used for sowing, germination rates are reduced.

ETL (Economic Thresholds Level)



Larva enter buds | Rosette flower | Damaged flower | Exit hole | Larvae inside boll

10 % damaged flowers (Rosette flowers) or 10 % damaged green bolls (at least 2 bolls out of 20 having white or pink larvae or exit holes) or 8 moth catch per pheromone trap per night for consecutive 3 days.

(*ETL – It is the pest population density or crop damage level at which the control measures need to be determined to prevent the increasing pest population)

IPM Approach for Pink Bollworm

To effectively tackle the pink bollworm menace, an integrated pest management (IPM) approach is highly recommended. IPM involves combining various strategies and practices to minimize pest populations while reducing reliance on chemical insecticides. Here are some key components of an IPM approach for managing pink bollworm.

Pre-sowing stage

- Deep summer ploughing to expose the pupa in the soil to birds and sunlight.
- Removal and destruction of alternate host of pink bollworm.
- Maintain field sanitation at the vicinity of the main field and keep nearby areas free from weeds.
- Crop rotation should be followed to break the life cycle of pink bollworm.

Sowing stage

- Do not sow cotton crop in the month of April-May as it will attract pink bollworm infestation at early crop stage.
- Take up sowing in the month of June with early maturing short duration Bt-cotton hybrid/ varieties recommended for particular region.
- Select tolerant/resistant cultivars.
- Use certified seeds.
- Refuge (20% non Bt seeds) should be planted along with Bt cotton, if provided in separate packet

Vegetative growth stage

- Undertake roving survey at every 10 km distance initially at weekly intervals and thereafter at 10 days intervals (depending upon pest population). Record incidence of pink bollworm on all host crops of the locality. Observe at each spot diagonally criss cross 20 plants/acre at random. Record the population potential of different biocontrol fauna.
- Undertake Field scouting for pink bollworm and biocontrol fauna once in 3 – 5 days to workout ETL. For pink bollworm eggs terminal leaves should be observed. Observe larvae on fruiting bodies and leaves per plant. For percent bollworm incidence count total and affected fruiting bodies on the plant and also in the shed material and work out the percent infestation.
- Install pheromone traps @ 5/ha, after 45 days of sowing or flowering stage to till harvest for monitoring the moth activity of pink bollworm.

Flowering, boll formation and picking stage

- Inspect the crop at squaring and flowering stage for the presence of pink bollworm larvae within flowers.
- Collect and destroy fallen squares, flowers and bolls in the field.
- If rosette flowers found in the field, pluck it mechanically and destroy to stop the further multiplication.

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Management of Crop Residue and Its Impact on Soil Quality

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Although crop wastes are regarded as raw materials for a variety of non-agricultural applications, they may be added to soil organic matter and employed as a surface soil cover with good results. Crop residues are the leftover stalks, straw, stems, and leaves that are left on the ground after harvesting different crops. Large volumes of leftovers are also produced by agro-based industries. The removal of residues can alter various soil qualities, reduce plant nutrients and soil organic matter, and have an impact on soil water conservation and storage. In order to increase agricultural yields, intensive farming techniques with brief fallow times and substantial fertilizer inputs have been employed. Regrettably, significant pollution and land deterioration have resulted from this agricultural practice. The result was a massive discrepancy between the demand and supply of nutrients. These leftovers may be utilized to improve crop yield, decrease pollution, improve soil health, and increase sustainability through the implementation of conservation agriculture-based technology.

The Indian economy's foundation and lifeblood is agriculture. In our country, a lot of agricultural waste is produced. This opens the door for the broad scope and idea of crop residue management, which originated with the burning issue of India's principal cropping system-wheat and rice. Because rice straw contains a lot of silica, it is thought to be a poor animal feed. According to National Policy for Management of Crop Residues (NPCMR), annually India generates about 500 Mt of crop residues. According to the National Policy for Management of Crop Residue, or NPMCR, the amount of rice crop residue created annually amounts to around 23 million tons, or 62.4% of all crop residue generated in the Indian subcontinent. In India, 80% of rice harvest waste is burned every year, according to IARI. Some of them are used to produce manure, industrial fuel, culinary fuel, and animal feed. The combustion of vital soil nutrients including nitrogen, phosphorus, potassium, and sulfur during crop burning reduces soil infertility. Crop residue management is predicted to provide 5.6 million tons of net primary kernel (NPK) each year (Bhattachariya *et al*., 2019). Crop leftovers are a valuable renewable resource that may be utilized to maintain crop output while protecting non-renewable soil and water resources. This article focuses on several solutions that are being implemented internationally to reduce the hazards to the environment, such as surface mulching, biochar production, and composting.

There are two types of agricultural crop residues

(A) Field residues

In these materials left in an agricultural field or orchard after the crop has been harvested includes stalks, stubble, stems, leaves, seed pods. The residue can be ploughed directly into the ground before sowing of succeeding crop.

(B) Process residues

In this, materials left after the processing of the crop into usable resources. These residues include husks, seeds, bagasse and roots. They can be used as animal fodder, in preparation of organic manures *viz*., Vermicompost and as soil amendment.

Adverse effect of open field burning

- Reduction in organic matter
- Environmental pollution
- Loss of plant nutrients

- Non-availability of straw to livestock
- Death of beneficial micro-organisms

Methods of Crop Residues Recycling

In situ incorporation

As an alternative to burning, residue incorporation which is defined as the use of tillage implements to bury remnant plant residues into soil. Ploughing is the most efficient residue incorporation method. Incorporation of the remaining stubble and straw into the soil returns most of the nutrients and helps to conserve soil nutrient reserves in the long term. Crop residues are incorporated in soil before sowing of succeeding crop. Crop residues having wide C:N ratio decomposes slowly in the soil. Indian Agricultural Research Institute (IARI), recently managed to find a promising eco-friendly alternative called 'PUSA DECOMPOSER' which includes the use of cocktail of microorganisms for fermentation of the rice residue and then converting it to manure.

Surface mulching

Direct drilling in surface mulched residues is a practice that leaves straw residues from a previous crop on the soil surface without any form of incorporation. Surface retention of residues helps in protecting the fertile surface soil against wind and water erosion. Mulch influences reflectivity of heat and water transmission characteristics of mulched soil. The mulch keeps the soil cool and doesn't allow the soil moisture to evaporate so rapidly. Beneficial effect of crop residue mulch on soil is moisture conservation and moderate soil temperature.

Composting from crop residues

Crop residues (Straw, stalk, leaves, stubbles etc.) are collected from field after harvest and kept into compost pit up to well decomposition and applied in the field before sowing of next crop.

Biochar production

An important role of biochar is long term Sequestering of carbon in the soil and plays pivotal role mitigation of greenhouse gases. Biochar is produced from crop residue biomass by heating in the absence of oxygen. Biochar application influences various soil properties including pH, bulk density etc. These changes in soil properties are likely to impact nutrient reactions on soil particles and microbial transformation of nutrients, maintains soil aggregate structure.

As livestock feed

The rice straw is considered poor feed for animals due to its high silica content. The nutritional value of rice straw can be upgraded by different methods. Physical, chemical and biological treatments have been used to weaken and break down ligno-cellulose bonds in crop residues, thereby increasing their nutritional value. Rice straw stems are more digestible than leaves because their silica content is lower, therefore the rice crop should be cut as close to the ground as possible, if the straw is to be fed to livestock. To complete the nutritional requirements of animals, the residues need processing and enriching with urea and molasses, and supplementing with green fodders.

As mushroom cultivation

Wheat and rice straws are excellent substrates for the cultivation of white button mushroom and straw mushroom. Straw for white button mushroom cultivation is usually mixed with horse manure and hay and a very high conversion efficiency of the substrate into fungal bodies is possible.

Crop Residue as animal bedding material

It has been found that the use of paddy straw bedding during winter helped in improving the quality and quantity of milk as it contributed to animal's comfort and health. Paddy straw bedding helped the animals keep themselves warm and maintain reasonable rates of heat loss from the body. In the animal shed each kilogram of straw absorbs about 2-3 kg of urine, which enriches it with N.

Mechanization in crop residue management

Happy seeder is a tractor mounted machine that cuts and lifts straw and sows succeeding crop into bare soil. The lifted straws are sown over the area as mulch. Crop residue management is possible by sowing a zero-tillage machine or happy seeder with a moong or daincha in the standing crop after harvesting of wheat.



Role of crop residues management on physical properties of soil

- Soil Structure: Favour the formation of aggregates due to addition of organic matter to the soil and structural stability increase by better aggregate size distribution.
- Bulk Density & Porosity: Low bulk density of soil and increases the porosity of the soil with addition of crop residues.
- Hydraulic Conductivity: Crop residues increase hydraulic conductivity by modifying soil structure (micro pores & aggregate stability).
- Soil temperature: Mulching with plant residues raised the minimum soil temperature in winter & decrease soil temperature during summer due to shading effect.
- Soil moisture: Reduces evaporation rate due to increase in number of residues on the soil surface.

Effect of crop residue management on chemical properties of soil

- Organic carbon: Increases with continuous organic matter addition.
- Soil pH: Decrease in the soil pH due to production of organic acids during decomposition.
- Cations Exchange Capacity: Soil organic matter as reservoir for plant nutrients essential prevents leaching of elements, required for growth. Addition of residues increase cations exchange capacity.

Influence of crop residue recycling on biological properties of soil

- It provides energy for growth & activities of microbes which helps in build-up of microbial biomass into soil.
- Provide suitable environment for biological N-fixation.
- Enzymes, microbial biomass, dehydrogenase & alkaline phosphatase activities increase with addition of crop residues.

Conclusion

The physical, chemical, and biological qualities of soil are enhanced by crop residue management techniques such as crop residue inclusion. It leads to environmentally sustainable farming by increasing agricultural output. Crop residue recycling enhances the soil's nutritional balance. It assists in reducing the pace at which crops are fertilized. The recycling and assimilation of crop leftovers lowers the cost of farming. Crop leftovers should be used wisely to preserve soil health, increase production, and improve soil fertility. Burning crop debris releases more harmful and hazardous materials into the air. Remainders can be effectively and recycled in a variety of methods, such as composting, making cow feed, and growing mushrooms, as opposed to being burned.

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Role of Agriculture Education as Anchoring Indian Food Security

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Agricultural education plays a critical role in boosting food security in India by addressing various challenges and equipping individuals with the necessary knowledge and skills. Here are several ways in which agriculture education contributes to enhancing food security in India: Bearing in mind that agriculture has a much greater impact on reducing poverty and improving food security than the other sectors of the economy and considering differences in the potential for agricultural production across countries. The aim of this paper is to identify relationships between the malnutrition scale and selected characteristics describing the agricultural sector within identified clusters of developing countries. Attempts have already been made to recognize groups of countries categorized according to measures of food security. It is shown that different research issues resulting in different sets of measures used in the classification can lead to different typologies and hence different conclusions. Focuses mainly on food availability issues, utilizing consumption, production and trade measures. They stressed that trade policies influence world food availability, as well as food production and food imports at the national level. The indicators used in the study include those describing food availability, access and utilization, *i.e.*, food production per capita, the ratio of total exports to food imports, calorie intake per capita, protein intake per capita and non-agricultural population, while the authors address the key question. They identify groups of countries with similarities in their food security profiles covering the results of agricultural activity and consumption levels rather than agricultural-based reasons for food insecurity.

Certain facts of world hunger problems

Alimentation a global population of about 10 billion people by 2050 would necessitate a drastic shift in how food is produced, processed, exchanged, and eaten (https://www.fao.org/food-systems/en/). Improvements at global, regional and local food systems is needed to feed the expanded population and so that decent employment and livelihoods of producers and actors is ensured. Recent developments in Indian agriculture indicate a stagnant or declining factor productivity causing a concern for scientists and planners. Among many factors causing this decline, natural resource degradation, slow pace of new innovations and human resource not matching with the challenges, are important.

Current Status Agricultural Education in India

Agricultural education modelled on the lines of US Land-Grant system introduced during early 60s along with other Green Revolution programmes has evolved considerably in terms of improved infrastructure, trained faculty, course structure, content and hands on practical training *etc.*, but still struggling to meet the expectations of the fast-changing technology of agriculture. Agricultural Education in India is supported and regulated by the Indian Council of Agricultural Research (ICAR) and is imparted largely through State Agricultural Universities (70), and few Deemed to be Universities (4), Central Agricultural Universities (3), Central Universities with Agriculture Faculty (4). Recently private sector institutions have also entered this arena. The intake capacity of students, which was less than 5,000 in 1960, has now gone up to 64,485 (https://education.icar.gov.in/). With about 350 constituent colleges, these AUs enrol, on annual basis, about 40,781 students at UG level, over 13,798 at Masters' level and 4,992 in PhD programmes. In addition to this, there are many private affiliated colleges are enrolling thousands of students annual.

Agricultural education plays a crucial role in the Indian food industry by contributing to the development and sustainability of the agricultural sector. In Madhya Pradesh School of Agriculture, Sanjeev Agrawal Global Education (SAGE) University, Bhopal, play a key role in area of agricultural education. Here are some key aspects of

the role of agricultural education in the Indian economy.

Skill Development

Agricultural education equips individuals with the necessary skills and knowledge to engage in modern and sustainable farming practices. This includes crop management, pest control, water conservation, and the use of advanced technologies in agriculture.



Source: smart gaon development foundation

Technological Integration

The students learn about training includes the proper operation and maintenance of modern agricultural machinery and equipment. Agricultural education introduces the use of technology, such as GPS and sensors, for precision farming to optimize resource use. Organic farming practices individual are educated on organic farming principles and practices, including certification processes. Techniques for producing organic fertilizers are taught to promote sustainable and environmentally friendly farming. Agricultural education includes market-oriented training, teaching individuals to analyse market trends and consumer preferences. Students learn business planning, financial management, and marketing strategies to start and run successful agricultural enterprises.

Research and Innovation

Agricultural education introduces research methodologies, enabling individuals to conduct experiments and contribute to agricultural research. Stay updated on emerging technologies and innovations in agriculture to remain competitive and sustainable. Agricultural education emphasizes environmentally sustainable farming practices, promoting biodiversity, and reducing the ecological footprint.

Entrepreneurship Development

Agricultural education fosters entrepreneurship by providing aspiring farmers and Agripreneurship with the knowledge and skills needed to establish and manage successful agricultural businesses. This can lead to the creation of new ventures and job opportunities within the food industry. Courses in agriculture education can include modules on business planning, financial management, and marketing strategies tailored to the agricultural sector. This prepares individuals to create viable business plans for their ventures. There are few ides which helps to set up the successful agribusiness. Environmental sustainability implements practices that promote environmental sustainability, such as conservation tillage, cover cropping, and organic farming methods.

Business Planning

Develop a comprehensive business plan outlining your goals, target market, production strategies, and financial projections. Identify key performance indicators (KPIs) to measure the success of your agribusiness.

Crop Selection and Diversification

Choose crops based on market demand, climate suitability, and your expertise. Consider diversifying your crops to spread risk and take advantage of different market opportunities. Soil is important factor. Soil & water management implement sustainable soil management practices to maintain soil fertility. Conduct soil tests regularly to assess nutrient levels and adjust fertilizer applications accordingly. Efficiently manage water resources through irrigation systems and water conservation practices. Monitor and control water usage to optimize crop production and reduce waste.

Integrated Pest Management (IPM)

Implement IPM practices to control pests and diseases while minimizing the use of chemical inputs. Regularly scout fields for signs of pests and diseases

and take appropriate measures. In view of technology adoption embrace modern agricultural technologies such as precision farming, drones, and automated equipment. Use farm management software to monitor and analyze data related to crop performance, expenses, and revenue.



Source: Cropaia Integrated pest management

Market Research and Marketing

Stay informed about market trends and consumer preferences. Develop effective marketing strategies to promote your products, such as participating in farmers' markets, establishing partnerships with local businesses, or creating an online presence.

Adoption of Modern Technologies

The Indian food industry can benefit significantly from the adoption of modern agricultural technologies. Agricultural education helps farmers understand and implement cutting-edge technologies such as precision farming, biotechnology, and data-driven agriculture, leading to increased efficiency and productivity. Agriculture education programs can facilitate access to resources such as finance, subsidies, and government support. Entrepreneurs need to know how to navigate these systems and leverage available resources to start and grow their businesses.

Sustainable Agriculture Practices

With increasing concerns about environmental sustainability, agricultural education promotes practices that are environmentally friendly. This includes organic farming, conservation agriculture, and the efficient use of natural resources. Sustainable practices contribute to the long-term viability of the food industry. Emphasizing sustainable agriculture practices is increasingly important. Education in sustainable farming methods, organic farming, and environmentally friendly approaches not only contributes to responsible entrepreneurship but also aligns with consumer preferences.

Quality and Safety Standards

Agricultural education emphasizes the importance of adhering to quality and safety standards in food production. This is crucial for meeting domestic and international regulations, ensuring food safety, and maintaining the reputation of Indian agricultural products in the global market.

Market Orientation

Agricultural education helps farmers understand market dynamics and consumer preferences. This knowledge enables them to make informed decisions about crop selection, production volumes, and marketing strategies, ultimately contributing to a more market-oriented and competitive food industry. Agricultural education provides farmers with knowledge about market dynamics, including supply and demand, pricing mechanisms, and factors influencing market trends. This understanding helps farmers make informed decisions about what crops or livestock to produce. armers with a market-oriented education are trained in market research. They learn how to identify market opportunities, assess consumer preferences, and analyze competitors. This knowledge enables them to tailor their production to meet consumer demands. Farmers learn about the entire agricultural value chain, from production to processing and distribution. This holistic understanding helps them identify areas where they can add value to their products, such as through processing or direct marketing, to capture more of the value chain benefits.

In summary, the role of agricultural education in anchoring Indian food security is multi-faceted, encompassing knowledge transfer, skill development, research, sustainable practices, extension services, entrepreneurship, policy advocacy, and diversification. A well-educated and skilled workforce in agriculture is essential for addressing the challenges of food production and ensuring a stable and secure food supply for the growing population.

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Benefit of Agroforestry Technology for Farmers in the Face of Climate Change

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Agroforestry, an innovative and resilient agricultural practice, has surfaced as a beacon of hope for farmers navigating the tumultuous landscape of climate change. As they grapple with the escalating challenges posed by erratic weather patterns and soaring temperatures, this pioneering technology stands tall, offering a plethora of advantages that extend far beyond the realms of traditional farming methods. At its essence, agroforestry represents a transformative integration of trees and shrubs into existing agricultural systems, heralding a departure from the confines of monoculture farming towards a more diverse and sustainable approach.

In the wake of escalating environmental concerns, the significance of agroforestry becomes increasingly apparent. Its multifaceted benefits serve as a robust response to the adverse impacts of climate change on agricultural landscapes. By fostering enhanced biodiversity, agroforestry acts as a bastion of resilience against the diminishing variety of species that often plagues monoculture farming. The amalgamation of trees and crops creates a harmonious ecosystem, providing habitats for diverse flora and fauna, thereby bolstering the ecological balance.

Furthermore, agroforestry stands as a stalwart guardian of soil health. The intricate root systems of trees and shrubs help prevent soil erosion, fortify its structure, and enhance its fertility. This natural shield against erosion safeguards vital topsoil, which is pivotal for sustaining agricultural productivity. Additionally, the diverse vegetation in agroforestry systems contributes organic matter to the soil, enriching it with nutrients and fostering a healthier microbial environment. Consequently, farmers witness an improvement in crop yields and the overall sustainability of their land, combating the adverse impacts of climate change-induced soil degradation.

Climate change brings about challenges such as extreme weather events, altered precipitation patterns, and the spread of pests and diseases. Agroforestry acts as a natural buffer against these challenges. The presence of trees in farming systems helps regulate temperature, reduce wind speed, and protect crops from intense sunlight. This microclimate moderation not only shields crops but also creates a more favourable environment for beneficial insects, fostering a balanced ecosystem. Furthermore, agroforestry contributes to carbon sequestration, playing a pivotal role in the global effort to combat climate change. Trees are renowned for their ability to absorb and store carbon dioxide, a major greenhouse gas responsible for global warming. By integrating trees into agricultural landscapes, farmers actively participate in carbon offset initiatives, contributing to the reduction of atmospheric CO_2 levels.

The diverse vegetation in agroforestry systems also serves as a reservoir for genetic diversity. In the face of changing environmental conditions, having a wide array of plant species enhances the resilience of the overall ecosystem. This genetic diversity provides a natural defence mechanism, allowing crops to adapt to new challenges such as emerging pests or diseases. Soil health is another critical aspect positively influenced by agroforestry. The root systems of trees and shrubs help prevent soil erosion by stabilizing the soil structure. This is particularly significant in regions prone to heavy rainfall or drought, where erosion can lead to loss of fertile topsoil. Additionally, fallen leaves from trees contribute organic matter to the soil, enhancing its fertility and water retention capacity.

Agroforestry also addresses the water management challenges associated with climate change. The intricate root systems of trees play a key role in water regulation, preventing both floods and droughts. In periods of excessive rainfall, tree roots absorb and store water, reducing the risk of flooding. Conversely, during dry spells, these roots release stored water, ensuring a more stable water supply for crops. The economic aspect of agroforestry should not be overlooked. While it may take time for trees to mature and yield significant financial returns, the long-term benefits are substantial. Once established, agroforestry systems can provide a diversified income stream for farmers. Beyond traditional crops, products

such as fruits, nuts, and timber from trees contribute to farmers' livelihoods, offering resilience against the uncertainties associated with climate change impacts on agriculture.

Moreover, agroforestry supports the concept of circular economies. The integration of trees and crops creates a symbiotic relationship where waste from one component becomes a resource for another. For example, crop residues can be used as mulch to nourish the soil, while tree pruning can serve as valuable fodder for livestock. This circular approach minimizes waste, maximizes resource use efficiency, and fosters a more sustainable agricultural model. Local communities also stand to benefit from the adoption of agroforestry practices. The increased biodiversity in agroforestry systems provides habitat for wildlife, supporting overall ecological balance. Furthermore, the aesthetic and recreational value of diversified landscapes can attract eco-tourism, offering an additional income source for communities.

In conclusion, agroforestry technology presents a holistic and sustainable solution for farmers facing the challenges of climate change. Its multifaceted benefits, including climate resilience, carbon sequestration, soil health improvement, and economic diversification, position it as a transformative approach to agriculture. As the world grapples with the urgent need for climate adaptation, agroforestry stands out as a beacon of hope, demonstrating that sustainable practices can not only mitigate the impacts of climate change but also foster a thriving and resilient agricultural future.

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Nurturing Nature's Bounty: The Organic Manure Revolution in Wheat Farming

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Modern agriculture is always changing, and as farmers realize more and more the significant benefits of sustainable techniques, the resuscitation of traditional methods takes center stage. Using organic manure in wheat farming stands out among these techniques as a key component that contributes to both increased crop vitality and ecological harmony. In contrast to its synthetic substitutes, organic manure is a comprehensive strategy that supports a symbiotic interaction between the soil and the wheat crop by healing the soil and nourishing the crop. An intriguing tale of nutrient-rich soils, hardy crops, and a sustainable agricultural future emerges as we explore the use of organic manure in wheat production**.** In farming, the best outcomes are frequently those that occur from a healthy coexistence with the natural world. With its focus on natural processes and sustainability, organic farming has drawn a lot of attention lately. Organic farming techniques are beneficial to wheat production because they improve the soil, produce healthier crops, and create a more resilient agricultural environment.

1. Soil Health and Fertility: The beneficial effects of organic farming on soil health are among the main advantages of wheat cultivation. Soil fertility and structure are improved by organic methods, such as the application of natural fertilizers like compost and manure. In turn, healthy soils give wheat plants the nutrition they need to thrive vigorously.

2. Reduced Environmental Impact: By avoiding the use of artificial fertilizers and pesticides, organic farming lessens the environmental effect of conventional agriculture. Organic wheat growing contributes to the preservation of biodiversity and the protection of water resources by using natural ways for managing nutrients and controlling pests.

3. Healthier Wheat Crops: Nowadays, consumers are becoming more aware of the food they consume. Pesticide residue levels are often lower in organic wheat since it is grown without the use of artificial chemicals. Customers now have a healthier option in organic wheat, which adds to the market's increasing demand for organic goods.

4. Resilience to Climate Change: Wheat crops may adapt to changing climatic conditions with the aid of organic farming practices, which place a strong emphasis on creating robust and healthy ecosystems. Utilizing organic matter, cover crops, and crop rotation all help the soil retain more water and be more resilient to harsh weather.

5. Enhanced Nutrient Content: Research has indicated that compared to wheat farmed conventionally, organic wheat crops frequently contain higher concentrations of specific nutrients. The higher bioavailability of important vitamins and minerals in organic wheat grains is a result of the nutrient-rich soil and the lack of artificial additives.

6. Economic Viability for Farmers: Although switching to organic methods of cultivation may present some early difficulties, producers may see long-term financial rewards. Organic wheat production can be financially feasible and sustainable for both small- and large-scale farmers due to less reliance on outside inputs and potential rewards for organic products.

7. Improved Water Management: The storage of water in the soil is enhanced by using organic agricultural techniques, such as the use of cultivation of cover crops and organic mulches. This helps to improve yields during times of water scarcity by ensuring wheat crops have a more consistent water supply while also conserving water resources.

Conclusion

Organic farming is emerging as a model of sustainable agriculture techniques in the face of environmental concerns and an expanding global population. It has numerous advantages when used in wheat farming, from improved soil and yields to less environmental impact. Adopting organic agricultural practices in wheat production will help us traverse the challenges of contemporary agriculture and pave the way for a more sustainable, healthier, and environmentally friendly future for both farmers and consumers.

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Terrarium: Bringing Nature Indoors

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Terrariums are a beautiful and low-maintenance way to bring a touch of nature into your home. These miniature gardens are perfect for small spaces and can be customized to fit any decor style. Whether you're an experienced gardener or a complete beginner, terrariums are an easy and rewarding project that can help you connect with nature and add a unique touch to your living space.

What is a terrarium?

A terrarium is like an aquarium, but for plants instead of fish. It is made in just about any glass container. The terrarium is a group of plants growing inside a glass-enclosed container. It is planted to look like a miniature garden or forest enclosed in its own little world. It's simple to create and maintain a little garden in a glass container. You can use any number of pots and plants that you have on hand. To create small settings, you can add rocks, shells, or pieces of bark in addition to plants. You and your loved ones or friends can enjoy this indoor gardening pastime. A terrarium makes a thoughtful gift, too.

Types of Terrariums

There are two main types of terrariums: open and closed. Open terrariums are designed to mimic dry or arid environments and usually include plants such as succulents or cacti. On the other hand closed terrariums are designed to mimic humid or tropical environments and are typically planted with ferns, moss, or other plants that thrive in a moist environment. Closed terrariums also require less maintenance, as the enclosed environment creates its own water cycle.



Fig.1. Open terrariums



Fig. 2. Closed terrariums

How it works?

In addition to providing protection from dust, wind, and temperature fluctuations, the glass walls let light into the plants. Typically, the plants that are utilized are those that have a high moisture requirement. As a result, the terrarium is configured to produce an extremely humid environment, meaning that there is a lot of water in the air.

How it functions?

Plants release gaseous water vapour, or water, from their leaves. Water vapour condenses, or turns into liquid, when air inside the container comes into contact with the cooler glass walls. This water seeps into the bottom soil as it flows down the sides of the container. At that point, the plants can absorb the water through their roots. You won't often need to water your terrarium because the water is reusable. A lid should always be on the container to protect the water from escaping and maintain a high humidity level.

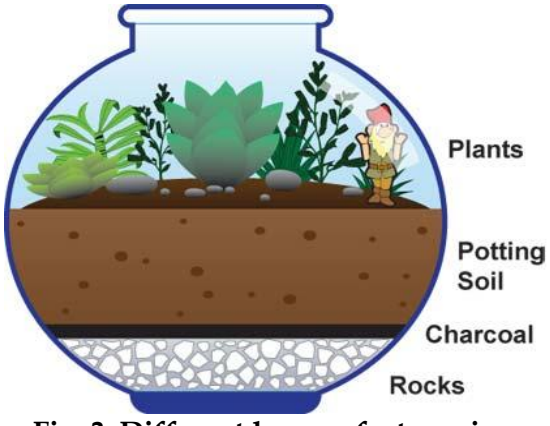


Fig. 3. Different layers of a terrarium

The things need for making a terrarium are

- Containers
- Soil
- Fertilizer (optional)
- Drainage material
- Plants
- Accessories
- Tools for planting

Containers

You'll need a glass container that can be seen through easily. Glass that is foggy or coloured lets less light reach the plant. You can use any size container, depending on how many plants you wish to use. To regulate moisture, the container needs to have a removable cover. If the lid of your container is missing, you can cover it with a piece of plastic or glass.

- Fish bowls,
- Fish tanks or aquarium
- Candy jars
- Glass bowl
- Conical flask, glass beakers or any transparent glass container can be used

Soil

A layer of soil between one and two inches deep needs to be created at the bottom of the container. A permeable soil is necessary for proper drainage. For planting, it should be slightly damp. Sand, peat moss, and garden soil in equal portions (1:1:1).

Drainage material

Because terrariums lack the drainage holes seen in outside pots, provisions must be made to allow excess water to drain. In very small containers, a layer of moss on the terrarium's bottom can act as a drainage layer. Regarding huge containers before the moss layer, you might add a layer of sand or fine gravel, charcoal, broken pieces of clay flower pots, or both.

Choosing of Plant for terrarium

Use slow-growing small plants. The plant should be fill but not crammed inside the container. You can gather plants from nearby nurseries, your own yard, etc. This is merely a suggested list; it is by no means comprehensive.

- Syngonium species
- Sansevieria species
- Bilbergia species
- Aechemea species
- Cryptanthus species
- Selaginella (Creeping moss, Peacock Fern, Spreading Clubmoss, Resurrection plant)
- Hedera helix (small leaf varieties)
- Pellionia (Watermelon Pellionia, Satin Pellionia)
- Maranta species (Herringbone Plant, Rabbit's Tracks, Prayer Plant)
- Peperomia species
- Small ferns
- Filtonia species (Snakesin Plant, Little Snakesin Plant, Nerve Plant, Little Nerve Plant, Painted Net Leaf, Silver Net Leaf)
- Money Plant (Pothos)
- Pilea (Creeping Charlie, Creeping Jenny, Aluminium, Friendship & Artillery Plant)
- Helxinesoleirolii (Mind Your Own Business Plant, Baby's Tears)

Other accessories (This adds beauty and Variety)

- Coloured pebbles
- Small toys
- Shells
- Barks
- Stones etc.

Planning

Plan the arrangement of your terrarium after choosing a container. Plants can be arranged in any pattern you choose. To add interest, people might wish to add some small pebbles, driftwood, or even stones. However, don't overcrowd the design with ornaments; they will simply detract from its organic appearance.

Tools required

1. Trowel
2. Spoon
3. Tongs
4. Rammer
5. Fork cum Rake

Care and maintenance

Once the terrarium is planted with suitable plants, the aftercare part is easy,

- Water sparingly
- Give it light- not direct sun light, diffused or indirect light or near artificial light sources
- Pinch and prune whenever necessary

Conclusion

Terrariums are a unique and beautiful way to bring nature into your home. They are easy to create and require little maintenance, making them a great project for beginners or those with limited space. Whether you choose an open or closed terrarium, the possibilities are endless, and the result is a beautiful, self-contained garden that will add a touch of natural beauty to any space.

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From Soil to Air: Exploring the Potential of Aeroponics in Farming

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Agriculture is undergoing major changes worldwide due to the increasing risk of frequent drought caused by global climate change. With the world's population projected to reach 9.6 billion by 2050, there is an increasing demand for food production. Providing a fresh and clean food supply for the fast-growing population using traditional agriculture methods will become increasingly difficult in the future. To effectively adapt to these circumstances, soil-less cultivation, specifically the aeroponics system, is being considered as an alternative technology. In aeroponics, plant roots are suspended in the air using plastic holders and foam materials instead of soil, while nutrient-rich water is delivered through atomization nozzles. This system has shown promising results in various countries and is recommended as the most efficient, economical, and convenient method for plant growth compared to traditional soil-based and other soil-less techniques. Aeroponics is a soilless farming method that allows crops to grow suspended in the air or mist without using soil. By providing optimal conditions for root oxygenation and moisture, aeroponics enables better plant nutrition assimilation and faster plant development. The system offers advantages such as easy separation of plants, simplified crop harvesting, precise control over nutrient and water regimes, and complete access to roots throughout the crop's life cycle. It is also considered a highly feasible method for producing uniform harvests and has shown potential in the cultivation of root crops used in herbal and phytopharmaceutical industries. The history of aeroponics dates back to the early 1920s and has evolved into a commercially successful method, with NASA conducting tests in space and confirming its productivity. Aeroponics is an effective solution for individuals with limited space for plant cultivation, requiring minimal water and space compared to traditional farming methods. It promotes rapid plant growth, increased mineral and vitamin uptake, and accelerated biomass growth. Moreover, it allows for increased planting densities and can be applied to various plant species, including seed production and biopharming. Overall, aeroponics offers a promising approach to address future food crises and promote sustainable agricultural practices.

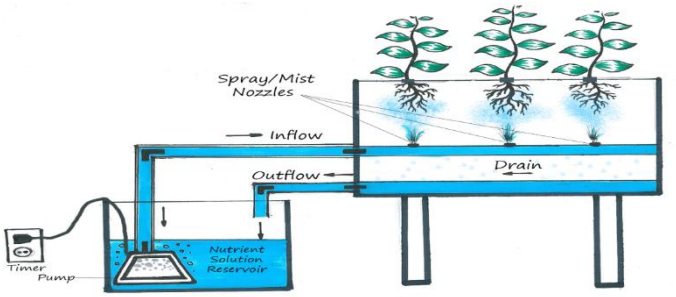


Fig 1: Diagrammatic view of aeroponics system

Recent trends

Aeroponics is a horticultural technique used for the cultivation of various crops, including fruits, vegetables, medicinal plants, and ornamental plants. Aeroponics has been utilized in the cultivation of medicinal plants, resulting in the discovery of new compounds with potential medicinal properties. Aeroponics has shown enhanced growth and root nodulation in *Acacia mangium*, an important legume tree. It has also been used for the cultivation of medicinal plants like ginger, burdock, and *Withania somnifera*, resulting in the discovery of new compounds One of the advantages of aeroponics is its ability to manipulate the root zone temperature, allowing for the production of subtropical and temperate crops in tropical environments. The technique has shown to promote larger root systems and improve the growth and physiology of crops compared to traditional cultivation methods. The aeroponic system has been developed in various structures, including seedbed and pyramid types, and has been used for commercial, experimental, and home gardening purposes. Routine and preventative maintenance are necessary for the efficient and trouble-free operation of the system. While aeroponics is still relatively unknown in many countries, efforts

are being made to promote its benefits among farmers and the local community.



Fig 2: Production of potato tuber



Fig 3: Lettuce growing



Fig 4: Aeroponics Strawberry in Tower Garden

Source: Internet

The horticultural aspect of aeroponics involves the propagation of various crops, including fruits, nuts, vegetables, medicinal and aromatic plants, and ornamental plants. It has been successfully used for the production of vegetable crops like cucumber, lettuce, tomato, and leafy vegetables. Aeroponics has also been employed for large-scale production of potato seed tubers and yam. Plants of ornamental value such as croton, geranium, and chrysanthemum have been studied using this technique. Additionally, aeroponics has been used to manipulate root zone temperature for the production of subtropical and temperate crops in tropical environments. The technique has been extensively researched and applied for commercial production, research, and teaching purposes, providing benefits such as reduced production costs and shorter growth durations. In Singapore, the aeroponic system has been utilized to grow a wide range of vegetables, including subtropical and temperate varieties, by controlling the root zone temperature while exposing the aerial parts to hot tropical greenhouse conditions. Studies have shown that cool root zone temperatures promote larger root systems in temperate vegetable crops. The aeroponic system is an economical and efficient technique that allows plants to quickly access nutrients in a controlled environment, and it has gained attention for its potential to reduce costs and improve the understanding of subtropical and temperate crop growth in tropical regions. Various types of aeroponic systems exist, ranging from commercial to experimental and kitchen gardening setups. However, there is a need for scientifically recommended and convenient aeroponic systems that can be widely adopted. Despite the existing aeroponic structures, including seedbed, vertical barrel, prototype, and pyramid types, there is still a need for scientifically recommended and convenient aeroponic systems. Several structures and designs have been developed using different materials, including wood, aluminum, and plastic. The evaluation of proposed aeroponic systems has shown successful plant growth, indicating their potential for sustainable future cultivation. These systems offer the advantage of easy design and suitability for various settings, allowing people to grow plants on balconies, terraces, and even in rooms.

Recent studies on aeroponics

Barker (1922) introduced the concept of air plant growing systems, which eliminate the need for soil incorporation. NASA (2006) highlighted the significant advantages of aeroponics, such as water conservation, nutrient efficiency, and reduced cultivation time. Hoffman and Kolb (1997) investigated the effects of barley yellow dwarf on winter wheat seedlings grown in an aeroponics

system, observing a decrease in root length and root-to-shoot ratio. Leoni *et al.* (2008) demonstrated successful tomato production using aeroponics, particularly in hybrid varieties, resulting in abundant and high-quality fruit. Luo *et al*. (2009) pioneered the cultivation of hearted lettuce in tropical regions through aeroponics and root cooling techniques, while also studying the impact of environmental factors on lettuce physiology. Bucksetha *et al*. (2016) and Stoner and Clawson (1998) emphasized the importance of optimizing water droplet size in aeroponic systems to balance oxygen availability and root development. Sun *et al.* (2004) reported improved physiological parameters in plants grown aeroponically, including increased stomatal conductance and net photosynthetic rate. Christie and Nichols (2004) successfully applied aeroponics for mass production of seed potatoes and gourmet early potatoes by controlling tuber initiation through intermittent irrigation. Irman *et al.* (2012) explored techniques for rapid multiplication of seed tubers, combining tissue culture with hydroponic and aeroponic systems. Chang *et al.* (2012) discovered that interrupting nutrient supply during stolon growth stimulates root activity and tuber initiation in hydroponic potato production. Chandra *et al.* (2014) compared the yield and phytochemical properties of aeroponically grown crops with conventional soil cultivation, finding comparable results and even higher yields in the aeroponic system. He *et al.* (2008) investigated the interaction between iron stress and root-zone temperature on Chinese broccoli grown aeroponically, observing negative impacts on productivity and nutrient uptake under high root-zone temperatures. Hartung *et al.* (2002) examined the growth of chickpea and lupin in aeroponic and hydroponic cultures, investigating the influence of root anatomy, pH, and abscisic acid concentrations on growth variations. Chica Toro *et al.* (2018) constructed absorption curves for white chrysanthemum in an aeroponic system, revealing variations in nutrient accumulation throughout different growth stages. These studies collectively contribute valuable insights into the application of aeroponics in diverse crops, the physiology of plants grown aeroponically, nutrient management strategies, and yield optimization.

Advantages

Aeroponic farming, a technique where plant roots are suspended in the air and a nutrient solution is misted over them, offers several advantages in agriculture. One key advantage is the reduction in fertilizer usage, as all the nutrients are contained and not wasted in groundwater or deep soil layers. Additionally, water usage is significantly reduced since evaporation and inefficient absorption are minimized. The cost-effectiveness of aeroponic gardens is higher compared to hydroponics, with fewer complex systems involved. Disease damage is also reduced, as plants are separated, preventing the spread of infections. The growth of plants is faster and healthier due to improved oxygen supply, resulting in a 45-70% faster harvest rate. Studies have shown increased flavonoid content in aeroponically grown plants. Furthermore, round-the-year cultivation is possible, independent of external weather conditions. Aeroponics facilitates fast plant growth, requires easy system maintenance, and decreases the need for nutrients and water. The mobility of plants is enhanced, and vertical farms can be constructed for high yield in limited space. It also has educational value, aiding plant and root growth studies. Other benefits include proper root growth, easy fruit harvest, disease-free produce, potential applications in moon stations, and the ability to grow healthier and more nutritious plants at home. Aeroponics is suitable for nurseries, enabling rapid propagation of seeds and cuttings. Additionally, it reduces water and fertilizer usage while maximizing crop yields. Even temporary power loss does not harm plants. The aeroponic farming system involves suspending plant roots in the air and misting them with a nutrient solution. This system offers advantages such as being lightweight, unlimited airflow, reduced disease spread, water savings, and flexibility in modifying root-zone environmental factors.

Disadvantages

Aeroponics, while offering numerous advantages in agriculture, also comes with some disadvantages that need to be considered. One drawback is that it can be more expensive for large-scale production, making it less accessible for ordinary

farmers who may struggle to manage the sophisticated instruments involved. There is also the risk of mister spray heads clogging, which can hinder the production of the necessary nutrient mist for the plants. Additionally, there is a common perception among consumers that aeroponically grown plants are not as nutritious as those grown through other methods. Maintenance of an aeroponics farm can be costly, and dependence on the system's components, such as high-pressure pumps, sprinklers, and timers, leaves the plants vulnerable to damage if any of these components break down. Technical knowledge is required to effectively maintain the system and ensure the right amounts of nutrients are provided. The root chamber must be kept sanitary to prevent diseases from affecting the roots, necessitating regular disinfection. The cost of aeroponic systems can be high, often amounting to hundreds of dollars. Power loss over an extended period can cause irreversible damage to the plants, highlighting the need for reliable electricity connections or backup power sources. Overcoming these technical challenges requires a multidisciplinary approach, incorporating knowledge from various fields such as engineering, biology, biochemistry, and computer science. It is essential to have independent and reliable power sources in place to ensure uninterrupted operation of the aeroponic system. Although initial costs may be higher, the long-term benefits include reduced labor costs, minimal input requirements for fertilizers and pesticides, and significantly higher plant yields, making it a potentially cost-effective choice.

Conclusion & future aspects

In conclusion, aeroponics not only presents a practical solution for current agricultural challenges but also holds great potential for future advancements. As the technique continues to be adopted in various settings, from laboratory experiments to greenhouse cultivation, there is room for further research and development to optimize aeroponic systems for commercial and home operations. By disseminating information and raising awareness about the benefits and maintenance of aeroponic systems, we can encourage its wider adoption among farmers and local communities worldwide. With its ability to conserve water, save space, and offer sustainable farming practices, aeroponics has the potential to revolutionize traditional agriculture and contribute to a more secure and productive food future.

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A Trailblazer in Sustainable Agriculture: Success Story of Sh. Ashwini Singh

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In the heart of Pipalyahama village of Ghattiya block of Ujjain district, a beacon of success shines bright – Ashwini Singh, 46 years visionary farmer who transformed his 100-acre land into a flourishing empire through strategic crop diversification. Ashwini's inspiring journey from traditional farming to becoming a millionaire is a testament to hard work, innovation, and leveraging government support.

Ashwini Singh inherited a vast expanse of land, but the journey to success was not without its challenges. Recognizing the need for change, he embraced crop diversification, a decision that would pave the way for his remarkable transformation. Instead of relying on a single crop, Ashwini diversified his cultivation to include Chickpeas, Wheat, Soybeans, Maize, Potatoes, Onions, Bananas, Lemons, Papayas.

Table 1: Resources owned by Farmer

Land (ha)	**09.88 ha**
Water bodies with irrigation capacity	a. Open wells (03). Installed 5HP electric pump with full discharge capacity covering entire land in 8 to 10 days b. Annicut type stop dam: 800 mt length, 15 mt wide and depth 10mt. (Capacity 1200 lac litres water)
Animal Resources including fish and Poultry	a. Cows: 05 (02 Gir + 03 Malvi) b. Buffalo: 08, Murrha c. Bullock: One pair d. Goats: 20 Barberi and Sirohi
Farm Machinery	a. Tractor 35 HP (Mahindra) b. Cultivator: 02 Duck foot type c. Ferti-seed drill (01) d. M.B reversible plough (01) e. Disc harrow (01) f. Raised bed planter g. Tractor operated blade harrow h. Potato planter with digger i. Tractor operated spray pump j. Tractor operated thresher cum grader k. Hydraulic trolley l. Land leveller tractor operated



Fig 1: Received IARI Farmer Fellow Award from Cabinet Minister of Agri. Sh. N.S.Tomar

To enhance efficiency and productivity, Ashwini embraced modern agricultural practices, including the use of machinery for cultivation. Investing wisely, he spent 40000 per acre on his farm, a decision that would yield substantial returns. The careful selection of crops and strategic planning allowed him to achieve returns ranging from 1 to 1.5 lakhs per acre.

One of Ashwini's key success factors was the adoption of drip irrigation on his farm. This modern irrigation technique not only conserved water but also increased crop yield. With the support of government subsidies, he implemented a drip irrigation unit at a cost of 9 lakhs, of which he received a substantial 6 lakhs in government aid. The 65% subsidy acted as a catalyst, empowering Ashwini to implement sustainable farming practices and significantly improve his overall yield.

Ashwini Singh's success story is not just about financial prosperity; it is a tale of resilience, innovation, and community upliftment. As a millionaire farmer, he has become an inspiration for others in Pipalyahama village and beyond. Through his journey, Ashwini has showcased the potential for transformation when traditional farmers embrace modern techniques, crop diversification, and government support.



In the quaint village of Pipalyahama, where the rhythm of rural life intertwines with the whispers of crops, Ashwini Singh's success story takes a new dimension. Beyond being a millionaire farmer through crop diversification, he has become a model of sustainable agriculture by seamlessly integrating livestock farming into his thriving agricultural landscape.

Ashwini's journey extends beyond the fields, where his daily expenses find sustenance through the sale of milk from his well-maintained cattle shed. Recognizing the symbiotic relationship between livestock and agriculture, he leverages cow dung and *gobar khad* (manure) to enhance soil fertility, creating a harmonious cycle of nutrient replenishment.

Table 2: Income through animal resources

Particular	Production	Exp. per annum	Gross Income	Net Income
Milk Production	50 liter/day (avg.)	1.17 Lakh	3.6 lakh	2.43 Lakh
Cow Dung Production	327.6 Qtl.	Nil	-	-

Note: Prepared the vermi-compost and NADEP organic fertilizer by using the cow dung and crop residue and utilized in field to maintain organic carbon. It saves the cost of chemical fertilizer.

The path to sustainable success for Ashwini was paved with knowledge and collaboration. With the support of scientists from Krishi Vigyan Kendra Ujjain and Malwa Green, he underwent a transformative shift in cultivation techniques. This partnership empowered him to adopt innovative practices that not only increased yields but also promoted eco-friendly farming.

Ashwini's commitment to agricultural advancement goes beyond his fields. Serving as a member of the selection committee of Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur, he actively contributes to shaping the future of agriculture, bringing a farmer's perspective to the decision-making process. He is also the member of Submission on Agriculture Mechanization, Ujjain district and District Cooperative Bank for Agriculture.

His dedication and exemplary contributions to agriculture have not gone unnoticed. Ashwini Singh stands adorned with various accolades, including:

- IARI Farmer Fellow Award 2022-23
- Jagjivan Ram Innovative Farmer National Award 2018(ICAR, New Delhi
- All India Students Agriculture Association Farmers of the Year 2018
- Krishi Gaurav Puraskar 2018(Rashtriya Krishi Patrakar Sangh, Indore)
- Best Farmer under Organic farmer and water management (Chief Minister, Government of MP.)
- Farmers Fellow Award 2018 (RVSKVV, Gwalior)
- IARI Innovative Farmer Fellow Award 2017-18
- Farmer Fellowship Award 2017(JNKVV, Jabalpur)
- Block lever best farmer 2010-11(ATMA, Ujjain)

In every acre of his farm, Ashwini Singh has sown the seeds of success, reaping not only bountiful harvests but also the rewards of dedication and forward-thinking. His story stands as a beacon for aspiring farmers, encouraging them to embrace change and turn their fields into landscapes of prosperity.

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Bio-Fertilizers: A Source to Improve Soil and Human Health

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Conventional methods of increasing production still rely on using inorganic fertilizers. Because using inorganic fertilizers on a regular basis would not help enhance soil health, it is vital to utilize environmentally friendly fertilizers, including bio-fertilizers. To meet this food demand and ensure food security, it is equally important to ensure food safety for consumption. Food safety measures need to be put in place throughout the food production chain lines. One of the fundamental measures is the use of bio-fertilizers or plant growth promoters instead of chemical or synthesized fertilizers, pesticides and herbicides that poise several dangers to human and animal health.

Nitrogen (N), phosphorus (P) and Potassium (K) are considered as an essential nutrient and a major constituent for all living cells. Although, soil constitute these nutrients but for the production of adequate amount of food there is need of supply of additional nutrient through fertilizers but application of chemical fertilizers has a considerably negative impact on environmental sustainability. Bio-fertilizers are microbial cultures of specific soil micro-organisms that have been intentionally multiplied to increase soil fertility and crop productivity by fixing atmospheric nitrogen, mobilizing or solubilizing the fixed phosphorus and potassium in the soil and root nodules of legume crops and make it available to the plant. Because they are inexpensive and sustainable sources of nutrients for plants, bio-fertilizers offer an economical alternative to chemical fertilizers. It reduces the toxic substances through chemicals to reach the food material as it avoids the application of other toxic chemicals in combination of it. Because they adequately maintain the soil's health and lower environmental pollution by using fewer chemicals, bio-fertilizers are currently very significant.

Importance of bio-fertilizers

Following are the reasons for importance of bio-fertilizers

- Improve the soil texture and yield of plants.
- Eco-friendly and cost effective.
- Protect the environment from pollutants since they are natural fertilizers.
- They do not allow pathogens to flourish.
- Destroy many harmful substances present in the soil that can cause plant diseases.
- Effective even under semi-arid conditions.

Types of Bio-fertilizers

Based on type of micro-organism, the bio-fertilizer can also be classified as follows:

- **Bacterial Bio-fertilizers**: e.g. *Rhizobium*, , *Azotobacter, Azospirilium* and *Phosphobacteria*.
- **Fungal Bio-fertilizers**: e.g. *Mycorhiza*
- **Algal Bio-fertilizers**: e.g. Blue Green Algae (BGA) and Azolla.
- **Actinimycetes Bio-fertilizer**: e.g. Frankia

Azotobacter

These bacteria belong to the family of *Azotobacteriaceae*, aerobic, free living, and heterotrophic in nature. They are found in neutral or alkaline soils and *A. chroococcum* are the most common occurring species in arable soils. *A. vinelandii, A. beijerinckii, A. insignis* and *A. macrocytogenes* are other reported species. The population number of *Azotobacter* rarely exceeds of 104 to 105 g^{-1} of soil due to lack of organic matter and presence of antagonistic micro-organisms in soil.

Phosphate solubilizers

These bacterial species has the ability to solubilize insoluble inorganic phosphate compounds, which are tricalcium phosphate, dicalcium phosphate, hydroxyapatite, and rock phosphate. The examples among the bacterial genera with this are *Pseudomonas, Bacillus, Rhizobium*.

Potassium solubilizer

Potassium (K) solubilizing bacteria (KSB) have attracted the attention of agriculturists as soil inoculums to promote the plant growth and yield. The

KSB are effective in releasing K from inorganic and insoluble pools of total soil K through solubilization. K solubilization is done by a wide range of saprophytic bacteria, fungal strains and actinomycetes.

NPK Consortia

It is consortium of rhizobium, azotobacter and acetobacter, phospho bacteria- Psuedomonus and potassium solution- baciles bacteria which are atmospheric nitrogen and phosphorus fixing organisms. NPK consortia has higher efficiency in nitrogen, phosphorus and potassium fixing to the soil and provide it to plants.

Rhyzobium

These bacteraial inoculantions has for the ability of fixing atmospheric nitrogen in association with plants forming nodules in roots stem nodules. RHZ are restricted by their specificity and only certain legumes are benefited from this symbiosis. They are found in Rhizobiaceae, symbiotic in nature that fixes nitrogen 50-100 kg ha^{-1} in association with legumes only.

Vermi-compost and Vermi-composting as a Part of Bio-fertilizer

Vermi-compost may be defined as the product of composting using various worms to create a heterogeneous mixture of decomposing vegetable or food waste, bedding materials, and vermincast. Vermi-composting technology also involves the biological conversion of organic wastes into vermin-casts and sometimes by the utilization of vermiwash utilizing earthworms. These earthworms always feed on the waste and the gut of the worm is the bioreactor where the vermicasts are generally produced.

Mass production of bacterial bio-fertilizer

- Isolated bacterial cultures are subculture into nutrient broth.
- Cultures are grown under shaking condition at 30 ±2 °C
- The culture incubated until it reaches maximum cell population of 1010 to 1011
- Under optimum condition this population level could be attained within 4-5 days for azospirillum and 6-7 days for azotobacter
- The culture obtained in flask is called Starter culture
- For large scale production, inoculum from starter culture is transferred in to large flasks/ fermentor and grown until required level of cell count is reached.

Mass production of fungal bio-fertilizer

- VAM spores are isolated
- These spores are mixed with sterilized soil
- Spore mixed soil is filled in pots
- Host plant is transplanted in pots
- It is kept in green house for 3-4 months
- Soil in the pot along with roots of host plant is moistened
- Dried till it attains 5% moisture
- Dried soil inoculants used for field application.

Carrier materials

The use of carrier material is necessary for good quality production of bio-fertilizers. Generally, farm yard manure, pit soil, lignite, vermiculture, press mud, charcoal and soil mixtures are used as carrier material. An ideal carrier material should be cheaper in cost, easily available, high organic matter content, toxic chemical free and more than 50% water holding capacity and easy to process.

Applications of bio-fertilizers

Seed treatment

Each packet (200 g) of inoculant is mixed with 200 ml of rice gruel or jaggery solution. The seeds required for one hectare are mixed in the slurry so as to have uniform coating of the inoculants over the seeds and then dried for 30 minutes in shed. The treated seeds should be used within 24 hours. One packet of inoculant is sufficient to treat to 10 kg seeds. *Rhizobium, Azospirillum, Azotobacter* and *Phospho-bacteria* are applied as seed treatment.

Seedling root dip

Five packets (1.0 kg) of the inoculants are required for one hectare and mixed with 40 litre of water. The root portion of the seedlings is dipped in the solutions for 5 to 10 minutes and then

transplanted. *Azospirillum* is used for seedling root dip particularly for rice.

Soil treatment

4 kg each of the recommended bio-fertilizers are mixed in 200 kg of compost and kept overnight. This mixture is incorporated in the soil at the time of sowing or planting.

Bio-fertilizers recommended for crops

- Rhizobium + Phosphotika at 200 gm each per 10 kg of seed as seed treatment are recommended for pulses such as pigeonpea, green gram, black gram, cowpea etc, groundnut and soybean.
- Azotobacter + Phosphotika at 200 gm each per 10 kg of seed as seed treatment are useful for wheat, sorghum, maize, cotton, mustard etc.
- For transplanted rice, the recommendation is to dip the roots of seedlings for 8 to 10 hours in a solution of Azospirillum + Phosphotika at 5 kg each per ha.

Case study

Parmar and Sindhu (2013) observed that inoculation of K-solubilizing isolate HWP47 in wheat (*Triticum aestivum* L.) var. WH711 caused 51.46 % increase in root dry weight in soil at 60 days after sowing in pots. Similarly, 44.28 % increase in shoot dry weight was found in HWP47 inoculated plants. Addition of rock material along with inoculation of HWP47 isolate showed 22.35 % increase in root dry weight and 73.68 % increase in shoot dry weight. Isolates HWP15 and HWP47 also caused significant K uptake in the shoot tissues.

Precautions

- Bio-fertilizer packets should be kept in cool and dry place away from sunlight.
- Rhizobium should use for specified crop only.
- Right combination of bio-fertilizers should be used.
- Other chemicals like herbicide, insecticide should not be used with bio-fertilizer.
- While purchasing one should ensure that each packet is provided with necessary information like name of the product, name of the crop for which intended, name and address of the manufacturer, date of manufacture, date of expiry, batch number and instructions for use.

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Role of Dairy Co-operative in Development of Dairy Sector of Haryana State

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In India the milk is produced by a large number of small and marginal farmers. In contrast, in western countries there are small number of farmers but each farmer is having huge quantity of milk produced at his farm. Whereas, in India the particular farmer is having only a small quantity of milk produced at his farm. In this case it is not possible for the farmer to sell his produce in the market because of the reasons like scattered production, small quantity of milk and lack of transportation facilities. Here comes the role of middlemen who collects the milk from a large number of farmers in India, and sell it in the market and earn huge profits. In this case the producers/farmers are exploited, they don't get fair price of milk. So, to improve the conditions of farmers and give them appropriate price of their milk dairy co-operatives are introduced.

Co-operative

A co-operative defined as an association of persons united voluntarily to meet their common economic, social and cultural needs and aspirations through a jointly owned and democratically controlled enterprise. The values behind a co-operative are self-help, democracy and equality irrespective of the equity of the member.

Co-operative movement in India

The co-operative movement in India started back at the time of independence. This movement was initially started in Gujrat, when the farmers of the state were exploited by some private organizations and they were not given proper price of their milk. This movement eventually leads to establishment National Dairy Development Board (NDDB) in Gujrat state.

Establishment of co-operative in Haryana state

After establishment of NDDB, the operation flood programme to increase milk production in India was launched in 1970. Under the operation flood programme various co-operatives were established in different states of the country. The co-operative of Haryana state i.e. Haryana Dairy Development Co-operative Federation (HDDCF) was established in 1970 as a part of operation flood programme under the brand name of "VITA".

At present there are six milk unions having their milk processing plants situated at Jind, Sirsa, Faridabad, Rohtak, Ambala and Kurukshetra distrct. The chilling centers of the unions are across all over the state. The HDDCF processes a vast number of dairy products, meanwhile Dahi remains the key dairy product to be consumed in rural as well as urban society (Kumari *et al.*, 2023).

Three tier system of the co-operative

The co-operative functions at three levels similar to that of the Amul model which are as follows-

Village level milk societies- The cooperative is having various societies at the village level in which the milk is procured two times a day i.e. morning and evening. The price of the milk is given on fat basis. The payment of money is done by the milk unions every 10 days to the farmers through the societies. In this way the farmers get fair price at regular intervals for their milk.

District level milk unions- The cooperative is having milk unions at district level in which there are milk processing plants are there. The procured milk is processed and converted into packed milk and milk products at this level.

State level federation- The cooperative is having a state level federation which is responsible for the

marketing of milk and milk products. All the decisions are taken at this level.

Various benefits of this model are as follows



Role in women empowerment

India is a country where the economy is rural and agro based, 54% workforce is engaged in agriculture, of which 37% are women (Sapovadia and Achutan, 2006). Women failed to achieve their potential in India (Parthasarathy, 2007; Srivastava, 2007). As dairying in India is a female dominated enterprise (Fulzele and Meena, 1995). The co-operative has helped a lot the women to organize themselves in participatory action (Dash *et al.*, 2007). Mainly the women are the one who work at home and take the milk to the societies and then they get the money by selling the milk. In this way the women are more financially empowered with the help of the co-operative.

Challenges faced by the Dairy Co-operative

There are a large number of challenges faced by the dairy co-operative. Haryana is at the second position at in terms of per capita availability of milk in India but, there are a large number of private players in the industry who serves as the competitors of the co-operative. The co-operative is although one of the oldest co-operatives established in the country but there is lack of advance technologies due to which other co-operatives of the industry gets an advantage in terms of quality of the dairy products. The middlemen are also a major challenge to the co-operative because there is lack of awareness among the consumers about the processed or packed milk.

Conclusions

The dairy co-operative is functioning well and significantly contributing to the development of the dairy sector and hence the state. But there are a large number of scopes of improvement. The procurement system needs to be revolutionized and establishment of bulk milk coolers should be done at the village level in order to ensure high quality dairy products. The co-operative should switch to the advanced and latest technologies in order to maintain the quality of the dairy product higher than its competitors. Overall, the co-operative has contributed a lot in the development of the dairy sector of the state but is must change with this changing world in order to beat competition and meet the goals of sustainable development.

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Voltilomics: A Key to Understand Plant-Microbe Interactions and Stress Management in Crop Plants for A Greener Tomorrow

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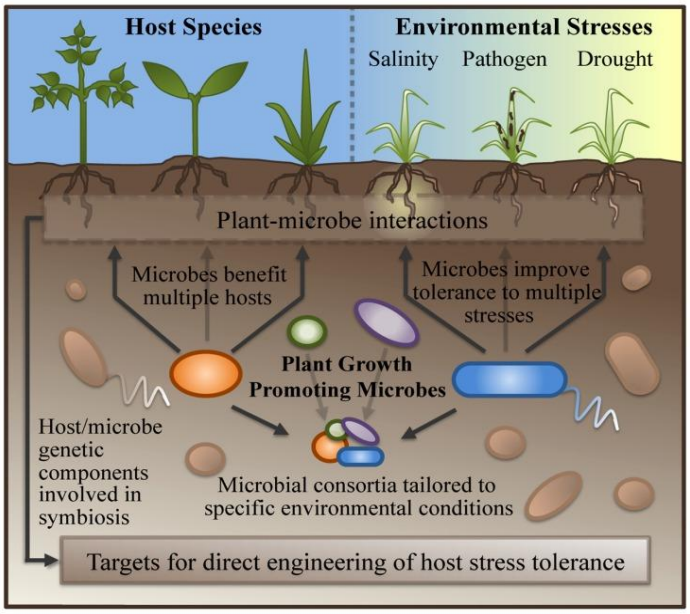
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Abstract

Voltilomics, a burgeoning field at the crossroads of plant biology and environmental science, delves into the study of volatile organic compounds (VOCs) emitted by plants and their pivotal roles in ecological processes. This emerging discipline offers profound insights into the intricate communication between plants and microorganisms, particularly in the realms of plant-microbe interactions and stress management in crops. VOCs serve as chemical messengers, enabling plants to establish symbiotic relationships with beneficial microbes, deter herbivores, and respond to abiotic stresses. This abstract encapsulates key aspects, including chemical communication, defense mechanisms, abiotic stress responses, the role of VOCs as biological indicators, and the integration of volatilities into precision agriculture. The elucidation of these complex volatilomic signals holds promise for sustainable agricultural practices, providing a foundation for stress-tolerant crop varieties, efficient pest and disease management, and the evolution of smart agriculture systems. As we embark on a quest for a greener and more resilient agricultural future, voltilomics emerges as a key tool in deciphering the chemical dialogues shaping the resilience and well-being of crop plants.

Introduction

"Voltilomics" refers to the study of volatile organic compounds (VOCs) produced by plants and their role in various ecological processes. Volatilomics, a burgeoning field at the intersection of plant biology and environmental science, holds tremendous promise in unravelling the intricate language of volatile organic compounds (VOCs) emitted by plants. These VOCs play a pivotal role in mediating plant-microbe interactions and influencing stress management in crop plants. The emissions of these compounds serve as a sophisticated means of communication, allowing plants to interact with a myriad of microorganisms, ranging from beneficial mycorrhizal fungi and rhizobacteria to potential pathogens. Understanding the complex web of volatilomic signals provides researchers and agriculturists with valuable insights into the physiological state of plants, their responses to environmental stressors, and the establishment of symbiotic relationships. As we embark on a quest for sustainable agricultural practices, volatilities emerge as a key tool in deciphering the chemical dialogues that shape the resilience and well-being of crop plants, paving the way for a greener and more resilient agricultural future.



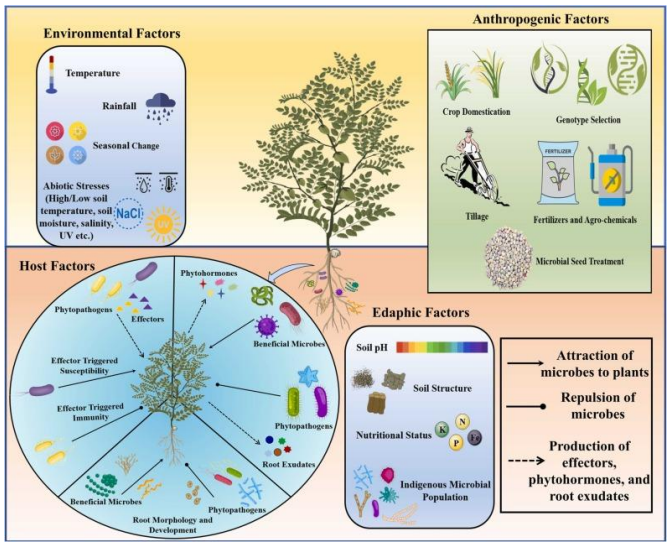
In plant-microbe interactions and stress management in crop plants, volatilities can provide valuable insights into the intricate communication between plants and their microbial partners. Plants release a diverse array of VOCs into the surrounding environment, and these compounds play crucial roles in mediating interactions with microorganisms, including beneficial microbes and pathogens.

Here are some key aspects of volatilities in understanding plant-microbe interactions and stress management in crops:

Chemical Communication

- Plants release specific VOCs in response to microbial signals, helping them communicate with beneficial microbes such as mycorrhizal fungi or rhizobacteria.

- VOCs can act as signalling molecules that attract beneficial microorganisms, promoting symbiotic relationships that enhance nutrient uptake, disease resistance, and overall plant health.
- Mycorrhizal Associations: Plants often form symbiotic relationships with mycorrhizal fungi to enhance nutrient uptake. Volatile compounds, such as strigolactones, are released by plant roots to attract mycorrhizal fungi. These fungi, in turn, release signalling molecules that influence the plant's growth and development.
- Rhizobacterial Interactions: Plants release specific VOCs to attract beneficial rhizobacteria. These bacteria can promote plant growth, fix nitrogen, and enhance resistance against pathogens. Volatile signals play a crucial role in establishing and maintaining these mutualistic relationships.

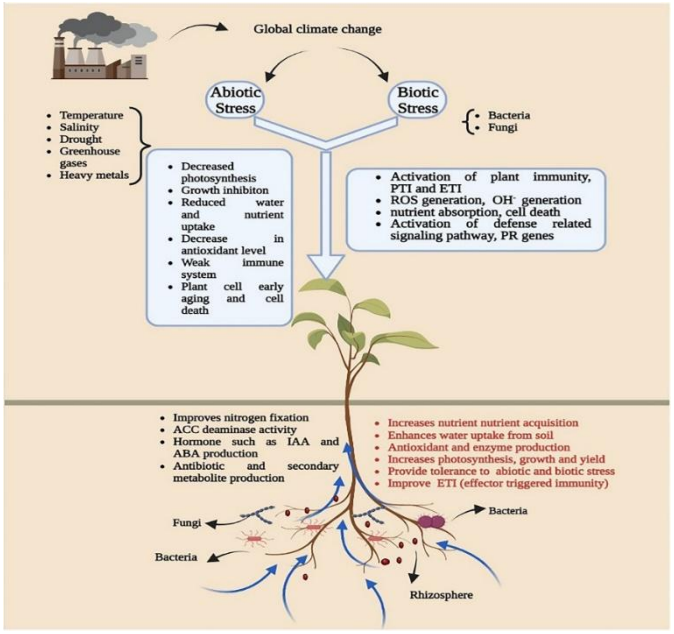


Defense Mechanisms

- VOCs released by plants can serve as defence mechanisms against herbivores and pathogens. Some VOCs act as repellents to deter herbivores, while others attract predators of herbivores, creating a natural defence system for plants.
- Understanding the specific VOCs involved in these processes can contribute to the development of biocontrol strategies for pest and disease management in agriculture.
- Herbivore Deterrence: When plants are attacked by herbivores, they release VOCs as a part of their defence mechanism. These compounds can act as deterrents by signaling neighbouring plants to activate their own defence systems or by repelling herbivores directly.
- Attracting Predators: Some VOCs emitted by plants attract natural predators of herbivores, creating a system of biological control. For example, parasitoid wasps might be attracted to the VOCs released by plants under herbivore attack.

Abiotic Stress Responses

- Plants emit VOCs in response to various abiotic stresses, such as drought, temperature fluctuations, or nutrient deficiencies.
- Studying volatilities under stress conditions can provide insights into the adaptive mechanisms employed by plants, potentially leading to the development of stress-tolerant crop varieties.
- Drought Stress: Plants subjected to drought stress release specific VOCs that can serve as indicators of water stress. Understanding these compounds can help in developing drought-tolerant crop varieties and efficient irrigation strategies.



- Temperature and Nutrient Stress: Similar to drought stress, plants respond to temperature fluctuations and nutrient deficiencies by emitting specific volatiles. Studying these responses aids in identifying stress factors and implementing suitable management practices.

Biological Indicators

- VOC profiles can serve as biological indicators of plant health and stress. Changes in the composition and quantity of emitted VOCs can reflect the plant's physiological status and response to environmental conditions.
- Monitoring volatilities can assist in the early detection of stress in crops, allowing for timely interventions and improved crop management practices.
- VOC Profiles as Indicators: Monitoring changes in VOC profiles can provide early indications of plant stress before visible symptoms appear. This early detection allows for timely interventions, reducing the impact of stress on crop yield and quality.
- Non-invasive Monitoring: Volatilomics offers a non-invasive way to assess plant health, enabling continuous monitoring in the field. This can be particularly valuable for large-scale agriculture where rapid and accurate assessments are crucial.

Precision Agriculture

- Integrating volatilities into precision agriculture practices enables more targeted and efficient management of crops. By understanding the specific VOCs associated with different plant-microbe interactions and stress responses, farmers can tailor interventions based on real-time data.
- Tailored Crop Management: Integrating volatility data with other precision agriculture technologies allows for customized and targeted interventions. Farmers can adjust their practices based on real-time information, optimizing resource use and minimizing environmental impact.
- Smart Agriculture Systems: Advances in sensor technologies and data analytics enable the development of smart agriculture systems. These systems can automate responses to volatilomic data, creating a more adaptive and efficient approach to crop management.

Conclusion

In summary, volatilomic is a promising field with significant potential for advancing our understanding of plant-microbe interactions and stress management in crop plants. By unravelling the complex language of volatile compounds, researchers and farmers alike can work towards developing sustainable and resilient agricultural systems for a greener tomorrow. The detailed study of volatilomics offers a comprehensive understanding of the chemical language of plants and their interactions with microbes. This knowledge has practical applications in developing sustainable agricultural practices, enhancing crop resilience, and contributing to the goal of achieving a greener and more environmentally friendly agricultural future.

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Flourishing Multi-Layer Crops in Natural Farming - Success Story in Gujarat

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Natural Farming is an agro-ecological farming approach that promotes growing crops in harmony with nature. A five-layer agro forestry model of cultivation is practiced by a tribal farmer in Navsari district. It is a very good perennial source of livelihood for the farming community and become a mock-up farm in and around the area. Shri. Manubhai Bhikhabhai Patel native of "Bhinar" village in Vansda taluka of Navsari district Gujarat, practicing agriculture farming since 15 years. Once he retired from the regular government job, he becomes a full-time farmer. He conducts many workshops on natural farming for a group of 40 farmers in each batch accompanied by ATMA and other agriculture departments, SAUs and NGOs. He became a resource person and said the five-layer farming model is good for soil health and the use of natural farming practices is essential for sustainable growth. Basically, multilayer cropping is a type of agro-forestry model which integrates trees with various levels of plant canopies, each layer at an optimum level to harvest the sunlight. It includes various crop and tree combinations, including living fences on the edges, and trenches for water harvesting. Farmers have further adapted this model according to their needs and in many states and many local versions have been found.

He practiced all the four basic principles of natural farming *viz.,* Bijamrith, Jeevamrith, Achhadan and Wapahasa as we all know Jivamrita: A fermented microbial culture derived from cow dung and urine, jaggery, pulse flour and soil It stimulate microbial activity to make nutrients bio-available. Bijamrita: a microbial coating for seeds, based on cow dung, urine, and lime it Protects young roots from fungus and seed borne or soil borne diseases. Acchadana- mulching: Covering the top soil with cover crops and crop residues; It produces humus, conserves top soil, increases water retention, encourages soil fauna, prevents weeds. Whapahasa: Soil aeration, a result of jivamrita and acchadana- represents the changes in water management brought about by improved soil structure and humus content it Increase water availability, water use efficiency, increase resilience to drought.



In the five / multi-layer farming mulching happens automatically when the farmers grow cereals, leafy vegetables, tubers and other small crops are grown. Intercropping and multi cropping is compensated by the additional income, making farming a close to zero budget activity. Continuous application of jeevamrith and other natural farming components has increased the soil microbial activity

and the revival of local deep soil earthworms through increased organic matter. It is a field practice to conserve the soil moisture and to control the weeds.



Crop residues like paddy straw, Sugar cane trash, Green gram husk, Maize stalks, Leaves, and Coir dust etc., Mulching adds humus to the soil, keeps soil cool in day and warm at night hours. Maintain optimum soil moisture, irrigation after a long dry spell results in cracking of fruits. Inter crops (up to 5 years old Mango orchards) like Millets, Pulses, Vegetables, Leafy vegetables and Creeper vegetables like Little gourd, Spine gourd and Bottle Gourd was grown in between two rows of Mango trees and plant filler fruit trees like Papaya, Drumstick, etc. were also observed in his farm. In the shady area he also cultivated Tuber crops like Turmeric, Ginger, Carrot, Beet root, Onion, Radish etc., and Leafy vegetables like spinach and amaranthus were observed. Farmer experienced the growing of multi crops/ Inter crops in between rows in areas with sunlight, must be integral part in Mango cropping system. Income from main crop and other crops are documented.

Natural Farming and Conventional Farming

Parameters	**Natural Farming (Area in ha)**	**Conventional Farming (Area in ha)** ***Mango as sole crop***
Name of Crop: **Mango**	1 ha	1 ha
Cost of cultivation (Rs)	65,000	1,04,900
Production (q)	100.8	80.8
Gross return (Rs)	2,52,000	2,02,000
Net return (Rs)	1,87,000	97,100
B:C ratio	3.87	1.92

Production quantity of Intercrops per ha

Year	**Turmeric (tonn)**	**Brinjal (tonn)**	**Ginger (tonn)**
2019	25	39	10
2020	25	40	10
2021	26	40	11
2022	28	43	13
2023	29	44	13

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From Gut to Glow using Probiotics to Prevent Skin Problems

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Beneath the apparent successes of contemporary medical practices, a concealed epidemic persists. Non-fatal ailments, such as dermatological disorders, have now taken precedence, significantly impacting our overall quality of life. According to the "Global burden of disease" report, these conditions rank as the fourth most significant threat globally, exerting a subtle yet substantial influence on millions.

The skin, acting as the body's expansive and versatile protective barrier, plays a multifaceted role beyond mere aesthetics. It serves functions such as sensation, heat regulation, protection, and defense against external threats. However, in developing countries, crowded living conditions, limited awareness, and financial constraints collectively contribute to the harsh reality of prevalent skin diseases.

Diseases Associated with Skin

Compounding the issue, these disorders can obscure more profound health threats like HIV/AIDS, leprosy, and onchocerciasis, underscoring the critical importance of timely diagnosis. While conventional treatments include ointments, antifungals, antibiotics, and herbal remedies, each therapeutic approach comes with its own set of challenges. Prolonged use of antibiotics fosters resistance, antifungal treatments may induce allergic reactions, and even seemingly benign topical creams can result in irritation, dryness, or unwanted hair growth. Herbal remedies, though generally free of side effects, demand a level of patience akin to saintly virtues.

Evidently, a more sophisticated armamentarium is imperative for addressing these challenges. As advocated by Nankervis *et al.* (2016), operational research should guide us towards interventions that not only heal but also empower, bringing us closer to realizing the full potential of skin health.

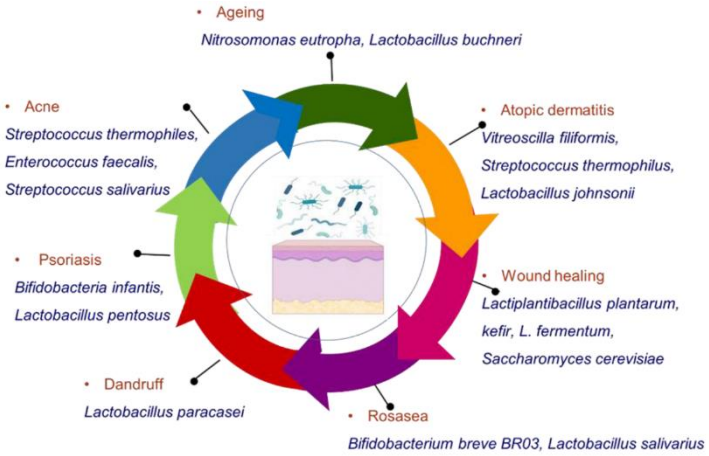


Fig. 1: Applications of Probiotics for Health Well-being

Applications of Probiotics

Numerous research studies have demonstrated the efficacy of probiotics through oral and topical administration in treating various disorders, circumventing adverse effects associated with conventional treatments (Kumari *et al.*, 2023). The International Scientific Association for Probiotics and Prebiotics (ISAAP) defines probiotics as live microorganisms that, when administered in adequate quantities, confer health benefits to the host. Compelling evidence indicates that the influence of gut microbiota extends to distant organs, including the skin, where probiotics exhibit therapeutic effects on conditions such as atopic dermatitis, psoriasis, rosacea, acne vulgaris, and other skin diseases. Topical application of probiotics has been shown to inhibit pathogen growth and prevent their adhesion to the skin (Najem et al., 2017).

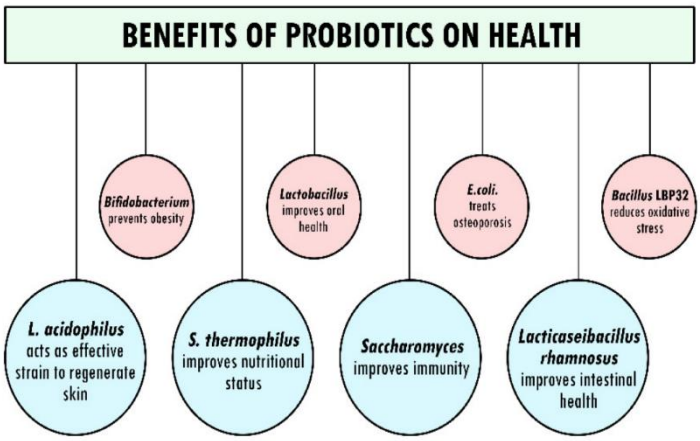
This article critically reviews the existing knowledge on the efficacy of probiotics in treating skin disorders, elucidating the underlying mechanisms. The correlation between gut microbiota balance and various skin disorders underscores the potential of intentionally modifying the gut microbiome to yield promising outcomes in treating skin conditions. Diet, a significant factor influencing gut microbiota, can be modulated effectively by incorporating probiotics,

presenting a novel therapeutic avenue in the face of antibiotic resistance and adverse effects associated with current treatments.

Recent scientific developments have heightened interest in probiotics as an alternative therapy for skin disorders, supported by positive study outcomes. Evidence suggests a deficiency of specific intestinal bacteria, notably Bifidobacteria, contributing to an imbalance in the Th1/Th2 immune response in patients with atopic dermatitis (AD). Supplementation of probiotics in the diet of pregnant women in the last trimester has demonstrated a reduction in AD occurrence in neonates. Clinical trials involving probiotic supplementation in children suffering from AD have shown a decrease in the AD scoring index.

Benefits of Probiotics

Probiotics have also proven effective in treating Acne vulgaris. Specific strains such as *Lb.brevis* and *Lb.rhamnosus* have been associated with inhibiting the growth of acne-causing bacteria. Peptides produced by *Lb.brevis* stimulate the growth of beneficial bacteria, indirectly controlling Acne vulgaris. Additionally, the expression of IGF-1, a factor linked to acne symptoms, decreased with the inclusion of *Lb.rhamnosus* in the diet. Historical studies, such as Robert H. Silver's 1961 investigation, reported improvements in acne symptoms in patients administered *Lb.acidophilus* and *Lb.bulgaricus*. A study involving Korean women revealed a correlation between gut microbial alterations and rosacea. Combining doxycholine and oral probiotics demonstrated positive outcomes in rosacea treatment, with doxycholine inhibiting pathogenic bacterial growth, and probiotics promoting the proliferation of beneficial bacteria.



Advancements in topical probiotic applications have exhibited positive effects in treating skin disorders such as acne vulgaris, rosacea, and psoriasis. Topical floras compete with pathogens for nutrients, inhibiting their growth, while increased production of ceramide and mucin traps pathogens. The application of topical Bifidobacterium longum lysate has demonstrated efficacy in reducing skin dryness, reactivity, and aging (Guéniche *et al.,* 2010).

Conclusion

Dermatological conditions represent a significant area of concern for researchers in the medical field due to their status as primary indicators of various serious diseases, such as cancer, HIV/AIDS, and the persistent human pursuit of aesthetically pleasing appearances. Current interventions for alleviating skin disorder symptoms include topical treatments, retinoids, moisturizers, medications, and light therapies; however, a definitive treatment remains elusive. Recent studies have highlighted the potential role of gut microbiota as a concealed regulator of skin health, proposing the use of gut-microbial balance as an alternative therapeutic avenue for addressing skin disorders.

This review focuses on elucidating the mechanisms underlying the development of diverse skin disorders, examining existing treatments, and exploring the influence of gut microbiota in sustaining optimal skin health. Additionally, it delves into available evidence suggesting the efficacy of probiotics in the treatment of skin disorders. Probiotics emerge as promising modulators of the skin microbiota, unveiling their potential as a covert regulator of skin health. Consequently, the integration of probiotics into the treatment paradigm for skin disorders could prove to be a promising and effective approach in the future landscape of medical interventions.

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Organic Farming: Nurturing Health and Sustainability

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India has a long and rich agricultural heritage that goes back thousands of years. Native crop rotation techniques, organic fertilizers, and natural pest control were the mainstays of Indian farming practices in the past. Increased reliance on chemical inputs resulted from the post-independence era's push towards industrialized agriculture. On the other hand, the growing popularity of organic farming signifies a return to the sustainable methods that are ingrained in India's agricultural heritage.

In the quiet expanses of organic farms, a silent revolution is taking root. Organic farming, with its commitment to natural processes and sustainability, has emerged as a beacon of health for both the environment and the consumers it serves. This article delves into the principles that underpin organic farming, explores the profound benefits it offers to the environment and human health, and sheds light on the surging demand for organic products in a world increasingly yearning for a more sustainable future.

Principles of Organic Farming: Sowing the Seeds of Harmony

At the heart of organic farming lie principles that eschew synthetic inputs and prioritize harmony with nature. Farmers practicing organic methods adhere to:

No Synthetic Chemicals: Unlike conventional farming, organic farmers reject synthetic pesticides and fertilizers, opting for natural alternatives and integrated pest management strategies.

Crop Rotation and Diversity: Organic farmers embrace biodiversity and crop rotation to enhance soil fertility, deter pests, and reduce the risk of diseases.

Soil Health Focus: The foundation of organic farming is healthy soil. Practices like composting, cover cropping, and reduced tillage contribute to the vitality of the soil ecosystem.

Animal Welfare: Organic livestock farming emphasizes humane treatment, access to pasture, and the exclusion of growth hormones and antibiotics.

Avoidance of Genetically Modified Organisms (GMOs): Organic farming prohibits the use of genetically modified seeds, preserving the natural genetic diversity of crops.

Benefits for the Environment: Cultivating Sustainability

Preserving Soil Health: Organic farming practices foster soil health by avoiding synthetic chemicals and embracing techniques that enhance soil structure and microbial activity. Healthy soils act as carbon sinks, mitigating climate change by sequestering carbon dioxide.

Biodiversity Conservation: The emphasis on crop diversity and natural pest control in organic farming contributes to the conservation of biodiversity. Fields teem with a variety of plants and insects, creating ecosystems that support a range of flora and fauna.

Reducing Environmental Impact: The absence of synthetic pesticides and fertilizers in organic farming reduces water pollution, minimizes soil erosion, and protects aquatic ecosystems. Organic farming is a proactive step towards sustainable water management and ecosystem preservation.

Benefits for Human Health: A Harvest of Well-Being

Reduced Exposure to Pesticides: Consumers of organic products enjoy a significant reduction in exposure to harmful pesticides commonly found in conventionally grown produce. Studies suggest a correlation between pesticide exposure and health issues, making organic choices a prudent decision for health-conscious individuals.

Nutrient-Rich Produce: Organic fruits and vegetables often contain higher levels of essential nutrients, including vitamins and antioxidants. The nutrient-rich soil nurtures crops, offering consumers a bounty of health benefits with each bite.

Antibiotic Resistance Mitigation: Organic livestock farming, which prohibits the routine use of antibiotics, helps mitigate the growing concern of antibiotic resistance. By choosing organic meat and

dairy products, consumers actively support the fight against this global health threat.

Rising Demand: The Organic Revolution

Consumer Awareness and Conscious Choices: As awareness grows about the environmental and health benefits of organic farming, consumers are making more conscious choices. The desire for pesticide-free, nutrient-dense food is driving the demand for organic produce.

Ethical Considerations: Consumers increasingly factor in ethical considerations when making food choices. The humane treatment of animals in organic farming resonates with those seeking ethically produced meat and dairy.

Sustainable Lifestyles: The surge in interest in sustainable living has spurred the demand for organic products. People are aligning their values with their consumption patterns, choosing food that reflects a commitment to the well-being of the planet and future generations.

Government Programs and Policies:

The Indian government has launched a number of programs and policies to encourage the adoption of organic farming since it understands its significance. Programs like the National Programme for Organic Production (NPOP) and Paramparagat Krishi Vikas Yojana (PKVY) are designed to encourage and assist farmers who are switching to organic farming methods. These programs help to foster the conditions necessary for organic farming to become widely accepted throughout the nation. Important government programs and directives that highlight the dedication to promoting organic farming in India include:

1. NPOP (National Organic Production Program)

Introduction: The Ministry of Commerce and Industry established NPOP in 2000 to control national organic agricultural standards.

Goals: To guarantee the authenticity of organic goods, open up new markets, and encourage the use of organic agricultural methods.

Certification: In order to guarantee that organic goods meet both national and international organic requirements, NPOP offers a certification system.

2.PKVY (Paramparagat Krishi Vikas Yojana)

Goal: Promoting organic and conventional agricultural methods is the aim of PKVY, which was established under the Soil Health Management (SHM) program.

Use: By giving farmers financial support for supplies, seeds, and training, the program promotes the use of organic agricultural practices.

Organic farming in clusters is encouraged by PKVY, which also creates organic hubs and community-driven techniques.

3. MOVCD-NER (Mission Organic Value Chain Development for the North Eastern Region)

Focus Area: By utilizing the biodiversity and long-standing organic traditions of the northeastern states, this goal aims to promote organic growth in that area.

Components: In order to support comprehensive organic development, MOVCD-NER consists of components including market linkage, certification, capacity building, and organic value chain development.

4.PMKSY (Pradhan Mantri Krishi Sinchayee Yojana)

Water Management: PMKSY has elements for improving agricultural water usage efficiency, which is advantageous for organic operations, even if it is not only focused on organic farming.

Micro-Irrigation: The program promotes the use of micro-irrigation methods, which are compatible with organic agricultural practices.

5.NMSA (National Mission on Sustainable Agriculture)

Sustainability Focus: Organic farming is seen as a crucial component of the sustainable agriculture practices that are included in the NMSA.

Soil Health Management: To improve soil health, lessen reliance on chemicals, and increase overall farm sustainability, the objective is to encourage organic inputs.

6.RKVY (Rashtriya Krishi Vikas Yojana) Organic Farming:

Inclusion: To encourage farmers to embrace organic techniques, some states incorporate organic farming components within their Rashtriya Krishi Vikas Yojana initiatives.

Financial Assistance: Under RKVY, farmers are provided with financial support for organic inputs, training, and certification.

7.Programs for Export Promotion:

Organic Export: The export of organic food is encouraged by a number of export promotion programs, including those run by the Agriculture and Processed Food Products Export Development Authority (APEDA).

Market Access: The goal of these programs is to increase Indian organic products' access to the international market.

Challenges and Future Prospects: Cultivating Change

Challenges in Scaling Up: While the demand for organic products is escalating, challenges such as limited land availability, higher production costs, and a shortage of skilled organic farmers pose hurdles to the rapid expansion of organic agriculture.

Government Support and Policy Changes: Government support through subsidies and policy changes that promote organic farming can play a pivotal role in overcoming challenges. The development of infrastructure and educational programs can encourage more farmers to transition to organic methods.

Global Collaboration: International collaboration is essential to address challenges on a global scale. Sharing best practices, research findings, and technological innovations can foster the growth of organic farming worldwide.

Conclusion: A Harvest of Hope

Organic farming is more than a method of cultivation; it is a philosophy that embraces the interconnectedness of the environment, human health, and sustainable living. As the world grapples with the consequences of unsustainable agricultural practices, organic farming stands as a beacon of hope-a promise to nurture the Earth and its inhabitants. The increasing demand for organic products signals a collective realization that the choices we make at the dinner table reverberate far beyond our plates. In cultivating health and sustainability, organic farming offers a harvest of hope for a better, more harmonious future

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New Generation Insecticides: A potential tool for the management of insect pest

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The development of effective, human friendly and environmentally safe pesticides has been a biggest challenge to feed the expanding population of our planet. In the history of insecticide development, trends have changed from organophosphates, carbamates, and synthetic pyrethroids to nicotinic and diamide insecticide. The extensive use of conventional insecticides (oraganochlorines, organophosphates, carbamates and synthetic pyrethroids) has resulted in the development of severe pest resistance to insecticides, pest resurgence, secondary pests out-break, unacceptable pesticide residues, inimical hazard to the users and detrimental effect on environment and non-target organisms. This has led to the search for novel compounds or newer bio-rationals or "low risk" insecticides viz., neonicotinoids, oxadiazines, diamides, tetramic/ tetronic acid derivatives, phenylpyrazoles, pyridine, avermectins, spinosyns, pyrroles, etc. which has now-a-days, because of their unquestionable insect pests controlling properties at minimal doses, high level of selectivity, greater specificity to target pests along with low toxicity to non-target organisms and the environment, supersede many old/conventional compounds.

As per the recent report, a total of 299 pesticides are registered by the CIBRC in India and 46 pesticides are banned. Furthermore, use of another 27 pesticides is in dilemma which includes insecticides like Chlorpyriphos, Carbofuran, Deltamethrin, Monocrotophos, Quinalphos and many more which is under review to be ban in India.

Different group of novel insecticides

Classification of novel insecticides includes the following groups -

1. Insecticides with synthetic origin (Neo-Nicotinoids, Oxadiazines, Phenylpyrazoles, Pyridine Azomethines, Diamides, Pyridine Carboxamid, Formamidines, Nereistoxin, METI etc.)

2. Insecticides derived from soil microorganisms/macrocyclic lactones (Avermectins, Spinosyns and Pyrrole insecticides)

3. Insect growth regulators (Benzylphenylureas, Thiadiazenes and Juvenile hormone mimics)

4. Miscellaneous (Sulfoximines, Butenolides and Mesoionic).

Neonicotinoides

Neonicotinoid	Year	Trade name	Agricultural Uses(Management of specific pests)
Imidacloprid	1991	Admire®, Gaucho®, Merit®, Provado ®	Brown plant hopper, White backed plant hopper and Green leaf hopper in paddy and jassids, aphids and thrips management in okra
Acetamiprid	1995	Assail®, Intruder ®	Jassids and whitefly in cotton and for control of aphids in cotton and cabbage
Thiamethoxam	1998	Cruiser®, Actara®	Hoppers in mango, Whitefly and jassids in cotton and Aphids and thrips in tomato and cotton
Clothianidin	2001	Poncho®	Brown plant hopper in rice and sucking pest complex of cotton
Dinotefuron	2002	Safari®, Venom®	Rice Brown plant hopper and whitefly, jassids, aphids & thrips in cotton

Neonicotinoids are neuro-active insecticides which are synthetic analogues of nicotine. This group has broad insecticidal spectrum, exhibiting systemic and translaminar properties, and high residual activity with unique mode of action. First commercialized neonicotinoid was Imidacloprid in 1991. Insecticide act as Nicotinic acetylcholine receptor (nAChR) competitive modulators as they mimic the

action of neurotransmitter acetylcholine and bind at a specific receptor site on the postsynaptic membrane leading to nerve overstimulation which ultimately leads to paralysis and death of insect within few hours. The major demerit of application of neonicotinoide is toxicity to bees possibly leading to Colony Collapse Disorder.

Oxadiazine

Oxadiazines are a family of voltage dependent sodium channel blockers that act by occluding the sodium channel pore, blocking nerve action potentials and paralyzing insects. Paralysis by sodium channel blockers has been called relaxed paralysis, to distinguish it from the tetanic paralysis caused by many other insecticides. Most promising example of oxadiazine group is Indoxacarb developed by DuPont in 2000 (Avaunt®) which has good field activity against number of lepidoptera pests, specially *Helicoverpa armigera* and DBM, *Plutellla xylostella.*

Phenylpyrazoles

This group of insecticides discovered in 1987 includes GABA-gated chloride channel antagonists that perform by obstructing the chloride channel pore leads to overstimulation and convulsions. They exhibit both herbicidal and insecticidal activities with contact, stomach and systemic action and highly effective against lepidopterous larvae, onion maggots, termites and coleopteran larvae in soil. The major examples under this group are Fipronil (against Diamond Back Moth) and Ethiprole (against Sugarcane Borers).

Pyridine Azomethines

They are the selective homopteran feeding blockers effective against aphids, cicadas, whiteflies and leafhoppers. It includes insecticides like Pymetrozine (Chess®, Plenum®, Fulfill®) developed in 1999 by Novartis (now Syngenta).

Diamides

These insecticides activate ryanodine receptors, which are calcium-activated channels in the sarcoplasmic reticulum of muscle cells. The diamides bind to the ryanodine receptors and cause the calcium channels to remain partially open and causing sustained muscle contractions leading to rapid feeding cessation, regurgitation, lethargy and tetany (sustained contraction of muscles).

Pyridine Carboxamid

The classical member of this class of insecticide is Flonicamid which is systemic as well as translaminar in nature and provides long term control against aphid, thrips, whitefly, planthopper, plant bugs by its antifeedant effect due to action of the compounds on chordotonal organs, proprioceptive sensory organs. It is commercially available as Ulala®.

Formamidine

These group of insecticides (Amitraz) were introduced in 1975 and are primarily responsible to manage ticks, lice and mites on domestic animals and also to control psyllids, whiteflies and mites on certain crops by acting specifically on the octopamine receptor agonists which triggers many excitatory effects related to fight-or-flight which results in tremors and convulsions, as well as suppression of feeding.

Tetronic Acid Derivatives

Tetronic acid derivative insecticides are inhibitors of Acetyl CoA Carboxylase, the principal enzyme involved in the catalysis of fatty acid biosynthesis and exposure to these insecticides inhibits lipid biosynthesis, halting the development of immature insects, including whitefly pupae, which are not controlled by many other insecticides. Adults are not acutely affected, but it alters the fecundity. Some basic members of the group include-

a) Spirodiclofen- the first product in this group, was introduced in 2003 as a selective acaricide on citrus, grapevines and pome fruits. Trade name - Envidor® 24% SC.

b) Spiromesifen- introduced in 2005, controls whiteflies in addition to mites. Trade name - Oberon® 22.9% SC.

c) Spirotetramat- introduced in 2008, is systemic and controls aphids, scales, mealybugs, psylla, phylloxera and thrips, as well as mites and whiteflies. Trade name- Movento® 15.31% OD.

Thiourea Derivatives

Diafenthiuron is the representative molecule of this group that is known for inhibiting mitochondrial

ATP synthesis i.e. oxidative phosphorylation and are effective for the management of white flies, aphids, thrips and jassids in cotton, diamond back moth in cabbage and red spider mites of citrus and chilli.

Nereistoxin Analogues

These compounds are known as thiocarbamate insecticides or analogs of nereistoxin, a natural toxin of the marine worm Lumbriconereis heteropoda. This class includes Thiocyclam, Cartap, Bensultap, and Monosultap. Cartap hydrochloride is used for controlling Colorado potato beetles, diamondback moths, rice stem borers, and thrips on rice and vegetables as nicotinic acetylcholine receptor channel blockers.

METI Insecticides

As the name suggests they act by mitochondrial complex I electron transport inhibitors. This group contains insecticides like fenazaquin, fenpyroximate, pyridaben and tolfenpyrad used to control leafhoppers, mites and whiteflies in fruit crops, vegetables, ornamentals, nuts and cotton.

Insecticides derived from soil microorganisms / macrocyclic lactones

Avermectin

Avermectin is broad spectrums chemical that are obtained through fermentation of microorganism *Streptomyces avermitilis* isolated from soil that have contact as well as stomach poison to mites and insects. They kill the target organism by increasing flow of chloride ions into cells by binding to GABA-gated chloride channels receptor of insect nervous system.

Table 2: Agricultural uses of avermectins as recommended by CIBRC Report 2021

Crop Common	Name of the pest
Abamectin 01.90% EC	
Rose (Ornamental)	Red spider mites (*Tetranychus urticae*)
Grapes	Mites
Emamectin benzoate 05.00% SG	
Cotton Boll worms	Cabbage Diamond back moth
Red gram (Arhar/Tur)	Pod borer
Emamectin benzoate 01.90% EC	
Cotton	Boll worms
Chilli	Fruit borer, Thrips
Paddy	Leaf folder & hispa

Spinosyns: These bioinsecticides derived from macrocyclic lactones produced by soil actinomycete, *Saccharopolyspora spinosa* through fermentation. These classes of insecticides are effective for controlling lepidopteran, thysanopteran and dipteran pest that act as nicotinic acetylcholine receptor (nAChR) allosteric modulators, leading to nervous system hyperexcitation and contractive paralysis.

nsect growth regulators: Insect growth regulators (IGRs) are the compounds that alter the normal growth of insects by interfering with insect metamorphosis, embryogenesis or reproduction. IGRs are mainly classified into chitin synthesis inhibitors and Juvenile hormone analogues.

Methoprene was the first juvenile hormone analogue in 1970 marketed in the US. Other examples include Hydroprene, Kinoprene, Fenoxycarb and Pyriproxifen etc. They are used as household insecticides. Chitin synthesis inhibitors are another important IGRs. It comprises benzoyl phenyl urea (diflubenzuron, triflumuron, teflubenzuron, hexaflumuron and novaluron), triazine/ pyrimidine derivatives (Cyromazine, Dicyclanil), and buprofezin. They effect the production of new exoskeletons at the time of moulting. These substances are mainly interference with the pupation and induce the vitellogenesis at the time of the reproductive stage of the insect.

Miscellaneous: They all act as nicotinic acetylcholine receptor (nAChR) competitive modulators.

Sulfoximines

It includes insecticides with broad spectrum activity against key sap feeding pests and control of many imidacloprid-resistant insects.

Butenolides

Butenolides are the class of systemic insecticide lactones with a four-carbon heterocyclic ring structure intended for controlling sucking pest such as aphids, hoppers and whiteflies. It includes Flupyradifurone.

Mesoionics

This group includes synthetic compounds like Triflumezopyrim which is effective against BPH in rice.

Conclusion

These new generation insecticides are need of the hour and the development strategy for creating new pesticides, which includes the basic three agendas i.e. development of pesticides that are effective at an extremely low dosage, development of pesticides that are readily degradable and less residual in the environment and development of selective toxic agrochemicals. New generation insecticides often have diverse modes of action, targeting specific biochemical pathways in insects. This helps in reducing the development of resistance among pest populations. While new generation insecticides offer promising solutions, it's crucial to consider their potential impact on human health, non-target organisms, and the environment. Sustainable pest management practices that integrate various approaches, including biological control, cultural practices, and judicious use of chemicals, are essential for long-term success.

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Carbon Sequestration Potential of Different Agroforestry Systems in India

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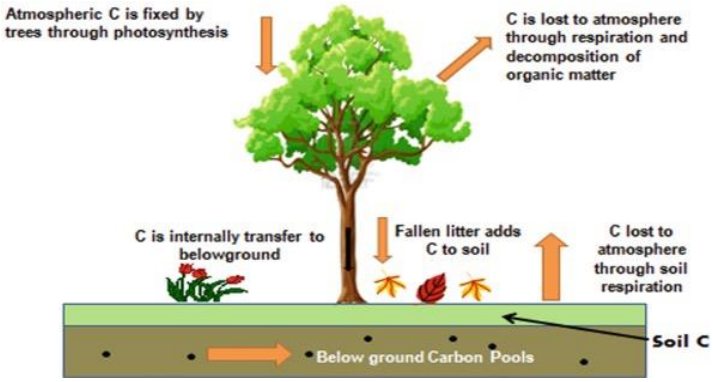
The greenhouse gases cause global warming, in which carbon dioxide (CO_2) alone account for 60% share. Plant act as a sink for carbon dioxide (CO_2) by absorbing it through photosynthesis process and naturally storing it as biomass. Continuous growth of plant also increased the carbon stock and different plant species have different capacity of carbon sequestration. The deforestation contributes about 5.9 Gt carbon dioxide (CO_2) in the world. Since the late nineteenth century, global surface temperatures have risen by 0.8 ^{0}C, and 11 of the 12 warmest years on record have happened since 1995. In India, the temperature has risen by 0.4 to 0.6 ^{0}C over the past 100 years. By increasing carbon storage in soil and trees, carbon sequestration operations can contribute to the prevention of global climate change. Activities related to plantations and reforestation are crucial in the fight against global warming. Compared to short rotation species, long rotation species have a longer carbon locking period.

Carbon sequestration

The Concept of Carbon Sequestration emerged in 1980s due to consequences of steadily increasing level of Carbon dioxide in the atmosphere. Carbon sequestration is one of the major tool for reducing anthropogenic carbon emission. Carbon sequestration is the process through which agriculture and forestry practices remove carbon dioxide (CO_2) from the atmosphere.

Definitions

Carbon sequestration is the process of capture and long term storage of atmospheric carbon dioxide (CO_2) to mitigate global warming and to avoid dangerous impact of climate change. Carbon sequestration is the process of extraction of the atmospheric carbon dioxide (CO_2) and storing in a terrestrial or aquatic body for a long period of time.



Type of carbon sequestration

Carbon sequestration in an ecosystem are mainly through three forms:

i. Terrestrial Carbon sequestration.
ii. Geological Carbon sequestration.
iii. Ocean Carbon sequestration.

Table 1: Different Carbon Pool in Forest:

	Pools	Description
Living biomass	**Above Ground biomass (ABG)**	All living biomass above the soil including stem, stump, bark, branches, seeds and foliage.
	Bellow Ground biomass (BGB)	Roots of all plants and living organisms
Dead organic matter	**Dead wood**	Including all non-living woody biomass such as, dead woods, dead roots and stumps larger than or equal to 10 cm in diameter are also includes.
	Litter	Includes all non-living biomass with a diameter less than a minimum diameter chosen by the country (for FSI 5 cm).
Soil	**Soil Organic Matter (SOM)**	Includes organic carbon in mineral and organic soil (including peat) for specific depth chosen by country (for FSI 30cm).

Carbon Pool

Carbon pool are major components of an ecosystem that can either accumulate or release carbon, i.e. a reservoir where sequestered carbon is stored.

Forest and Carbon sequestration

Forest vegetation and soils constitute a major terrestrial carbon pool with the potential to absorb and store carbon dioxide (CO_2) from the atmosphere. The world's forests store more than 650 billion tonnes of carbon, 44% in the biomass, 11% in dead wood & litter and 45% in the soil. Deforestation and forest degradation are still very much challenging the living beings on earth due to the increased production of greenhouse gases.

Forestry practices to increase carbon sequestration

i. Reforestation.
ii. Afforestation.
iii. Preservation of forest land.
iv. Adoption of agroforestry practices.
v. Establishment woody biomass plantations.

Agroforestry- an old practice, but a new science:

A multifunctional land use system. A specialized way of farming crops and trees in various combinations on the landscape. It enhances livelihoods and contribute to resolving climate change effects.

Agroforestry can be practiced at-

i. On farm
ii. Road side
iii. Canal embankments
iv. On degraded land
v. Homeland
vi. Sliding terraces
vii. Common property

Advantage of agroforestry

i. Carbon sequestration
ii. Reduce pressure on natural forest
iii. Soil conservation
iv. Reclamation of degraded land
v. Employment opportunity
vi. Aesthetic value

Agroforestry as an option for carbon stock

A significant portion of the resources found in forests are the tree plantations that have been built both inside and outside the forest region. The sequestration of carbon may be facilitated by improved land management. A young plantation can operate as a reservoir, whereas a mature plantation can sequester substantially higher amounts of carbon. Additionally, production from plantation forests might reduce pressure on timber extraction from natural forests, aiding in the preservation of forests.

Agroforestry for carbon sequestration:

i. Potential to limit carbon emissions and sequester carbon
ii. Microclimate amelioration
iii. Protection and stabilization of ecosystem
iv. Soil and water conservation
v. Sustainable diversification of agricultural systems
vi. Improvement in rain water efficiency
vii. Interventions for drought mitigation

Role of agroforestry in Carbon sequestration

Agroforestry system recognized as a carbon sequestration strategy because of its applicability in agricultural lands as well as in reforestation programs. Agroforestry offers the highest potential for carbon sequestration

Direct role: Carbon sequestration rates ranging from 1.5 to 3.5 Mg C per ha per yr in agroforestry systems

Indirect role: Agroforestry has also some indirect effects on C sequestration since it helps to reduce pressure on natural forests

Potential area of agroforestry in India

India has a 328.2 million hectare (ha) total geographical area, of which 141 million hectares (ha) are agricultural. Agroforestry techniques have the ability to store a significant quantity of carbon. According to India's land capability categorization, 96.40 mha of its land is considered to be degraded. By the year 2030, this combination of forestry alternatives and land capacity might increase the sequestration

potential by an extra 78 million tons of carbon annually.

Factor determining carbon sequestration in agroforestry

i. Site quality.
ii. Protection against fire, disease and pest infestation.
iii. Silvicultural Management practices.
iv. Species adaptability.
v. Rate of growth.
vi. Spacing.

Conclusion

One of the key strategies for reducing anthropogenic carbon emissions is carbon sequestration. One significant terrestrial carbon sink is the carbon reserves in the currently existent forests and crops. Agroforestry techniques have the potential to store large amounts of carbon while simultaneously supplying fruit, fiber, and organic fertilizers as well as fuel and fodder. Carbon Sequestration Potential of agroforestry at districts and state levels helps to support India's position in climate change scenario. By the year 2030, the use of agroforestry on land might increase the sequestration capacity by an additional 78 million tons of carbon annually. The most significant function of agroforestry is its ability to sequester carbon. Agroforestry systems are thought to yearly offset 109.34 million tons of CO_2 on a nationwide level.

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Production Technology for Successful Cultivation of Cherry Tomato and Capsicum in Eastern Region

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Vegetable is an edible plant parts usually roots, stems, leaves, fruits, or seeds that can be eaten raw or in cooked form. It is a rich source of essential vitamins, minerals, and antioxidants that provide many important health benefits to our body and is termed as protective food. Cherry tomato and capsicum are vegetable crops having high commercial value. It is more nutritious has much more demand in a national and international market and grown well in marginal land also. As farmers are not much aware of these crops, it needs to popularise its cultivation practices among farmers of an eastern region to get maximum benefit from them. It is a boon for the rural economy.

Cherry Tomato

Cherry tomato is a rich source of vitamins, minerals, and antioxidants (like carotenoids, ascorbic acid, vitamin E, and phenols). There are three different types of carotenoids present in fruits lycopene, β-carotene and lutein. Lycopene imparts a red color in fruit and all these carotenoids reduce the risk of heart disease and cancer. Among this lutein has the best anti-inflammatory properties that protect the eye and improve brain health of human beings.

The Cherry tomato (*Solanum lycopersicum* var. *cerasiforme*) is a highly valued culinary as well as ornamental vegetable crop. It is a small, round, or oval-shaped fruit, not a vegetable crop. It makes kitchen gardens not only more attractive but, also have high commercial demand and rich in nutritional and pharmaceutical properties. The popular var. of cherry tomatoes is Sweet Million, which bears fruits in clusters. Fruits are sweet and tomato red in colour. The variety Sun Sugar produces golden fruit having high flavour and is sweeter than the earlier one and the heirloom is called blackberry, which has a complex, rich, and sweet flavor. For backyard gardens, the most popular variety is Sungold as it is resistant to heat, drought, and many diseases. The fruits are orange colour having a sweet and crispy taste. All these varieties are indeterminate means grow continuously up to the death of plants.

Climate and Soil

The Cherry tomato is a warm season crop. It requires an optimum temperature of 20-30 °C with low humidity and plenty of sunshine for its proper growth and colour development in fruit.

Soil should be rich in organic matter, sandy loam to loam with a pH value of 6.5 – 7.5. The soil should be well aerated and having drainage facility. Under protected conditions, nursery production can be advanced by 15-20 days. Under greenhouse, fruits can be picked till November-December compared to normal cultivation where it lasts till July-August.

Nursery Raising

Seeds of cherry tomatoes are minute and delicate, so their nursery should be raised very carefully. It gave the better response in portraying production using coco peat as a growing medium. Portray ensure proper care and least damage to root zone due to retention of soil ball during transplanting. There should be drainage facility and protected from over watering. Seeds could be treated with Captan or Thiram @ 1-2 g/kg before sowing to protect the seedlings from wilting and damping off disease. Small polythene tunnels or poly houses can be used to protect plants from cold/frost.

Seed rate is 300-400 g/ha for normal variety and 100-150 g/ha for hybrid variety. Weed and insect-disease management of the nursery should be done on regular basis to get good harvest.

Fertilizer Requirements

Basal fertilizer doses of 10 tons FYM, 60 kg DAP, 45 kg MOP, 50 kg secondary nutrient mixture, and 10 kg micronutrient per acre may be required. Half doses of the DAP and MOP may be applied as basal dose and the remaining half at 15-20 days intervals throughout the life cycle. Biofertilizers (*Azospirillum* and *Phosphobacteria*) can also be applied

along with FYM to enhance and prolong the nutrient use efficiency for a longer duration.

Harvesting

The fruit should be harvested early in the morning, singly or in bunches along with calyx. It can be harvested at different developmental stage depending on the market distance. The fruit harvested pink or light red stage for local market and colour break or turning stage for distant market. Fully ripe or ripe fruits has been harvested for processing and local market. The average fruit yield under protected condition ranged from 20-50 tons/ha depending on varieties.

Disease and Insect Pest Management

The disease that affects the plant are bacterial (Canker, Wilt), fungal (Early & Late Blight), and viral (Mosaic and Leaf curl).

Symptoms of fungal infection are yellowing of leaves, moldy blotches and dark spots. The infected plants can be controlled with the use of suitable fungicides like brand name of daconil and garden safe etc.

Cherry tomato can be affected by many pests like thrips, aphid and white fly. The common pest is stink bug and potato beetles. White flies affect leaf and fruit of the plant and is a vector for tomato yellow leaf curl virus. They lay eggs on the underneath of leaf. It causes irregular ripening of fruits. It can be controlled by orchard sanitation, crop rotation with non-host along with use of insecticides like azadirachtin and horticultural oil etc.

Capsicum

Capsicum (*Capsicum annum*) is also known as bell pepper or sweet pepper or Shimla Mirch, belongs to the family Solanaceae. It is a high value spice crop grown under green house and shade net. It is native of America and cultivated all over the world. Plants are busy, semi-perennial, 60-80 cm in height and grown as annual at commercial level and fruit does not contains capsaicin. Capsicum is an admirable source of micronutrient and antioxidant that helps in preventing chronic and age-related diseases.

On the basis of color, there are different types of capsicum viz., Red, Yellow, Green, Orange, and purple/black. The phytonutrient contents are more in red capsicum than all the other types of capsicum. Red varieties have more antioxidant i.e., 11 times more β-carotene and 1.5 times more vitamin C content than the green varieties. Whereas, green varieties have less sugar content than red, yellow, and orange type. It has very low fat and having very high amount of fibre along with water content which is beneficial for proper body functioning. It is very rich source of vitamin C content that full-fill 213% of daily recommended allowance. It also helps in improving the immune system, wound healing, and synthesize the collagen. Capsicum also contain high amount of Vitamin B6 which helps in metabolism of protein, fats and carbohydrates. The folate content of capsicum helps in white and red blood cells production in the bone marrow.

Climate and Soil

Capsicum can be cultivated in soil which is well drained and rich in organic matter. The sandy loam soil with pH value of 5.5 to 6.8 is most ideal and does not prefer salty or saline soils. The site for protected cultivation should be easy to reach, sunny with proper drainage facility.

It is mainly temperate vegetable and prefers comparatively low temperature (20-25 ◦C) for fruit set and its development. Red or yellow colour develops under low temperature. It grows well in summer season in hills and cooler places in plains. Seed germination shows good response at temperature range of 20-25◦ C.

Nursery Raising

Seeds are sown in raised bed under protected condition in prepared nursery bed at a depth of 2.5 cm. Seeds are sown in line at spacing of 2.5 cm and covered with top soil and rice straw. Water should be applied daily with watering cane. The prepared nursery bed should be drenched with *Trichoderma* + *pseudomonas* @ 2% before sowing to protect plant from damping off and the seedling should be dipped in these solution before planting to prevent wilt problem. Seed rate of capsicum is 250-300 g/ha and are sown during September – February month.

Planting should be during evening to avoid desiccation and gap filling after 7 days of planting for

good harvest and returns. Hoeing and weeding has to be done once after 30 days.

Fertilizer Requirement

Capsicum requires FYM @ 5.0 kg/m2 along with neem cake @ 200g/m2. Seedling should be treated with *Azospirillum* + PSB culture (20%) for 15 minutes before planting in addition 1kg/m2 vermicompost after one month of planting should be applied. Nutrient deficiency causes poor fruit growth and size.

The light earthing up should be done after 30 and 45 days of planting. Irrigation water should be applied at weekly interval. To prevent plant from lodging, staking must be there.

Harvesting

The fully mature green fruits of capsicum should be harvested before its ripening. It can be harvested at an interval of 3-4 days. The average number of fruits is 20-30/plant and fruit weight is 40-50g. Under open condition the optimum yield varies from 20-30 ton/ha and under protected condition it may vary from 90-110 ton/ha. After harvest, fruit should be kept in cool place and without direct exposure of sunlight. Harvested fruit should be handled carefully with less friction.

Disease and Pest

Major pests of capsicum are thrips, mites and aphids. Thrips infestation may be recognized as upward curling of leaves due to continuous sucking of leaf sap and reduces its growth and yield. On the other hand, mites feed on leaves, buds, fruits and causes downward curling of leaves. It can be controlled by removing infected plant parts and keeping field free from debris along with insecticidal spray like imidacloprid 17.8% SL @ 0.5ml/L, neem seed kernel extract (4%), pongamia oil (5-8 ml/L) etc.

Different diseases affect the plants are damping off, anthracnose, powdery mildew and bacterial blight.

Damping off- It is a fungal disease that affect young seedling causes patches and shriveling and lastly death of plant. Whole plants are affected within 4-5 days. It can be managed by the spray of Bordeaux mixture @ 0.5-1.0% or copper oxychloride-based fungicide (Blitox or Phytolon).

Anthracnose: - It is also a fungal disease that affect stem, leaf and fruit of the plant. Affected fruit shows dark and round spot and black minute spot on seeds. Affected fruit drop prematurely and it occurs mostly in high humid condition. To prevent this, seed treatment with thiram 75% @ 20g/kg.

Powdery mildew: - Mostly occurs in summer season that causes powder like appearance on leaf, stunted growth and leaf shedding. It can be controlled by the application of Sulphur based fungicide @ 0.2% at 15 days intervals.

Bacterial wilt: - It causes wilting of leaf and fruit. It can be controlled by the application of bleaching powder and growing of resistant varieties like Arka Gaurav.

Conclusion

The Cherry tomato and capsicum is a vegetable crops having high commercial as well as nutritional value. It can be grown successfully in backyard and at large scale that give high economic return. Cherry tomato used as a fresh table purpose as well as in processed form. Capsicum is used for weight loss and as a healthy light snack.

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Need of Paper Mill Effluent in Recent Agriculture

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Water is a valuable and indispensable natural resource and is an essential base for all life on earth. The paper industry is one of the top water consumers and top producers of wastewater in the world. The release of these effluents into water bodies changes the natural quality of water and other hazardous substances. However, treated wastewater includes a sizable amount of nutrients that may be helpful for plant growth. Furthermore, it has been viewed as a potential water resource and contains a rich source of plant nutrients. Hence, this effluent can be used as alternate sources for irrigation water and conventional inorganic fertilizers.

The paper industry is one of the top water consumers and top producers of wastewater in the world. In India, approximately 700 paper mills (Kumar *et al*., 2017) are functioning and generate 8.5 million tonnes of paper/year. Typically, one tonne of paper requires 273-450 m^3 of water, which consequently, generates 300 m^3 of waste water

(Hazarika *et al*., 2007). The release of these effluents into water bodies changes the natural quality of water by increasing the pH, BOD, COD, lignin, total suspended particles, colour, heavy metal ions and other hazardous substances. However, treated wastewater includes a sizable amount of nutrients that may be helpful for plant growth. Moreover, treated paper mill effluent is a rich source of plant nutrients and used as an alternate source for irrigation water and conventional inorganic fertilizers. It has properties similar to fertilizer, improves nutrients uptake and promotes the growth and yield of crops. Hence, the use of wastewater in agriculture is gaining importance rapidly.

Properties of the paper mill effluent

Wastewater originating from the paper industry, specifically from pulping, bleaching and washing operations, is frequently identified by a set of distinctive features. The treated effluent discharged from paper mills typically exhibits reduced contamination levels and, in most cases, it complies with the standards set forth by the World Health Organization (WHO). The raw pulp and paper mill effluent typically exhibited a dark brown tint. The paper mill effluent has potential to improve agriculture due to the presence of various chemical properties (Fig.1).

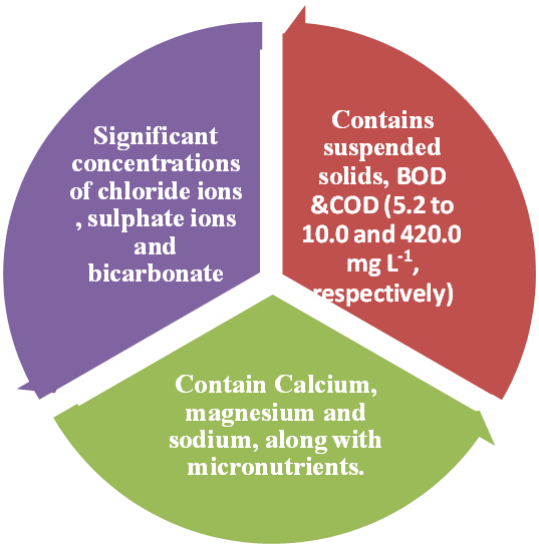


Figure 1. Compounds present in the treated paper mill effluent

Role of paper mill effluent in soil fertility status

The application of paperboard effluent on soil had several positive effects. Treated wastewater is now recognized as a potential water resource in agriculture. It contains a substantial amount of nutrients that are beneficial for plant growth. The application of treated paper mill effluent has a capacity to improving the permeability, infiltration and total porosity on soil. The levels of exchangeable basic cations, including calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K) improve soils nutrient sources (Gomathy *et al*., 2021). Continuous irrigation with effluent from the paper industry can lead to higher levels of organic matter in the soil. Soil nutrient enrichment and enzyme activity by paper mill effluent irrigation also have ability to increase the abundance of bacteria, fungi and actinomycetes.

Paper mill effluent as a water and nutrient for crops

The paper mill effluent has various impacts on the growth and yield of different crops. As

industrialization has increased at a stimulating rate the effective usage of industrial waste in agriculture supports as a new source and alternative for irrigation water and fertilizers. paper mill effluent had a positive impact on crop growth which leads to an increase in biomass and yield (Rashid *et al*. (2021). The further application of treated paperboard mills effluent irrigation in combination with the application of solid waste viz., bio-manure, vermicompost, farmyard manure and fly ash could increase the growth, yield and quality of crops.

The use of treated paper mill effluent at diluted concentrations and particularly when combined with organic manures, can be a sustainable approach for crop production without any adverse effects on either soil or yield or quality. Moreover, the paper mill effluent helps in improve soil nutrients.

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The Healthy Diets: Human Health and Current Scenario

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Why we need to eat well!!

It protects you against many chronic non communicable diseases, such as heart disease, diabetes and cancer. Eating a variety of foods and consuming less salt, sugars and saturated and industrially-produced trans-fats, are essential for healthy diet. A healthy diet comprises a combination of different foods.

Eating healthy, balanced diets provide

- plenty of energy to work and enjoy themselves;
- fewer infections and other illnesses and bust-up the immunity.
- Children who eat well usually grow well.
- Women who eat well are likely to produce healthy babies.

That is why it is important to know which combinations of foods make good meals

Stuff We Need

Macronutrients:

that we need in large amounts

- Carbohydrates
- Proteins
- Lipids

Micronutrients:

that we need in small amounts

- Vitamins
- Minerals

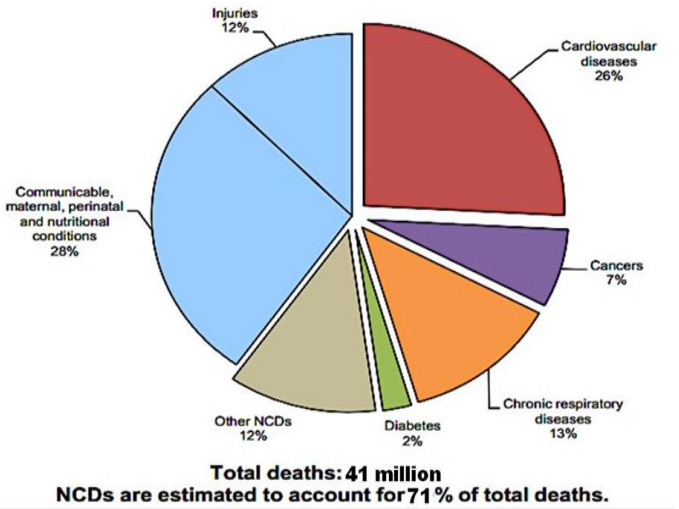
…and, of course, Water Diet & Nutrition

Inadequate Medical Infrastructure: India has a shortage of hospitals, particularly in rural areas, and many existing healthcare facilities lack basic equipment and resources. According to the National Health Profile. According to global healthcare security index 2021 India ranked 66 out of 195 countries with an overall Index score of 42.8 and along with a change of -0.8 from 2019. According to Health and health systems ranking of countries worldwide in 2021, by health index score India was ranked 111 out of 167 countries. Heart disease and stroke still the leading causes of death for both U.S. men and women. NIH-funded scientists currently are looking to the power of precision medicine to better understand and manage these disorders. The most common health issues are physical inactivity and food, obesity, tobacco, substance abuse, AIDS, mental health, falling and injury, environmental quality, immunization, and healthcare access. These all-personal health issues require attention to improve the quality of life and keep you free from diseases. The Indian healthcare system is faced with several challenges, including increased healthcare costs, need for nursing and long-term care for senior citizens due to the rise of the nuclear family system, high financial burden on the poor, increasing burden of new diseases, and negligence of public health. Global Health Security Index (2021).



Human Health: Present scenario

Proportional mortality (% of total death, all age group, & both sex)

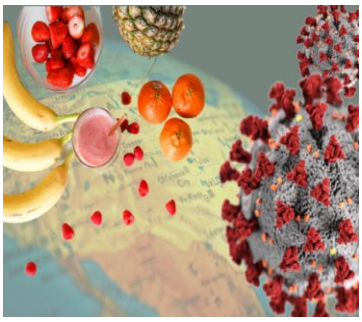


Covid-19 pandemic & Role of Fruits and Veggies

- Eating the right kinds of foods, in the right amount is very crucial for our health. Covid-19 pandemic has changed a lot in the daily lives

of people. During this difficult time, it has essential to maintain healthy life style.

- While no foods or dietary supplements can prevent or cure COVID-19 infection, but healthy diets can keep our immune system strong for fighting the disease.



- Fruits and veggies: we can say they are the best natural supplements for busting our immune system, having no side effects.

Conclusion

Fruits and vegetables contain important vitamins, minerals, dietary fibre and phytochemicals. There are many varieties of fruit and vegetables available and many ways to prepare, cook and serve them. A diet high in fruit and vegetables can help protect you against cancer, diabetes, obesity and heart disease. Eat five kinds of vegetable and two kinds of fruit every day for good health. When buying and serving fruit and vegetables, aim for variety to get the most nutrients and appeal.

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E-NAM: One Nation One Market

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Agriculture is critical to every country's economic growth, predominantly in emerging and developing countries where most of the population relies on farming for a living. With the growth and improvement in technology in recent years, several ground-breaking and innovative solutions to solve the difficulties encountered by farmers in terms of market access, price discovery, and profitability have developed. The Electronic National Agriculture Market (e-NAM), for example, attempts to develop a single online platform for agricultural commerce across India through networking all Agricultural Produce Market Committee (APMC) mandis. This article will investigate the function of e-NAM, its implementation process, and the impact it has had on farmer profitability by investigating the platform's benefits and problems, as well as highlighting some success stories.

Role of e-NAM

The Indian government launched the e-NAM platform in14th April 2016 with the goal of integrating APMCs (Agricultural Produce Market Committees) across the country into a single electronic platform and to promote better marketing opportunities to farmers in selling their produce through online and transparent price discovery and online payment facility. The main purpose of e-NAM is to remove current obstacles to interstate agricultural trade and commerce, cut market inefficiencies, and boost farmers' income by assuring a fair and competitive price for their goods. The e-NAM aspires to empower farmers and build a more equitable, inclusive and efficient agricultural marketing system by giving accurate price information, access to a broader and expandable consumer base, and minimizing intermediaries. On April 2, 2020, new features of e-NAM were also launched which provides contactless remote bidding and mobile based anytime payment which ensures that traders need not to visit mandis or banks. The major crops traded on e-NAM portal are wheat, paddy, cotton, chilli, soyabeans, maize, potato, chana, tomato, groundnut, mustard seeds, guar seeds, onion, turmeric, arhar, bajra, moong, castor seed, lentil, sweet lemon etc.

Implementation Process

E-NAM is completely funded by the central government and is implemented by Small Farmers Agribusiness Consortium (SFAC), under ministry of agriculture and farmer's welfare. The implementation of e-NAM has been done gradually and in phases. Initially, 585 regulated markets were intended for integration with the network, out of a total of 6,900 APMCs in India. The procedure entailed digitizing critical market information such as commodity arrivals, quality and pricing, buy and sell offers and e-payment settlement directly into farmer's account. APMCs were expected to set up an e-NAM mandi portal, create a library of quality criteria, and offer physical infrastructure like as grading, weighing, and auction facilities. It promotes uniformity in marketing by streamlining the procedures across integrated markets, removing asymmetry in information between buyers and sellers. It also promotes real time price discovery based on the data of demand and supply.

The government gave financial support to states for infrastructure construction, training and capacity building programs, and promotional initiatives to ensure the platform's successful operation. The launch of the NAM App software program, which allows farmers to obtain and access real-time information on mandi pricing and trade statistics, additionally facilitated simplified transaction process.

Objectives of e-NAM

- To integrate markets on single online market platform, first at state level covering all country eventually to enable pan-India trade in agricultural commodities.
- To promote efficient functioning of the markets through streamlining of uniform transaction procedures across all markets.
- To endorse improved marketing prospects for farmers/sellers by making more accessible markets and buyers to farmers, by removing

information asymmetry, real time price discovery based on actual demand and supply, transparency in auction process, price based on quality of produce and ultimately improving marketing efficiency.

- To establish quality evaluating systems for quality assurance to promote informed bidding by buyers and to promote price stabilization and availability of quality produce to consumers.

Impact on Farmers Profitability

The establishment of e-NAM has had a substantial influence on the profitability of farmers throughout the country. The platform has significantly reduced marketing expenses by removing intermediaries and facilitating direct interactions between buyers and sellers. According to a National Council of Applied Economic Research (NCAER) report, e-NAM has helped farmers save up to 15% on transportation expenses while also reducing the number of middlemen engaged in the trade process.

In addition, the platform has also increased price discovery and transparency. Farmers previously had little access to pricing information, making them more vulnerable to exploitation by traders and dealers. E-NAM has solved this issue by supplying farmers with real-time market pricing information, allowing them to make well-informed decisions about when and where to sell their crops. This has resulted in higher price realization for their products, leading to enhanced profitability.

E- NAM helps in expanding market access for farmers. Farmers were previously limited to selling their goods in local mandis, which frequently resulted in overstocking and frequent price swings. Farmers are now able to sell their commodities to buyers in many different states via e-NAM network, which has helped them in reducing market risks through customer diversification. This expanded market reach has raised farmers' profit by encouraging farmers to use better production techniques to fulfill the quality criteria of distant markets.

Furthermore, e-NAM has aided in the integration of technology in the agriculture industry. The emergence of digital trade platforms has prompted farmers to embrace digital payment methods, minimizing their reliance on the cash-based economy. The integration of e-NAM with e-NAMsatta, a pan-India electronic trading platform, has improved the trading experience even more by allowing for easier price discovery and online bidding.

Benefits and Challenges

The e-NAM platform is extremely helpful to all parties. It provides various advantages to farmers, including increased price realization, broader market access, lower marketing expenses, and improved price discovery. It has also empowered farmers by providing them with real-time information, as well as reduced farmers' reliance on intermediaries. It reduces collusion of traders which helps in getting better prices to farmers. It increases market access through warehouse-based sales, which also help in reducing need to transport the produce to mandis. Farmers have 24/7 access to commodity price information on their e-NAM mobile app.

However, significant obstacles to successful e-NAM implementation and execution persists. Foremost obstacle was APMC framework itself as each state has its own APMC act, with different provisions in states which causes lack of uniformity and compatibility in markets and fragmented markets. There is challenge in alignment of nationwide APMC and states and also lack of awareness and adoption of e-NAM among key stakeholders is major obstacle. One significant barrier is opposition from middlemen and commission agents who fear a decline in their responsibilities and revenues as a result of the elimination of intermediaries. This resistance has occasionally resulted in demonstrations and pushback from various stakeholders, delaying the platform's smooth operation. Rural infrastructure and connection concerns are also a challenge. Providing smooth access to e-NAM is a huge problem in India, because a considerable share of the agricultural industry is situated in distant and impoverished regions. Limited internet access, a lack of energy, and a lack of expertise about digital platforms all impede efficient e-NAM adoption in these locations.

Success Stories

Despite these obstacles, some success stories have emerged that demonstrate the positive impact of e-NAM on farmer profitability. Sivam Spices and Foods, a small-scale spice processor in the state of

Andhra Pradesh, is one such example. Prior to the establishment of e-NAM, the firm obtained raw materials through middlemen. Sivam Spices and Foods, on the other hand, was able to directly contact with farmers and get excellent products at competitive costs by using the e-NAM platform. This not only increased their profit margins but also allowed them to retain consistency in their product quality.

Vidyasagar from Telangana by selling through e-NAM has received benefit and stated that it was a never before experience of selling his produce walking away with more profit and hassle-free transaction on the same day of selling. Farmers now have more profit by reduction in intermediation charges.

Outcomes of e-NAM

- Single license for trading across all markets in a state
- Single point of market fee
- e-auction for transparent price discovery
- Uniform and continuous transfer of agricultural commodities
- Reduction in fragmented markets
- Improved supply chain and decreased post-harvest wastage
- Fair prices to farmers

Conclusion

The deployment of e-NAM has resulted in a paradigm change in India's agriculture marketing system. e-NAM will not only beneficial to the farmers for real-time price discovery and reduced intermediation, but also help in ensuring efficient supply chain, transparency and uniformity in quality standards. The platform has empowered farmers, decreased marketing costs, enhanced price discovery, and extended market access by employing technology. Farmers' experiences and success stories highlight how e-NAM has improved their profitability and livelihoods. To ensure the long-term viability of e-NAM, however, it is critical to overcome the implementation issues, such as intermediaries' opposition and infrastructural shortcomings. Adequate infrastructure development, capacity-building initiatives, and strong government backing are required to overcome these obstacles and improve the e-NAM ecosystem. Overall, e-NAM has emerged as an influential tool for reforming the agricultural sector, and its numerous advantages make it a must-have platform for farmers, traders, and other stakeholders. As digital technology advances, the potential for e-NAM to change agricultural commerce and boost farmer profitability grows, making it a crucial driver of rural development and economic growth. Although to ensure success of e-NAM, the government have to run awareness programs among key stakeholders like farmers, mandis, traders, banks for their participation and adoption in e-NAM.

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Genotyping by Sequencing: A Powerful Tool for MAS

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Abstract

The ability to withstand and overcome challenges from living organisms or environmental factors is crucial for the survival and growth of plants. The latest development in genotyping-by-sequencing (GBS) has revolutionized the field of marker-assisted selection (MAS), leading to faster advancements in plant breeding and crop enhancement.

Introduction

Utilizing molecular markers, specifically single nucleotide polymorphisms (SNPs), marker-assisted selection (MAS) is a technique in crop improvement that aids in the identification of favourable traits. The advancement of next-generation sequencing (NGS) technologies has greatly enhanced whole genome sequencing, allowing for the analysis of large amounts of genetic information that has transformed plant genotyping and breeding methods. To overcome the challenges posed by complex crop genomes like maize and wheat, genotyping-by-sequencing (GBS) has emerged as an extension of NGS applications. GBS is a cost-effective and robust MAS tool, widely used in various plant breeding programs for activities such as genome-wide association studies (GWAS), assessment of genomic diversity, genetic linkage analysis, discovery of molecular markers, and large-scale genomic selection. MAS entails utilizing molecular markers to indirectly select desired traits in crops (Zhao et al., 2014).

Need

Plant breeding can be achieved through classical breeding and molecular breeding. Classical breeding involves interbreeding closely related individuals to create new cultivars with desired traits, but it is limited in addressing global food security (Tester and Langridge, 2010). Molecular breeding includes marker-assisted selection (MAS) and genetic transformation to develop new cultivars (Moose and Mumm, 2008). although genetic transformation is hindered by concerns over food safety and environmental impacts (Nicolia et al., 2014). MAS, which uses molecular markers for indirect selection, has been widely used to enhance crop yield, quality, and tolerance to stresses. Genotyping-by-sequencing (GBS) is a powerful MAS tool is using for accelerating plant breeding and crop improvement.

Advances in NGS have made GBS (genotyping-by-sequencing) feasible for high diversity and large genome species (Elshire et al., 2011). GBS developed in Buckler lab, is a simple and cost-effective system for constructing reduced representation libraries for genetic analysis and genotyping (Elshire et al., 2011). It has several advantages like reduced sample handling, fewer PCR and purification steps, low cost, no size fractionation, no reference sequence limits, that make it efficient and easy to scale up (Davey et al., 2011) that makes it important for genomics-assisted breeding in various plant species.

Procedure

The process of genotyping-by-sequencing (GBS) involves several steps, which can be summarized as follows. Firstly, the genomic DNA is quantified using a fluorescence-based method. Next, the genomic DNA is normalized in a fresh plate to ensure that all samples are equally represented and that the molarity of the DNA and adapters is consistent. Then, a master mix containing restriction enzyme(s) and buffer is added to the plate and incubated. After that, the DNA barcoded adapters are introduced, along with ligase and ligation buffers. The samples are then pooled and cleaned. Following this, the GBS library is amplified through polymerase chain reaction (PCR). The amplified library is subsequently cleaned and evaluated using a capillary sizing system. Finally, the libraries are sequenced. In terms of data analysis, the raw data from the sequencing run, stored in FASTQ files, is used to assign sequencing reads to their respective samples by utilizing the DNA barcode sequence. Once the reads are matched to individual samples, they are aligned to a reference genome. In cases where the species lacks a complete reference genomic sequence, the reads are internally aligned, and single nucleotide polymorphisms (SNPs) are identified based on a 1 or 2 bp sequence mismatch.

Errors in sequencing can lead to the presence of single nucleotide polymorphisms (SNPs) (Zhao et al., 2014).

Applications

Genomic selection (GS), a quick and affordable method require to genotype large populations of potential selection candidates. In 2001, Meuwissen et al. introduced genomic selection as a means to incorporate all small effect loci in genomic prediction models. This approach utilizes dense genome-wide molecular markers, fitting effects to all markers simultaneously, and avoids statistical testing. By employing GS models, breeders can forecast the performance of new experimental lines early on and make informed decisions regarding crosses and selections based on these predicted results (Jannink et al., 2010). When combined with quick generational turnover, selection based on predicted breeding values determined by GBS marker data has the potential to significantly enhance gains in plant breeding programs (Meuwissen et al., 2001; Jannink et al., 2010).

Poland et al. (2012b) specifically focused on the complex wheat genome and demonstrated the applicability of GBS markers in developing GS models. Remarkably, these markers exhibited high prediction accuracies for yield and other agronomic traits, making them ideal for breeding purposes.

High-density markers derived from Next-Generation Sequencing (NGS) are becoming essential in genomics. Genotyping-by-sequencing (GBS) is a cost-effective and efficient tool for genetic mapping, breeding, and diversity studies. GBS is particularly useful for researchers working with obscure or foreign species. In plant breeding, GBS has great potential for implementing genomic selection on a large scale. Ongoing advancements in sequencing output will lower costs even further. GBS is also valuable for genomics-assisted breeding in orphan and commercial crops. Despite challenges in data management, genomic selection through GBS holds promise for enhancing traditional crop development. Sequence-based genotyping will continue to be important for diversity and genomic studies in various fields (Allendorf et al., 2010).

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Designer Egg: A Novel Method in Contemporary Healthcare

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An egg is a naturally occurring chemical storehouse that supports life and provides extremely nutritious nourishment, including important human nutrients. Customers are constantly looking for novel items, and they are also pushing the market for a food category that has potential health advantages that go much beyond what has been historically acknowledged. Owing to its superior nutritional profile, low cost, and adaptability in culinary preparation, eggs are a widely consumed food in all global communities. They provide protein as a single item as well. The body needs protein to create and repair bodily tissues. Many customers want relatively different items in terms of flavor, color, freshness, safety, and other factors. Changing the old product is one strategy for marketing the new one. One of the most difficult issues confronting the business is the rapid fall in egg consumption over the past 50 years, but since eggs are a significant source of protein in the COVID-19 age, demand has grown. Designer eggs can help to reduce this issue.

What Happening with Designer Eggs in Our Region? Is there Any Promising Market for these Products in Our Country?

Compared to ordinary eggs, designer eggs are more costly. It implies that not every social class is able to purchase these eggs. In Wayanad (Kerala), a group of farmers near Vaduvanchal display customized eggs. Despite the fact that eggs are thought to be a complete food, providing the majority of the nutrients required by the body, many people are put off by their high cholesterol level. Recently, a group of farmers in Vaduvanchal in Wayanad, who are part of the Kisan Jyothi Farmers Club (KJFC), funded by NABARD, have unveiled redesigned eggs, which they say would allay concerns. They claim that their "Omega" brand eggs provide the answer and dispel the concerns of those who are worried about cholesterol.

Need For Designer Eggs and its Preparation

Due to chickens' special capacity to incorporate dietary lipid into the yolk of their eggs, hen eggs may be a source of unsaturated fatty acids.



Pharmacological agents reduce cholesterol in eggs by preventing the hen from synthesizing cholesterol or by preventing cholesterol from the blood from entering the developing yolk on the ovary. Currently, the FDA has not authorized Atorvastatin or any other medication for commercial usage, despite the treatment showing promise in decreasing cholesterol. A different strategy to lessen the effects of cholesterol from eggs is to change the fatty acid makeup of the yolk.

Ways to Produce Designer Eggs

Through special feeding practices, it has been possible to produce eggs with even less cholesterol and saturated fat and with substantially increased amounts of omega-3 polyunsaturated fatty acids, carotenoids, vitamins, minerals, antibodies and even bioactive peptides. Inducing metabolic changes in the hen that can result in synthesis of compounds that essentially end up in the egg. Change the characteristics of membrane transport to facilitate movement of compounds into the egg.

Modification in Nutritional Profile with Designer Eggs

1. Omega-3 enriched egg
2. Low cholesterol eggs
3. Immunomodulating egg production
4. Mineral enriched designer eggs
5. Herbal enriched designer eggs
6. Pigment enriched designer eggs

7. Antioxidants enriched eggs

8. Vitamin enriched designer eggs.

Omega-3 Enriched Eggs

Omega-3 fatty acids called as n-3 fatty acids are a family of PUFA. Egg contains high proportion of n-6, PUFA but is a poor source of n-3 fatty acids. Feeding diets high in omega-3 fatty acids produce eggs with high omega-3 fatty acids content in yolk. There are two types of omega-3:

1. Marine type- PUFA, DHA and EPA which are more commonly found in deep-sea cold-water fish, fish oil and marine algae.

2. Terrestrial type- PUFA, LNA found in canola oil, soybean oil, flaxseed, walnuts, and spinach and mustard green

Reduction in Cholesterol Content

The poultry industry is well aware of the cholesterol health issues. Product quality and safety have always been of primary importance. Designer eggs containing lower cholesterol and saturated fat concentrations are available to the general public. The yolk cholesterol levels can be significantly reduced by supplementing herbal plants and products like basil (tulsi), bay leaves, citrus pulp (nirangenin), grape seed pulp guar gum, roselle seeds, spirulina, tomato pomace (lycopene), and many more herbs in chicken diets will reduce the chicken and yolk fat cholesterol levels by 10-25%.

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Herbal Tea: A Sip of Wellness and Serenity

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In recent years, global mortality arising from no communicable diseases has overtaken infectious diseases, with ischemic heart disease the most prevalent, and dementia and diabetes now placed within the top 10 causes. Tea was first introduced in China as a traditional medicine. It is today produced in countries such as India, Sri Lanka, Kenya, Indonesia, Japan, Vietnam, Bangladesh, Uganda, Malawi, Tanzania, Rwanda, Burundi, Zimbabwe and South Africa. The top producer of tea is China while South Africa has the lowest yield of all the tea-producing countries. Black tea is the most widely consumed tea (80%) followed by green tea (around 20%) and the remainder being oolong tea (2%). Herbal teas or tisanes are herbal infusions made from any plant other than the leaves of *C. sinensis*. These teas are made from one or more of the herbal. Different parts of the plants (fresh or dried fruits, leaves, flowers, roots, seeds and stems) are used for the preparation of aqueous extracts. The different fermentation processes and the diverse plants for herbal tea increase the availability and usage of tea. Tea is usually consumed with honey, sugar, milk or lemon because people believe that these will enhance the benefit and taste of the beverage. The consumption of herbal teas has increased significantly in recent years with most consumers cognizant of the health attributes of herbal teas.



Type of Herbal tea

There are numerous types of herbal teas, each made from different herbs, flowers, fruits, and spices. Here are some popular types of herbal teas

Green Tea

Green tea, derived from the leaves of *Camellia sinensis*, stands out as a beverage with a rich history and a plethora of health benefits. Known for its subtle, earthy flavor and lower caffeine content compared to black tea, green tea has become a popular choice for those seeking a refreshing and health-promoting drink. Regular consumption of green tea has also been associated with improved cognitive function and a reduced risk of certain chronic diseases. Whether enjoyed hot or cold, green tea continues to captivate enthusiasts worldwide, not only for its distinctive taste but also for its potential contributions to overall well-being.

Chamomile Tea

Chamomile tea, crafted from the dried flowers of the (*Matricaria chamomilla)* plant, has earned a reputation as a soothing and calming herbal infusion. Renowned for its mild, floral aroma and delicate flavor, chamomile tea has been cherished for centuries for its potential therapeutic effects. Traditionally recognized for its ability to promote relaxation and alleviate stress, chamomile tea is a popular choice before bedtime, aiding in improved sleep quality. Additionally, its gentle nature makes it suitable for individuals with digestive discomfort, as it may help ease indigestion and bloating. As a caffeine-free option, chamomile tea offers a comforting and natural remedy, making it a beloved choice for those seeking relaxation and a moment of tranquility in their daily routine

Peppermint Tea

Peppermint tea, derived from the leaves of the Mentha piperita plant, is a refreshing and aromatic herbal infusion that has been enjoyed for centuries for its delightful flavor and numerous health benefits. With its invigorating and cooling properties, peppermint tea is a popular choice for relaxation and digestive relief. Additionally, the tea is often praised for its ability to promote mental clarity and alleviate stress, making it a popular choice for those seeking a calming beverage. Whether sipped hot or enjoyed over ice, peppermint tea offers a delightful and revitalizing experience that goes beyond its delicious taste, making it a cherished beverage in various cultures worldwide.

Ginger Tea

Ginger tea, brewed from the rhizome of the (*Zingiber officinale)* plant, is a warming and flavorful

beverage celebrated for its unique taste and medicinal properties. Renowned for its spicy and slightly sweet flavor profile, ginger tea has been a staple in traditional medicine for centuries. Beyond its health benefits, ginger tea is cherished for its comforting and invigorating qualities, especially during colder months. Whether enjoyed plain, with a hint of honey, or combined with other herbs and spices, a cup of ginger tea offers a warming and soothing experience that extends far beyond its culinary appeal.

Turmeric Tea

Turmeric tea, crafted from the rhizome of the Curcuma longa plant, stands out as a vibrant and healthful beverage with a rich history in traditional medicine. Renowned for its earthy and slightly bitter taste, this tea is often infused with complementary ingredients like ginger, black pepper, or citrus to enhance its flavor profile. Widely consumed for centuries in various cultures, turmeric tea has gained popularity for its holistic approach to well-being. Whether enjoyed for its distinctive flavor or as a part of a wellness routine, a cup of turmeric tea offers a flavorful journey through both taste and tradition.

Hibiscus Tea

Hibiscus tea, brewed from the vibrant and magenta-hued petals of the Hibiscus sabdariffa flower, is a visually stunning and refreshing herbal infusion that captivates the senses. With its tart and slightly tangy flavor, hibiscus tea is often enjoyed both hot and cold. Hibiscus tea is also known for its diuretic properties and its potential to promote liver health. Commonly consumed in various cultures around the world, this floral elixir has become a popular choice for those seeking a caffeine-free and flavorful alternative. Whether relished on its own or blended with other herbs and fruits, hibiscus tea offers a delightful and visually striking beverage that combines taste and well-being.

Lemon Balm Tea

Lemon balm tea, derived from the leaves of the (*Melissa officinalis)* plant, is a fragrant and soothing herbal infusion celebrated for its gentle lemony flavor and calming properties. The tea is esteemed for its historical use in traditional medicine to alleviate stress, anxiety, and promote relaxation. This caffeine-free tea is often enjoyed before bedtime to help induce a sense of calm and improve sleep quality. Its bright and citrusy notes make it a delightful and refreshing beverage, whether consumed hot or cold. Lemon balm tea is not only valued for its potential stress-relieving benefits but also for its subtle yet invigorating taste that appeals to those seeking a comforting and aromatic herbal infusion.

Echinacea Tea

Echinacea tea, crafted from the roots and above-ground parts of the (*Echinacea purpurea*) plant. Widely recognized in traditional medicine, particularly by Native American tribes, the tea is characterized by its slightly earthy and floral taste, often accompanied by a mild sweetness. Whether enjoyed as a preventive measure during colder seasons or as a comforting beverage when under the weather, Echinacea tea offers a holistic and herbal approach to immune support, making it a favored choice among those seeking natural remedies for wellness.

Nettle Tea

Nettle tea, crafted from the leaves of the stinging nettle plant (*Urtica dioica*), is an herbal infusion that has been cherished for centuries for its numerous health benefits. Despite its reputation for causing irritation when touched, the nettle plant transforms into a nourishing and earthy tea once dried. Rich in vitamins, minerals, and antioxidants, nettle tea is believed to have detoxifying properties and may aid in purifying the blood. The tea has a mild, grassy flavor and is often enjoyed on its own or blended with other herbs for added complexity. Whether sipped for its potential health benefits or appreciated for its unique taste, nettle tea offers a wholesome and herbal option for those seeking a natural approach to wellness

Dandelion Tea

Dandelion tea, crafted from the roasted roots or dried leaves of the humble dandelion plant (*Taraxacum officinale*), is a herbal infusion that has gained popularity for its potential health benefits and unique earthy flavor. Despite being commonly dismissed as a weed, dandelion has a long history of use in traditional medicine. It is believed to be rich in

vitamins and minerals, particularly vitamin A, C, and potassium. The tea has a slightly bitter taste, reminiscent of coffee when made from the roasted roots, making it a caffeine-free alternative for those seeking a warm and comforting beverage. Beyond its distinct flavor, dandelion tea has garnered attention for its potential liver-cleansing properties and its role in supporting overall well-being. Whether enjoyed for its taste or as part of a holistic health regimen, dandelion tea offers a unique and beneficial addition to the world of herbal infusions.

These are just a few examples, and there are many other herbal teas with various flavors and potential health benefits. Keep in mind that herbal teas can be enjoyed for their taste and aroma, and some people also appreciate them for their potential therapeutic effects.

Advantage of Herbal Tea

Here are some advantages of herbal tea:

- **Calming and Relaxing:** Some herbal teas, such as chamomile or peppermint, have natural calming affects that can help reduce stress and anxiety. They may also aid in promoting better sleep.
- **Digestive Aid:** Certain herbs like ginger or peppermint have been traditionally used to soothe digestive issues. Herbal teas can help alleviate symptoms such as indigestion, bloating, and nausea.
- **Immune Support:** Some herbs, like echinacea or elderberry, are believed to have immune-boosting properties. Drinking herbal tea regularly may support the immune system and help prevent illness.
- **Weight Management:** Certain herbal teas, such as green tea, are often associated with potential weight management benefits. Green tea, in particular, contains compounds like catechins that may help boost metabolism and fat burning.
- **Rich in Nutrients:** Herbal teas can provide essential vitamins, minerals, and other nutrients depending on the herbs used. For example, nettle tea is known for its high content of vitamins and minerals like iron.
- **Traditional Medicine:** Many cultures have a long history of using herbal teas for medicinal purposes. While not a replacement for professional medical advice, herbal teas have been used traditionally to address various health concerns.

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Horse gram - Underutilized climate resilient Nutrition Boon Pulse

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Horse gram (*Macrotyloma uniflorum*) is an annual, herbaceous, protein rich, underutilized legume crop belonging of family Fabaceae. It is commonly known as kulath, kulith, ulavalu, gahot, hurali, kollurmuthira, etc. in various parts of India. It is mainly grown in Africa, Australia, Burma, India, Malaysia, Mauritius, and West Indies. It is generally considered as protein-rich poor man's crop that grows well under dry conditions (low rainfall) and marginal soil fertility. Horse gram is a staple healthy diet rich in protein, fiber, ash, and low in fat. for humans for millennia, food legumes are the second most significant group of crops in terms of their contribution to human and animal nutrition. Some of the underutilized native legumes, like horse gram, have great significance in the nutritional security of rural, tribal, and underprivileged masses. It is also used as cattle feed (both fresh and dried) for dairy as well as poultry animals.

Horse gram gains special importance in semi-arid regions as its requirement for water is very low. The crop accounts for about 5-10% of pulses production in India and its annual production is about 0.65 million tones 5. Since, horse gram has good nutritive potential, and it is fairly resistant to various abiotic and biotic stresses. It has also has been identified as a potential future food crop by the U.S. National Academy of Sciences (NAS, 1978). Its resistance to various pests/pathogens is attributed to a dual function of LOX protein like lectin and lipoxygenase. Also, it has a higher production potential under salt stress conditions 8. In India, horse gram is known as a legume with ethnomedicinal values. It forms major portion of the diet of the rural people during drought and dry seasons.

Further, it is considered as an excellent source of dietary fiber, molybdenum, iron, calcium, other micronutrients and other bioactive phytochemicals. In the classical Indian texts like Charak Samhita and Sushruta Samhita about traditional Indian medicinal system, the seeds of *M. uniflorum* are known to cure abdominal lump, bronchial asthma, hiccup, piles and also in regulating/stopping excessive perspiration. One of its common names "gahot" (Kumaon and Garhwal region), etymologically means to destroy kidney stones in the initial stage is attributed to its usefulness in curing kidney stones. Some of its pharmaceutically important properties include anti-hypercholesterolemic, anti-microbial, anti-obesity, anti-helminthic, analgesic, antiinflammatory, anti-diabetic, anti-cholelithiasis, anti-histaminic, anti-peptic ulcer, anti-oxidant, antiobesity, anti-urolithiasis, diuretic, hemolytic, hepatoprotective, anti-diabetic and antihypertensive properties. Seeds contain plethora of bioactive compounds which exert medicinal/nutraceutical values and also play inhibitory role by reducing establishment of various diseases like coronary heart diseases, diabetes and obesity.

Nutritional features of Horse gram

- Rich in proteins (Globulin, albumin and prolamines). This high proportion of essential amino acids will reduce the protein energy and malnutrition and increase the lean muscle mass and act as natural relaxant.
- Rich in carbohydrates (alpha amylase resistant starch, free sugar and oligosaccharides) which leads to slow and gradual digestibility. Hence have antidiabetic uses and prevent colorectal cancer.
- Horse gram having lipids with essential fatty acids, phytosterol esters leads to antiulcer activity and combat ace gastric ulceration. Enzyme inhibitors (Bowman-Bink type inhibitors) lead to anti- inflammatory activities, for treatment of ulcerative colitis and multiple sclerosis.
- Dietary fibres (soluble and insoluble fiber) can reduce in serum cholesterol and glucose content, that will decrease risk of cardiovascular diseases, gastro intestinal disorders and constipation). Crystallizing inhibitors have anti calcifying effect on calcium

phosphate that will facilitate for removal and cure of kidney stones.

- Horse gram have secondary metabolites (ply phenols, tannins, flavonoids, saponins and alkaloids) act an antioxidant and free radicals scavenging activities. React as positive cardiovascular effects, protection from UV radiation, arthritis, immune deficiency disease and ageing.

Health Benefits of Horse gram

In the southern regions of India, horse gram is a common staple meal that is regarded as a wonder superfood. It is loaded with vitamins and minerals, including phosphorus, calcium, protein, and iron. As a result, it is well known to be particularly advantageous for both human and animal health. Let's now carefully examine and discover more about the advantages of horse gram for our general health.

1. Diarrhoea

Horse gram contains a sizable quantity of fibre, which aids in digestion and absorbs extra liquid from the stomach and intestines. This makes normal bowel motions possible and lessens the likelihood of diarrhoea and loose motion. The digestive tract functions better when a handful of pre-soaked horse gram beans are consumed in the early morning.

2. Weight loss

Weight reduction According to Ayurveda, if one consumes horse gram on a daily basis, weight reduction will undoubtedly occur. This only occurs when you ingest horse gram in powder form, to which a dash of cumin seeds should be added. Two times a day, on an empty stomach, the two should be combined in a glass of water and consumed as desired. It's fine if some people don't want to consume horse gram in this form for weight loss. In these circumstances, the bean can be consumed raw and soaking, or combined with Bengal gram and pepper to make a crispy salad that can be eaten.

3.Menstrual Disturbances

Menstrual issues are incredibly upsetting, and unless you experience them, you won't understand how painful and draining they may be. You can either consume horse gram soup or salads containing horse gram to assist you get through this unpleasant condition. Both of these foods reduce the irritability caused by menstruation irregularities. The high iron content of horse gram will assist maintain the levels of haemoglobin in the body when you have irregular menstruation cycles or severe bleeding. For this reason, holistic specialists advise ladies with menstrual problems to take horse gram.

4. Cholesterol

According to research, horse gram aids in lowering blood levels of LDL, or bad cholesterol. When horse gram is ingested, the bad cholesterol that has become lodged in the veins is eliminated.

5. Constipation

Constipation is brought on by a diet low in fibre, a lack of water intake, a deficiency in minerals, as well as by an unhealthy lifestyle, stress, and a number of other factors. This occurs when the intestines and the lining of the stomach above the duodenum are unable to expand and contract appropriately, preventing the waste from being expelled. Horse gram can aid in the fight against constipation because it contains potent minerals and a lot of fibre. In these situations, horse gram should be pre-soaked and eaten raw as a salad.

6. Piles

When the veins in the rectum enlarge and become irritated or painful, piles develop. Holistic specialists advise using horse gram as opposed to running to the pharmacy for drugs and treatment. Eat a cup of horse gram uncooked as a salad garnish as well as soak a cup in water overnight and drink it the next day. Its combination of roughage and fibre aids in the treatment of piles.

7. Common Cold and Fever

We experience the common cold and fever when our bodies' immune systems are compromised and viruses take up residence in our bodies. For this, ancient Ayurvedic academics suggested consuming horse gram when you have a fever, cough, or cold, as well as bronchial issues and asthma. Consuming horse gram in soup form helps to clear congestion and opens up the nasal passages by causing the mucus membranes to soften and melt. This facilitates

breathing because the body's metabolism and immunity are both increased by the necessary nutrients.

8. Urinary Discharge

The humiliation that comes with urine discharge in women is real. This is particularly true when the urine is heavy, inconsistent, occasionally foul-smelling, and occasionally continuous. Around the cervix and the vagina, there may be aches, infections, and inflammation. This occurs when the membrane's lining becomes irritated, and the discharge may smell bad or be thick. When puberty begins or when sexual excitement is at its highest, the amount of discharge increases. According to Ayurveda, one should boil some horse gram the following day after soaking it in a basin of water for the previous night. To treat the symptoms of this condition, this water should be drunk three times each day.

9. Diabetes

Researchers from the Indian Institute of Chemical Technology have discovered that raw, unprocessed horse gram seeds have characteristics that lower insulin resistance in addition to anti-hyperglycemic effects. Horse gram has the ability to provide strategies for preventing the development of hyperglycemic qualities in the body, making this possible. Horse gram in turn aids in reducing the body's insulin resistance. Blood glucose levels are reduced and managed, and it may also help slow down the rate of carbohydrate digestion, which further lowers blood glucose levels. Because of this, it is frequently used as a superfood to treat type 2 diabetes.

10. Digestion

After a substantial meal, if your stomach doesn't feel comfortable or feels acidic for minutes to an hour or longer, you probably have indigestion. This might cause problems like GERD and acid reflux, which can be uncomfortable for you as well. For this reason, it is advised to take horse gram on an empty stomach first thing in the morning. This facilitates the digestive process and makes digestion simple.

11. Kidney Stones

Horse gram can help prevent kidney stones from forming or even help remove them from the body when consumed regularly. The main component of kidney stones is a substance called calcium oxalate. Additionally, kidney stones in horses can be removed the same day. This is due to the fact that horse gram is high in polyphenols and rich in iron. Additionally, kidney stones have high antioxidant levels. The next morning, eat a cup of horse gram that has been soaked in a basin of water. This seems to have positive outcomes after a week of use.

12. Ulcers

Horse gram, but not stomach ulcers, can be highly helpful in healing different types of ulcers. Horse gram contains lipids that are particularly beneficial for people who have oral and stomach ulcers when they eat the legume. Rats have been the subject of research and studies on the subject, and the animals have recovered. The same research and studies have also been conducted on humans, with encouraging results. Even in Ayurveda, it has been demonstrated that eating mashed horse gram twice a day produces the lipids the body needs to heal itself of ulcers. (Aditya et al.,2019).

Horse gram is a significant food and feed crop that has historically been farmed in dry areas of impoverished countries. It is frequently referred to as the "poor man's pulse and is overlooked or underutilized. After a thorough analysis of horse gram's nutritional value and positive effects, we can conclude that those who understand its significance find it to be well-liked. It is relatively simple to digest and one of the key substances used to treat kidney stones, but it also contributes to a number of other aspects of human health. It is one of the foods with almost no negative effects and is excellent for all age groups. It is a reliable, nutritious, and therapeutic food crop that has long been despised by cynics. Its current level of use cannot minimize the many positive bioactivities it possesses. There are natural chemicals in our possession that can heal us, despite our busy lifestyles where we favor all medications and spend our money on therapies. "Eat healthy, live healthy" is the quotation that applies to this situation.

Consequently, depending on its nutritional content, we can employ Horse gram in the food sectors and in the pharma industry.

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Horseradish: The Pungent Powerhouse

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Horseradish, botanically known as *Armoracia rusticana*, belongs to the Brassicaceae (Cruciferae) family, which also includes mustard, cabbage and broccoli. Native to the mud swamp lands of southern Europe and western Asia, horseradish has a long history of cultivation and use, dating back to ancient times.

Botanical characteristics of horseradish

The horseradish plant is a perennial herb with a fleshy, white or buff coloured taproot, which is the primary source of its pungent flavour. The taproot is about 30 cm long with several swollen roots branching out from different angles. The plant is characterised by its large, dark-green, lance-shaped leaves, which are wavy and resemble spinach. The leaves are coarse and can grow up to 28 inches in length. It produces clusters



Fig. 1: Horseradish



Fig. 2: Horseradish



Fig. 3: Horseradish



Fig. 4: Horseradish



Fig. 5: Horseradish

of small, white, aromatic flowers during the late spring. The fruit pods are short, oblong and crinkled, but frequently fail to mature or contain viable seeds. Understanding the morphology of horseradish is essential for both cultivation and identification.

There are two varieties of horseradish–the common type with broad, crinkled leaves having high quality roots and the Bohemian type with narrow, smooth-edged leaves and inferior quality roots.

Culinary history

The culinary use of horseradish can be traced back to ancient Greece and Rome. The Greeks valued it for its pungent taste and used it to enhance the flavour of their dishes. Similarly, the Romans incorporated horseradish into their cuisine, recognising its ability to complement a wide range of foods. Over the centuries, horseradish has continued to be a staple in various culinary traditions for its bold and pungent flavour, making it a popular ingredient in various dishes and condiments:

a) **Condiments and sauces:** One of the most well-known uses of horseradish is in the preparation of condiments and sauces. Horseradish sauce, a classic accompaniment to roast beef, is made by combining grated horseradish with ingredients like mayonnaise, mustard and vinegar. The sharpness of the condiment adds a zesty kick to meats and sandwiches.

b) **Pickling and fermentation:** Horseradish roots can be pickled or fermented to preserve their pungent flavour. Pickled horseradish is often served as a side dish or garnish, providing a tangy and spicy element to meals.

c) **Culinary pairings:** Beyond condiments, horseradish is used to flavour various dishes, including soups, stews and salads. Its versatility makes it a valuable ingredient in the culinary world, allowing chefs to experiment with different flavour profiles.



Fig. 6: Horseradish



Fig. 7: Pickled



Fig. 8: Horseradish

Phytochemical composition

The distinctive flavour and medicinal properties of horseradish can be attributed to its complex phytochemical composition. The plant contains a variety of bioactive compounds, each contributing to its unique characteristics:

a) **Glucosinolates (GSLs):** One of the key components in horseradish is glucosinolates, sulphur-containing compounds, that are responsible for its pungency. When the plant is crushed or cut, an enzyme called myrosinase interacts with glucosinolates (sinigrin) in presence of water, leading to the release of allyl isothiocyanate (AITC). AITC is known for its antimicrobial and anticancer properties.

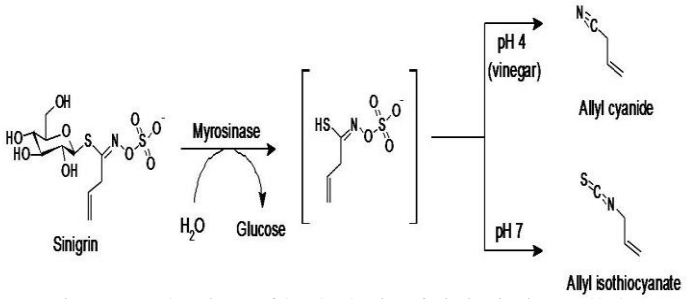


Fig. 9: Mechanism of hydrolysis of sinigrin into allyl isothiocyanate (AITC)

b) **Phenolic compounds:** Horseradish root also contains phenolic compounds (481 mg/100 g), such as flavonoids and phenolic acids, which contribute to its antioxidant properties. These compounds play a role in neutralising harmful free radicals in the body, potentially reducing the risk of chronic diseases.

c) **Essential oils:** The essential (volatile) oils present in horseradish contribute to its aromatic and flavourful profile. These oils, including mustard oil, add depth to the culinary applications of horseradish.

Medicinal uses

Horseradish is a neglected and underutilised plant species (NUS), especially concerning the potential benefits to improve human health. It has a long-standing reputation for its medicinal properties. It has been utilised as a stimulant, antiseptic, diuretic, aid to digestion, remedy for worm's expectorant and in treatment of scurvy. Horseradish has been traditionally used to alleviate respiratory issues such as congestion and coughs. The inhalation of allyl isothiocyanate, released when horseradish is grated or crushed, can help clear nasal passages and provide relief from respiratory discomfort. Research has demonstrated the antimicrobial properties of horseradish, particularly due to allyl isothiocyanate, against various bacteria and fungi. Horseradish is believed to stimulate the production of digestive enzymes and enhance overall digestive function. While more research is needed to fully understand these effects, the historical use of horseradish in digestive health provides a foundation for further investigation.

Cultivation and harvesting

Successful cultivation of horseradish requires an understanding of its growth requirements, propagation methods and harvesting techniques:

- **Growing conditions:** Horseradish thrives in deeply worked medium-textured, well-drained soil rich organic matter and potash, with a neutral pH. It prefers full sunlight but can tolerate partial shade. Adequate moisture is crucial, especially during the early stages of growth.
- **Propagation:** Horseradish is commonly propagated through root cuttings of 5-8 cm length. These cuttings, known as sets, are sections of the plant's root containing both the crown and the upper part of the taproot. Planting sets in early spring or fall allows for optimal root development.

Note: It is advisable to grow horseradish in a distant and less formal place in the garden as it grows out of control. Once it is strongly grown in an area, it is very difficult to completely eradicate the plant as the smallest piece of root will grow again.

- **Harvesting:** The roots of horseradish are typically ready for harvest after six to eight months of growth. Harvesting is usually done in the fall or early spring before new growth emerges. Careful digging and cleaning of the crowns and roots are essential to preserve their quality. The straight lateral roots are preserved for planting. Roots to be marketed are trimmed, washed and packed. They are never exposed to light as they will turn green, which is undesirable.

Conclusion

Horseradish (*Armoracia rusticana*) stands as a testament to the harmonious interplay between

culinary delight and medicinal benefits. From ancient civilisations to modern kitchens, this robust herb has earned its place as a versatile and esteemed plant. As ongoing research unveils more about its phytochemical composition and potential health benefits, horseradish continues to captivate the attention of scientists, chefs and health enthusiasts alike. Horseradish is truly an underestimated, underexploited and neglected species for various reasons, but especially regarding its potential benefit to improve human health.

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Intercropping Systems in Sugarcane

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Growing two or more crops simultaneously on the same field is known as intercropping/ companion cropping. Crop intensification is in both temporal and spatial dimensions. Until recent years, sugarcane crop was cultivated as a single crop. But rapidly increasing population, insufficient food, limited scope for extension of cultivation to new areas, diversified needs of small farmers for food and cash etc. have forced the adoption of intercropping systems.

Much of the space between two rows of sugarcane remains unutilized for an initial period of 100-120 days, because of slow growth. Companion cropping offers opportunity for profitable utilization of available space.

1. The crops suitable for companion cropping should have following characteristics:
2. The duration of intercrop should be less than 4 months to avoid contention with sugarcane.
3. Intercropping should not be competitive with the main crop in respect of sunlight, air, water and nutrients.
4. The growth habit of intercrop should be erect type and should have dissimilar root system.
5. The intercrop should not host insect and diseases which might affect sugarcane adversely.

Maximum cane yield, can be obtained when potato/ onion is grown as a companion crop with autumn planted sugarcane, followed by potato/wheat, toria/onion. The best crops identified with spring planted sugarcane were moongbean and urdbean. Moongbean, Sunflower or Soybean as an intercropping sugarcane field has been found to be profitable.

Suitable crop combinations

Most successfully adopted combinations are given as under -

- Sugarcane + Early potato (K. Chandramukhi)-Onion (Kalyanpur red).
- Sugarcane + Early Potato- Wheat (K 816).
- Sugarcane + Toria (T.9)-Onion.
- Sugarcane+ Early Potato/Vegetable Pea-Barley (Jyoti)

Planting mechanisms for potato and sugarcane

Potato Planter

Potato is an important crop in India. It requires a lot of labour for sowing seeds in fields. Potato planters are becoming very popular now days. Planting of potato starts by creating a open furrow, drop and space the seed pieces at various distances, place fertilizer to sides and below the level of seeds and cover the seed and put fertilizer to a desired depth. There are three main types of potato dropping mechanisms:

1. **Automatic Planters:** It consists of a hopper for each row and cups with chain drive mechanism. Graded potatoes are picked up by the cup and carried to furrow opener sprout and released in furrow. A feeder roller connected to compensating tray which contains spare potato checks for each cup. If a cup is empty a potato is released from compensating tray ensuring a uniform seed spacing with no missing. The fertilizer and pesticide can also be placed simultaneously. It can plant 2-4 rows. Its capacity may be 6000-14000 potatoes/hr.
2. **High Speed Automatic Planter:** It has two picker wheels, each having eight picker arms. Two picker wheels revolve only half as fast as a single picker wheel used at a normal speed. High speed planting is done at twice the normal speed but picker arms do not revolve faster than the single wheel.
3. **Semi-Automatic Planter:** It consists of hopper, metering disc and furrow openers. Fertilizer application unit can be attached separately. Potatoes, from hopper, are placed in metering disc which has compartments. The metering disc is rotated through gear drive mechanism. The potatoes drop due to gravity in furrow openers. Ridges are also formed by furrow

openers. It may plant 2 – 4 rows at the rate of field capacity of 0.15 – 0.25 ha/hr. It may be operated by a 20 – 25 hp tractor.

Sugarcane Planter

It is used for planting sugarcane sets. Desired spacing between row to row and plant to plant is maintained for sugarcane planting. The fertilizer and chemical pesticides can be applied simultaneously. The machine consists of a hopper, two rotating distributor discs, two fertilizer hoppers, pesticide tank with a distribution value and two furrow openers. All these components are mounted on a frame and two wheels. Seed distributor box and applicator are powered from ground wheel through a set of roller chains and gears. Two persons are required to put sets in seed rotor manually from hopper. Machine is mounted on a tractor. Output may be 0.6 ha/h and it requires 4-6 men for field operations.

Objectives of Planting

1. To establish an optimum plant population and plant spacing to obtain the maximum net return per hectare.
2. Population and spacing requirements are influenced by
3. Kind of crop
4. Type of soil
5. Fertility level of soil
6. Amount of moisture available
7. Effect of plant and row spacing upon cost and convenience of operations such as thinning, weed control, cultivation and harvesting.
8. Principal requirement from yield point is to keep the number of plants per hectare more as with many crops. There is fairly narrow range of plant population that will give maximum yield under a particular combination of soil and the fertility conditions. So as the optimum number of plants per hectare is increased and the productivity of soil also increases. But for other crops like cotton and small grains there is a wide range of plant population over which yields do not vary appreciably.

Factors affecting Germination and Emergence

1. Factors affecting seed emergence rate are influenced by:
2. Viability of seed (percentage germination under controlled laboratory conditions)
3. Soil temperature
4. Availability of soil moisture to seeds
5. Soil aeration
6. Mechanical impedance of seedling emergence (resistance of soil to penetration by seedling)

These are influenced by:

1. Soil type
2. Physical condition of the soil
3. Depth of planting
4. Intimacy of contact between seeds and soil
5. Degree of compacting of soil above the seeds
6. Formation of surface crusts after planting
7. Final field stand is also due to disease, insects, and adverse environmental conditions.

Field emergence rate of 80% to 90% are typical for corn and other crops that tolerate a fairly wide range of planting conditions. Field emergence with sugar-beets and many small seed vegetable crops is so low and unpredictable i.e. 35% to 50%.

Functions of Seed Planter

Seed planter is required to perform following mechanical functions

1. Open seed furrow to proper depth
2. Meter the seed
3. Deposit the seed in the furrow in an acceptable pattern
4. Cover the seed and compact soil around seed to the proper degree for type of crop involved
5. Planter should not damage the seed enough to appreciably affect the germination
6. Seed should be placed in the soil in such a manner that all the factors affecting germination and emergence will be as favorable as possible.

Effect of Planter or Planting System upon Emergence Factors

1. Good planter performance is essential for obtaining an adequate stand with crops whose emergence is critical.
2. Precise depth control, placement of seeds into moist soil and non-crusting conditions above the seeds are important for small seed vegetables and some other crops.
3. Packing of soil by planter can affect the availability of moisture, availability of oxygen and mechanical impedance.

Devices for Metering Single Seeds

Devices having cells on a moving member (cells sized to accommodate one seed or group of seeds) e.g. Horizontal plate planter.

1. **Horizontal plate planter** has a spring-loaded cut-off device that rides on top of the plate and wipes off excess seeds as the cell moves beneath it. A spring-loaded knock-out device pushes the seeds from the cells when they are over the seed tube.
2. **Plates with round or oval holes** are used for drilling or hill dropping of various row crops.
3. **Edge-cell**, edge-drop plates are used for planting relatively large, flat seeds.
4. **Inclined plate metering devices** have cups or cells around the periphery that pass through a seed reservoir fed under a baffle from the hopper, lift the seeds to top of plate travel and drop them into delivery tube. A stationary brush is provided for more positive unloading. Seeds are handled more gently than with horizontal plate unit because there is no cut-off device. The metering unit has an edge-cell plate with sizes available to fit various kinds of small vegetable seeds. Plate and surrounding ring are accurately machined to provide uniform cell sizes for precision metering.
5. **Vertical-rotor metering devices** are used for precision planting of vegetables and sugar-beets. In some units seed tube is omitted and rotor placed as low as possible and discharge seeds directly into the furrow. These units also have seed cups which move up through a shallow seed reservoir, pick-up single seed, carry them over the top of the circle and discharge them during the downward travel.
6. **Cells in a Belt** is also another type of precision metering device in which seeds are fit to size. Seeds from hopper enter the chamber above the belt through opening and are maintained at a controlled level. As belt moves clockwise, counter-rotating seed repeller pushes back excess seeds so there is only one in each cell. Seeds in cells are conveyed over the base and discharged from belt beneath the seed repeller wheel. Lack of positive unloading device causes some variability in seed spacing.
7. **Single seed metering devices** that do not have cells are used for all type of seeds. In these twelve spring-loaded cams operated fingers on radial arms rotate, gripping one or more seeds as they pass through the seed reservoir. One seed is released as each finger passes over to small indents near top of stationary disk. As finger continues to rotate it throws the remaining kernels into one of 12 cells in the adjacent, rotating seed wheel and seed wheel discharge the individual kernels into furrows.
8. **Pneumatic (air-pressure) Metering System** has a centralized hopper and metering unit that serves 4, 6 or 8 rows. The ground driven seed drum has one circumferential row of perforated seed pockets for each planter row. A shallow reservoir of seed is automatically maintained in the drum by gravity flow from the hopper. A PTO driven fan supplies air to the drum, maintaining a pressure of about 4 kPa (0.6 psi) in the drum and in the hopper. Air escapes through holes in the seed pockets until a seed enters the pocket. Differential pressure holds the seeds, the revolving drum carries a stationary brush near the top that knocks off any excess seeds. Air-cutoff wheels on top of drum momentarily block the holes, causing seed to drop into seed-tube manifold. Air flow through the tube

carries the seeds to the planting units and deposits them in the furrows. This is generally used for crops such as corn, beans, grain sorghum.

- Pneumatic principle is also used for single row metering devices for unit planters. Small blowers driven by electric motors connected to the tractor's electrical system provide air-pressure in metering chamber. Seeds are held against the holes in the rotor. Seed pockets are carried upward and around in a counter-clockwise direction in the unit. The seeds are released into seed tube when pockets pass a baffle that cutoff the inner air pressure to the front (left hand) portion of the rotor. Different disc rotors are used for different kinds of seeds.

9. **Vacuum Pick-Up Devices** are also available for seed metering. In this there is a central vacuum pump with valves to each pick-up orifice, seal between stationary piping and rotating pick-up assembly. A stationary cam extends the piston to produce pressure for unloading the seeds and a spring retracts it to develop the vacuum for seed pick-up. Vacuum pick-up devices can perform effectively with small, irregular shaped seeds like lettuce. These are sensitive to dust and dirt.

- The average spacing of seed and hill is determined by ratio of linear or peripheral speed of seed pick-up units (cells, fingers etc) to the forward speed of planter and by the distance between seed pick-up units on the metering unit. Changing the speed ratio is the most common method of changing seed spacing.

10. **Seed Tape Planting System** is the precision planting system. Seeds are deposited either singly or in groups (hills) on a water soluble table in a laboratory under controlled conditions. Equipment is available for single out and spacing small, irregular shaped seeds on tape with high degree of accuracy. The seeds are placed on the tape at the desired field spacing and a continuous strip of tape is un-released and placed beneath the soil by a simple planting unit. The tape is a polyethylene oxide that is stable under normal atmosphere conditions but dissolves in one or two minutes when placed in most soil. It is used for planting lettuce, tomatoes, cucumbers and some other vegetable crops. The tape is expensive and good soil preparation is imperative. A large amount of tape per hectare is needed especially for close spaced rows i.e.20 km/ha for 51 cm row spacing Precise depth control is difficult to maintain but planting can be done at relatively high forward speed. Seed spacing in the row is pre-determined when seed tape is made and is precise in the field. Increased yields are reported with this for lettuce and cucumbers. A special planter that cuts the tape into single seed sections and deposits these sections in cone-shaped pockets are pressed into the soil. An arrangement is provided to meter a charge of non-crusting soil amendment (vermiculite) into each pocket to cover the tape. Perforations along one side of seed tape synchronized the depositing of seeds on tape and cutting the tape into sections by planter.

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Indigenous Traditional Knowledge: Blending Traditional Cuisine and Scientific Knowledge

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India is a land of numerous people and cultures. Many different ethnic groups found here outnumber many countries. It has a rich culinary heritage that has evolved over centuries. Traditional foods give an exquisite vision of India's rich cultural heritage. Each region of India, and the world, is diverse in its food habits. Each region has its own recipes; it cooks with different ingredients and, it eats differently. Traditional food habits across the country are primarily based on a holistic approach to nutrition. However, with rapid urbanization, our eating habits are also rapidly changing, and we run the real danger of losing our rich traditional food knowledge, built with the wisdom of centuries.

Apart from being healthy traditional foods are also very delicious. Their several health benefits include supporting the immune system, circulatory system, brain function and several other metabolic functions in the human body.

Traditional knowledge often forms part of people's cultural and spiritual identity of most local communities. It is a key constituent of a Community's social and physical environment and, as such, its preservation is of paramount importance. The preservation, protection and promotion of the Traditional Knowledge-based innovations and practices of local communities are particularly important for developing countries like India.

Importance of Traditional Knowledge

- An African proverb says: "**When an old knowledgeable person dies, a whole library dies**" indicating the importance of TK.
- Indian Systems of Medicine (Ayurveda, Siddha, Unani) are part of the official healthcare system in India, and depend on a diversity of biological resources and traditional knowledge.

Traditional cuisine used during festivals in India

India is known for its rich culture, festivals, rituals, traditions, and religious functions, which makes it a radiant nation. Almost every religious festival makes an important contribution to diets.

Ram Navmi

- The ninth day of the month, the bright half of the *Chitra* (March-April) is observed on the birth of Lord Rama, the seventh incarnation of Lord Vishnu. It is an important Hindu festival celebrated all over the country by all the sects of the Hindu fold.
- On this day *Panjeeri* is special indigenous foods, prepared on *Ram Navmi*.
- *Panjeeri* is a prasad prepared on *Ram Navmi* and offered to God Ram. It is sweet and pungent in taste. It is prepared out of coriander seeds, sugar and dry ginger.
- Coriander seeds is the main ingredient of Panjeeri. It has a refrigerant property. Hence, consumption of the *Panjeeri* gives cooling effect to the body.

Akshaya Trutiya

- *Akshaya Trutiya* is observed on the third day of the bright half of *Vaishakha*. This is also believed to be the first day of *Satyuga*.
- *Pannha* is offered to the forefathers, on the occasion of *Akshya Trutiya*.
- *Pannha* is a refreshing drink of cooked green mango popularly consumed in, the month of *Vaishakh* in *Vasant* season.
- *Pannha* is recommended to all age groups. *Pannha* is the unique energy imparting and disease preventing drink used in *Vasant* season. According to Deshpande (2001) mango is laxative, diuretic and antiscorbutic, which tones up the inner muscles. Hence, it is used for various gastrointestinal, bilious and blood disorders.

Pola

- *Pola* is the harvest festival, celebrated by farmers all over Maharashtra. This festival is celebrated

on the fifteenth day of the dark fortnight in the month of Shravan (July-August). On this day, bullocks, which are an integral part of the agricultural chores and consequently the village economy, are honored.

- *Poi bhaji* is prepared on the festival *Pola*. Mayalu vegetable is easily available in uncultivated land in forest and near the farm. This vegetable is available during the months, of July-August and September only. The botanical name is *Basella rubra* or *Basella alba*.



- *Poi bhaji* can be recommended for people suffering from iron deficiency anaemia, protein calorie malnutrition. *Poi Bhaji* is a rich source of dietary fibre, hence it is recommended during constipation and in febrile disorders. *Poi* leaves are good substitute for spinach when boiled it becomes mucilaginous and their flavour improves. It is a good source of vitamins and minerals. Hence, it can be used to check malnutrition in children, pregnant women, in case of constipation and in urinary disorders (Rajasab and lsaq, 2004). The family members relish this *bhaji* together which not only fulfils the physiological needs but also has socio cultural values.

Diwali

- The word Diwali is the corruption of the sanskrit word Deepavali. Deepa means light and Avali, means a row. It means a row of lights and indeed illumination forms its main attraction. Multi coloured rangoli design, floral decorations and fireworks lens and grandeur to this festival which heralds joy, mirth and happiness in the ensuing year. This festival is celebrated on a grand scale in almost all the regions of India.
- *Shankar pale* is a diamond shaped sweet preparation. *Shankar pale* are used as a snack prepared on the festival *Diwali*. It is prepared out of refined flour, sugar and milk.



- According to Charak, in summer one does not need as much fat as in winter. In winter, appetite is better and man can digest a larger quantity of other protein foods, which in summer may lead to gastrointestinal disorder. Carbohydrate needs are also increased in winter due to contact of cold air, digestive fire is confined, hence its vitality is increased and, therefore in winter one can digest much more heavy stuff than in summer (Narsinga Rao *et al.* 1989), hence, Shankarpale eaten in winter are helpful to fulfil requirement of energy. It is recommended to all age group.
- As it is a low fibre high starch recipe, it can be recommended to the people with gastric ulcers and digestive troubles. Chewing of *Shankarpale* stimulates ptylin in the mouth due to its crispeness, hence, aid digestion of starch. It gives soothing effect in peptic ulcer.

Makar Sankrant

- The festival of *Makar Sankrant* traditionally coincides with the beginning of Sun's northward journey (The Uttarayan) when it enters the sign Makar (Capricorn). It falls on the 14th January every year according to the solar calendar.
- *Til ladu* is a special indigenous food prepared on the occasion of *Makar Sankrant*. It is a sweet confection eaten as a snack in which crunchy

materials like roasted sesame seeds, kneaded with a hot viscous solution of jaggery into balls.



- Gingelly seeds are rich source of vitamin A and vitamin E, thiamine, riboflavin and niacin. Gingelly seeds are a virtual store house of minerals like calcium, phosphorus, copper, zinc, manganese, molybdenum and chromium.
- Almost half the weight of gingelly seeds is fat since this fat made up largely of mono and polyunsaturated fatty acids (PUFA) besides essential fatty acids (EFA) that the diet must provide as they are not sysnthesised in the body (Corolyn, 2002).
- It can be recommended to all aged groups. It can also be recommended to patient suffering calcium deficiency. Til ladu may be used for the treatment of kwashiorkar due to malnutrition anaemia.

Holi

- *Holi* is the last major festival in the Hindu calendar and falls on the last day of *Phalguna* (February-March) which is the day of the full moon. During this time, the winter crops are ripe for harvesting and the spring starts blooming.
- *Puran poli* is a very prestigious dish in Hindu festivals. It is sweet pancake. In most of the festivals people prepare *Puran poli* as an important recipe, hence, it is also known as *Mahanaivedya*.
- According to Ayurveda, bengal gram is cool, laxative, diuretic and anabolic. Bengal gram consumed over period of several weeks may



reduce serum cholesterol levels by increasing fecal excretion of total bile acids.

- *Ghee*, in India, has always been regarded as the supreme cooking fat. An Ayurveda terms ghee as a sweet food, it strengthens, aids digestion and tampers the over activity of all three bodily doshas i.e. Vatta, Pitta and Cough. Cardamom act as a carminative, aromatic, stimulant and diuretic (Pruthi, 1998). *Puran poli* has been used as an expression of love, friendship and social acceptance. It is also used as a symbol of happiness on certain occasions in life.

Conclusion

It can be said that indigenous foods often have some significance. The people will also know the nutritional, therapeutic, medicinal and socio-cultural values of the recipes done on festival days. This may be also helpful to some value in preservation of unique indigenous knowledge which disappear owing to the lack of proper documentation.

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Studies on the Medicinal Plants Wealth in Nilgiris

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Abstract

Nilgiris which forms part of the biodiversity rich Nilgiri Biosphere Reserve, harbours a lot of indigenous flora of excellent medicinal value and provides employment opportunities to the local community. The six tribal communities *viz*., Thodas, Kotas, Kurumbas, Irulas, Paniyas and Kattunayakas are present in this district and their traditional knowledge towards the use of medicinal plants in their day-to-day life were documented from the present study. A total of 66 medicinal plant species with uses were explored from the present study using pre structured questionnaire and various PRA tools.

Introduction

Forest is a very important natural resource of a nation, because it contributes enormously to its overall development. Nilgiris, popularly known as "The Blue Mountains" is part of the biodiversity rich Nilgiris Biosphere Reserve. It harbours lot of indigenous flora of excellent medicinal value and provides employment opportunities to the local community. The average annual rain fall ranges from 1600-1800 mm, which favours the growth of native shola forests with rich diversity of medicinal plants and other interesting floristic elements.

The following six tribal communities *viz*., Thodas, Kotas, Kurumbas, Irulas, Paniyas and Kattunayakas were present in this district and live in harmony with the Mother Nature and the total tribal population of the district were 25,048 (Mugendhiran *et al*., 2022). The ecological conditions of Nilgiris differ entirely from the other forest types. In the mountain of the Nilgiris above 1800 m, the cool average temperatures of the coldest months, (10-15^0 C) together with the frost phenomenon during the North East monsoon period imply a strict selection of botanical species. Another important bio-climatic factor is the extremely variable humidity of the air in the non-forest areas; it varies within very short distances between saturation point and 30 per cent or less. Champion and Seth (1968) considered the plant life of Nilgiri district and Palney sholas to be temperate forests due to the moderately low heat of winter months. The diurnal difference in hotness here during winter months is also very wide. Therefore, these regions were described as the tropical montane forest type.

The lack of information on medicinal usage of various indigenous plants utilized by these tribes requires immediate attention on this aspect. Hence, the present work on exploring the vast knowledge base of these tribes on the medicinal uses of plants available in the eastern slopes of Nilgiri Biosphere Reserve was studied between the year 2021 and 2022.

Materials and Methods

Selection of study area

The forest of Tamil Nadu is famous for their wide variation in their floristic composition. Most of the very good forests are found in Western Ghats and Nilgiris is rich in plant diversity which harbours a number of plant species. Because of the highest diversity and different forest types, varieties of medicinal plants are available in this area. The selection of study area was based on the availability of maximum number of medicinal plants including trees. In order to conduct the present work, ten villages in the eastern slopes of Nilgiris were selected for in depth study. In each village, 10 per cent of the population were surveyed and the data on the local / common name, scientific name of the medicinal plants, parts used and the uses were documented.

Methodology

From the selected sample tribal households, general information on number of households in each village, size of the family, educational status of the family members was collected by interview method using pre-tested structured questionnaire developed for the study. In addition to that, the wealth of medicinal plants utilized by these tribes were documented with the following information *viz*.,

method of harvesting, distance travelled to collect, collection period, method of harvesting and number of days engaged for collection was also elicited. Apart from the interview method, Participatory Rural Appraisal (PRA) Techniques were also used for the collection of data on medicinal plants to cross check the information obtained through questionnaire method. The PRA tools used in this study were, (i) Resource mapping, (ii) Transacts walk and (iii) Ven Diagram.

Table 1. General characteristics of the sample households

Sl. No.	Name of the village	Total Number of households	Size of the family (%)			Nature of the forest
			<5	5-8	>8	
1.	Attadi	25	28.5	14.0	57.1	Dense forest
2.	Baviyur	24	16.6	33.3	50.0	Dense forest
3.	Gudhagur	15	25.0	25.0	50.0	Dense forest
4.	Kambiyur	20	20.0	20.0	60.0	Dense forest
5.	Kolikarai	91	22.7	31.8	45.4	Dense forest adjoining with tea plantation
6.	Melkoep	15	25.0	25.0	50.0	Dense forest
7.	Mettikal	60	26.6	33.3	40.0	Dense forest
8.	Semmanarai	106	29.6	25.9	44.4	Dense forest
9.	Thalamuk	54	42.8	21.4	35.7	Dense forest
10.	Vagapanai	53	30.7	38.4	30.7	Dense forest

Table 2. List of medicinal plants explored from the study area

S. No.	Local Name	Botanical Name	Parts used	Uses
1	White babul	*Acacia leucophloea*	Bark	Constipation
2	Agave	*Aloe vera*	Leaves	Coolant
3	Vellanagam	*Anogeissus latifolia*	Bark	Fever
4	Aravadanthalai	*Ruta graveolens*	Leaves	Fever
5	Vasambu	*Acorus calamus*	Root	Snake bite
6	Athi tree	*Ficus sp.*	Fruit	Reduce swelling
7	Banana flower	*Musa paradisiaca*	Flower	Food
8	Chavali kodi	*Rubia cordifolia*	Leaves	Fever
9	Chedichi	*Murraya paniculata*	Leaves	Stomach pain
10	Chinnapudha	*Sterculia guttata*	Leaves	Reduce heat
11	Coffee bark	*Coffea arabica*	Bark	Fever
12	Etti	*Dalbergia latiflia*	Bark	Tire ness, bath
13	Eecham bark	*Cycus circinalis*	Bark	Edible
14	Gilgirinji	*Crotalaria spp.*	Leaves	Fever
15	Kumil	*Gmelina arborea*	Bark	Stomach bain
16	Gurkathi kodi	*Hiptag bengalensis*	Leaves	Cough
17	Honey	Honey	Honey, wax	Blood purifier
18	Ilaikalli tree	*Euphorbia nivulia*	Bark	Head ache
19	Jack bark	*Artocarpus heterophyllus*	Bark	Psoriasis
20	Kaalaan kodi	*Cyclea peltata*	Leaves	Juice to drink
21	Kadambai kodi bark	*Ichnocarpus frutescens*	Leaves	Back pain
22	Kadukai fruit	*Terminalia chebula*	Fruit	Cough
23	Kalakundri mani	*Abrus precatorius*	Fruit	Insect killer
24	Karu oomathai	*Datura metal*	Fruit	Fever
25	Keelanelli	*Phyllanthus amarus*	Leaves	Jaundice
26	Kolikokkai chedi	*Thunbergia fragrans*	Leaves	Food
27	Konderikkai kodi	*Aristolochia indica*	Leaves	Pain relief

28	Konnai tree bark	*Cassia fistula*	Leaves	Fever
29	Koonjai	*Bridelia retusa*	Leaves	Headache
30	Kottai tree	*Zizyphus xylopyrus*	Fruit	Hip pain
31	Kundhi cheddi	*Atylosia spp.*	Leaves	Pain relief
32	Kurkathi kodi	*Hiptag bengalensis*	Leaves	Religious
33	Lantana	*Lantana camara*	Leaves	Pain relief
34	Maligai chedi	*Jasminum spp.*	Leaves	Strength
35	Mango bark	*Mangifera indica*	Bark	Warm killer
36	Maratti tree root	*Senna auriculata*	Root	Fever
37	Mavali kilangu	*Decalypis hamiltonii*	Rhizome	Food
38	Mottori	*Passiflora subpeltata*	Leaves	Fever
39	Naval	*Syzygium cumini*	Bark, fruit	To cure burns
40	Onnai bark	*Calophyllum inophylum*	Bark	Cure insects bite
41	Oppai tree	*Canthium dicoccum*	Bark	Cooling
42	Orange leaves	*Citrus reticulata*	Leaves	Headache
43	Ottai plant root	*Triumfetta rhomboida*	Root	Food
44	Paanduva tree	*Jatropha curcas*	Fruit	Oil
45	Paathi sundai root	*Solanum torvum*	Root	Strength
46	Pacilkidam	*Euphobia hirta*	Flower	Stomach pain
47	Palagai chedi root	*Strobilanthes spp.*	Root	Food
48	Pappirattai chedi	*Cassia tora*	Leaves	Cooling agent
49	Pathi chedi	*Ageratina adenofora*	Leaves	Food
50	Poochakai root	*Sapindus emarginatus*	Root	Pain
51	Puda tree root	*Sterculia guttata*	Root	Fever
52	Pungam bark	*Pongamia pinnata*	Bark	Snake bite
53	Puruvai tree bark	*Dalbergia sp.*	Bark	Stomach pain
54	Seengai bark	*Acacia intsia*	Bark	Cooling
55	Shikakai	*Acacia coincina*	Fruit	Dandruff
56	Silai thatthiri kodi	*Canavalia sp.*	Leaves	Food
57	Kolanji fruit	*Citrus sinensis*	Fruit, leaves	Fruit edible
58	Sirumushttai kilangu	*Argyreia pilosa*	Rhizome	Food
59	Thadasu bark	*Grewia tiliafolia*	Bark	Astringant
60	Thagarai	*Rhynchosia sp.*	Fruit	Edible
61	Thulsi leaves	*Ocimum sanctum*	Leaves	Cooling
62	Thumbai chedi	*Leucas aspera*	Leaves	Fruit
63	Thumbikkai	*Leucas aspera*	Leaves	Fruit
64	Ulluku chedi	*Cynoglossum zeylanicum*	Leaves	Edible
65	Vengai bark	*Pterocarpus marsupium*	Bark	Stomach pain
66	Wrong seengai root	*Acacia pennata*	Rhizome	Food

Results and Discussion

The results obtained from the study area *viz*., total number of households in each village, family size and the nature of the forest are presented and discussed hereunder to understand the circumstances under which they live.

Exploring the Medicinal Plants

Medicinal plant species represent a variety of life form ranging from lichen, algae, herbs, shrubs, climbers and trees, which were annuals to perennials. Moreover, these species are distributed all over the forest area and are characterised by seasonally. It is essential to have precise information on frequency of occurrence, distribution and the number of medicinal plants available in the natural forests for its sustainable management. From the present study it was clearly observed that, 90-95 per cent of the medicinal plants collected from the natural forests

were utilized for their local use and only limited quantity was traded both in national and international level. Unfortunately, most of the plants were being collected by these tribes and sold to the traders for a meagre amount as raw form without any value addition. They even unaware of the high value of the end products obtained from these medicinal plants.

Out of the 66 medicinal plant species explored from the present study, the maximum share was for trees with 30 species which recorded for various medicinal usages by these tribal communities and was followed by herbs (18 species), shrubs (12 species) and climbers (6 species) which were also assessed for various medicinal usages (Table 2). The plant species found most frequently were collected by these tribes from the forest for their regular day to day consumption use and some of the rare medicinal plants were also collected only during certain season and occasionally from the adjoining forest areas. There is a need to document the threats which increase biotic interference and climatic change and that requires an urgent need to create awareness among the local people for the sustainable utilization as well as conservation of these medicinal plants in their original habitat (Vishnu Kumar *et al*., 2022).

The observation of the present study revealed that traditional medicine plays an important role in the life of the common public. Nilgiris district, the ecologically rich and diverse area comes under the Western Ghats range of mountains, which is known to have
a flora for its fortune and variety has only a few parallels in the world. Unfortunately, such a rich tropical forest is deteriorating due to various forces both by natural and human being. The use of medicinal plants for curing diseases in human culture is almost as old as man himself. In India, the most primitive mentioned use of medicinal plant is found in Rig veda.
It is remarkable to note that, most of the drugs derived or initially isolated from higher plants were exposed in an ethno botanical context.

Overall availability is limited not only by its quantity but also seasonal requirements of demand. However, the oldest, richest and most diverse cultural trading associated with the use of medicinal plants by the villagers make its sustainability. As for as medicinal plants were concerned, all the people in these villages never involved in harvesting these plants from the forest areas and the same was confirmed by these villagers by themselves during the data collection. Only limited people having the knowledge on the use of medicinal plants were collected and used for treating others.

Conclusion

The present study concluded that, the tribal community depend on the medicinal plants available in the nearby forest areas to use in their day-to-day life, even if they have the accessibility of Western medicines through primary health care centres. The joint family system of living which was observed in the study area could help in transferring the vast traditional knowledge base of the elders in using the medicinal plants to the next generation people. In the current situation, resource evaluation has to be taken up on priority basis and proper documentation of the traditional knowledge base of the tribal community is very much required for the benefit of the future generation and to develop local industries. Also, indigenous research and development efforts are also necessary to generate rural employment.

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Micro Greens – A Novel Nutrient-Packed Venture for The Improvement of Health and Income

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Microgreens are a stage between sprouts and fully grown greens, often known as Thalirkeerai in Tamil. They are popular in the West and gaining attraction in India. Unlike regular greens, microgreens include not only traditional leafy greens but also vegetables, pulses, and grains. Micro greens are tiny edible plants that are older than sprout, but younger than a full-grown plant harvested from 1-2 weeks after germination. They are harvested after the first "TRUE" leaves have developed. They have three basic parts such as a central stem, cotyledon leaf or leaves and typically the first pair of very young true leaves. About 4 to 40 times more nutrients are available in micro greens than their mature counterparts. They're rich in nutrients, easy to grow at home, and can be harvested within a week for freshness. Even picky eaters, especially kids, can enjoy them, offering a solution to malnutrition issues

Investment Cost

Starting a microgreens business is affordable, with an initial investment of Rs. 5000 to 10000. Quality seeds are the main expense. Home cultivation on racks is a good start before venturing into a business. Microgreens require minimal water, no soil medium, and can be grown without chemical fertilizers or pesticides, providing complete nutrition and chemical-free food.

A woman-friendly career

Microgreens cultivation is ideal for women at home or students due to its low labour requirements. The method allows for value addition, creating opportunities for additional income. Government incentives for food processing and value addition further support this venture. Besides being consumed fresh, microgreens can be dried and powdered, adding nutritional value to various foods,

Challenges

However, challenges include the need for immediate sale due to moisture loss, understanding market demand, and preventing fungal damage through proper ventilation and water drainage. Choosing a sunny spot with five to six hours of sunlight daily can help overcome some challenges

Cultivation of micro greens

Various seeds can be used for microgreens, making it profitable for farmers, especially in Tamil Nadu, where pulses like green gram, black gram, horse gram etc., are cultivated more. Seeds like fenugreek, mustard, sesame (black & white), wheat, barley, rye, green gram, black gram, horse gram, green and red amaranth, radish, cabbage, beetroot etc. Microgreens can even be grown hydroponically with just water. Overall, this technology not only provides nutritious greens but also offers self-employment opportunities for women and additional income for farmers, contributing to overall economic well-being. Media used for cultivation of micro greens are potting mixture, coca peat, hydroponic, tissue paper etc.

Value addition of micro greens

Microgreens can be used anywhere and everywhere in the diet like Salads, Smoothies, Rolls, Sandwiches, Chutneys, Raw consumption, Many Recipes from microgreens like Uttappa, Pulav, Potatao tikka, Idly, Poha, Paratha, Green Punch etc., Micro greens can be dried and powdered and can be



incorporated in the doughs prepared for cookies production,

Advantages of Micro greens

- Microgreens: Bridging the Gap between sprouts and fully grown greens
- Diverse cultivation options beyond traditional greens
- Harvesting within a week for optimum freshness
- Expanding nutritional choices beyond regular greens
- Encouraging children to eat healthier with microgreens
- Tackling malnutrition through innovative dietary solutions
- Affordable minimum investment
- Focusing on quality seeds as the key to success
- Recommending home cultivation on racks as a starting point
- Gradually transitioning from home cultivation to a business
- Highlighting the eco-friendly aspects of microgreens
- Empowering women and students through microgreens cultivation
- Utilizing spare time for a rewarding and flexible venture
- Exploring opportunities for additional income through value addition
- Government incentives for food processing and value addition
- Utilizing a versatile crop seed for profitable cultivation
- Tailoring microgreens to suit the pulse-centric agricultural landscape of Tamil Nadu

Conclusion

Microgreens can be utilised for improving health and prosperity. Microgreens can act as a solution for self-employment and increased income. It can be recommended for encouraging farmers to embrace microgreens cultivation for their economic improvement.

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Success Story: Rise of A Farmer as Leader in the Nursery Industry in Kalyan Karnataka Region

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Sri. Nagaraj S/o Basavaraj Segaji, 36 years old, 15 years farming experience B.Sc. graduate young farmer from Dhangapur village, Aland taluka, Kalaburagi district journey from a young farmer to a successful entrepreneur is an inspiring tale of determination and agricultural innovation. His venture into the nursery business began modestly with the cultivation of papaya and watermelon seedlings within a 30*40 feet shade house first time in Kalyan Karnataka region. Over time, fueled by his passion and dedication, he expanded the enterprise to include a variety of vegetable seedlings. Earlier this region farmers were highly depended on Maharashtra state border towns for vegetable and fruits seedlings, it leads to costly due to transportation also time consuming. In this regard, Segaji studied the situation and decide to start the nursery business, finally he succeed.

He was advised by the KVK experts to scientifically grow and raise the nursery of vegetable and fruit crops, for getting better returns. He took vocational training on scientific nursery raising of crops, their production and protection technology at KVK, Kalaburagi.



As demand for his high-quality seedlings grew, Mr. Nagaraj made strategic investments in advanced equipment, enhancing the efficiency and scale of his nursery operations. Recognizing the significant presence of sugarcane in the region, he seized the opportunity to the opportunity to diversify, adding sugarcane seedlings to his portfolio and he also purchased Sugarcane Combined Harvester. This expansion further solidified his position in the market.

A pivotal moment in Mr. Nagaraj's success story was the construction of a three-acre poly house, a testament to his commitment to adopting modern agricultural practices. This move not only increased



production but also showcased his forward-thinking approach to horticulture.

What sets Mr. Nagaraj apart is not just his entrepreneurial acumen but also his commitment to community development. Providing employment opportunities for 30 families, he has become a key contributor to the local economy. With an impressive annual turnover of 4 crores, his nursery business stands as a testament to the profitability achievable through sustainable and innovative agricultural practices.

One distinctive aspect of Mr. Nagaraj's enterprise is his hands-on approach to customer service. Operating his own vehicle for seeding directly to farms, he ensures a seamless and personalized experience for his clientele. His reputation for delivering top-notch seedlings has made his a trusted name in the industry.



In essence, Mr. Nagaraj's success story mirrors the transformative power of passion, hard work, and a commitment to quality. From the humble beginnings of a small shade house, he has cultivated thriving nursery business that not only sustains his livelihood but also enriches the agricultural lands cape of the region.

His immense contribution in the field of agriculture especially in nursery in the year 2020, he had been awarded as **'Super Star Farmer'** award at district and state level from leading Kannada daily Vijaya Karnataka and **'Best farmer'** award at taluka level under ATMA Scheme from state agriculture department, Kalaburagi. Recently he awarded **"Millionaire farmers of India Awards 2023"** by IARI, Pusa campus, New Delhi during 06-08 December, 2023.

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High-Throughput Phenotyping for Crop Improvement

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One of the most effective strategies for boosting the productivity of the main food and feed crops in the world is through breeding and genetic improvements in plants. Nonetheless, the field of crop improvement needs to change to meet the expanding challenges concerning climate change. In order to classify germplasm and experimental populations and find relevant genes or QTLs, modern crop improvement approaches rely on both precise quantification of plant attributes (phenotyping) and DNA sequencing (genotyping). Even with recent improvements in genomics, the development of genomics-assisted crop improvement initiatives has been hindered by inadequate findings in gene/QTL discovery due to inadequate phenotyping data (phenomics data). Thus, there is an urgent need to obtain the high-throughput, efficient, and thorough trait data required to comprehend the genetic contribution to phenotypic variation.

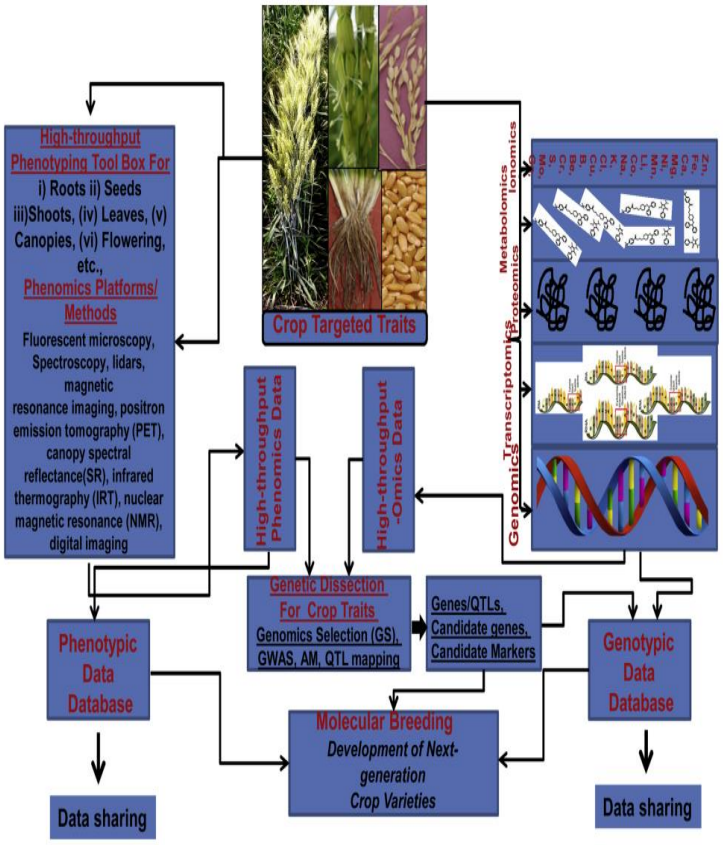


Fig. 1. Holistic view of role of crop phenomics in crop improvement.
[Source:10.1016/j.plantsci.2019.01.007]

The quick development of phenomics is now necessary to maintain and boost crop yields while utilizing the benefits of modern genetics methods. With the use of contemporary phenomics instruments, hundreds or even thousands of plants can have their characteristics, including growth, biomass, photosynthesis, and architecture, measured in a single day. Large plant populations, breeding material, germplasm collections (core collections), and population mapping could all be screened using high-throughput phenotyping platforms with greater accuracy and precision in the acquisition of phenotypic traits and less labour input thanks to automation, remote control, and data (image) analysis pipelines that support high-throughput. Progress has been already made, but more research is required to fully utilize genomics and molecular breeding tools in crop improvement (Fig. 1).

Networks and programs for plant phenotyping

Plant phenotyping is an ever-evolving field, with high-throughput, non-destructive techniques gradually replacing invasive, low-throughput approaches. Crop phenomics has been transformed in the last ten years by the quick advancement of low-cost, non-destructive sensors and imaging methods. Utilizing advanced technologies, non-destructive high-throughput phenotyping platforms are currently being implemented with the following capabilities:

i) scanning temperature profiles and transpiration using infrared thermography and imagery;

ii) measuring photosynthesis rates using fluorescent microscopy/spectroscopy;

iii) assessing plant growth rate and structure using 3D reconstruction;

iv) measuring growth rates using light detection and ranging (LIDAR);

v) measuring growth patterns, root/leaf physiology, water relations, and/or assimilate translocation properties using magnetic resonance imaging and positron

emission tomography and magnetic resonance imaging;

vi) canopy spectral reflectance for monitoring dynamic complex traits;

vii) scanning temperature profiles and transpiration using infrared thermography and imagery;

viii) measuring photosynthesis rates using fluorescent microscopy/spectroscopy;

ix) assessing plant growth rate and structure using 3D reconstruction;

x) measuring growth rates using light detection and ranging (LIDAR);

xi) measuring growth patterns, root/leaf physiology, water relations, and/or assimilate translocation properties using magnetic resonance imaging and positron emission tomography and magnetic resonance imaging;

xii) canopy spectral reflectance for monitoring dynamic complex traits;

xiii) nuclear magnetic resonance for monitoring the structure of tissues, mapping water movements, and monitoring sucrose allocation; and

xiv) digital RGB imaging for recording data on various attributes of roots, shoots, leaves, seeds and grains.

Phenotyping platforms in trait phenotyping: some examples

With the development of various high-throughput phenomics platforms and methods over the last ten years, a wide range of plant traits, including growth, phenology, physiology, disease incidence, insect damage, drought tolerance, and data on various plant organs like roots, seeds, and shoots, have been phenotyped. For instance, high-throughput and automated data collection has been conducted on various phenotyping platforms concerning plant height, leaf growth parameters (leaf area, canopy area, photosynthesis, photosynthesis efficiency, chlorophyll content, leaf nitrogen content, and canopy height) in various plant species, such as wheat, maize, barley, rice, pea, Arabidopsis, potato, canola, and soybean. Similarly, one of the most significant yet challenging to capture phenological features in rice is flowering, or spikelet anthesis.

Table 1. Details of use of selected phenomics platforms for trait phenotyping in plants.

Platform /Technique/Software	**Traits recorded/ Approach used**	**Crop**
Growth traits, phonological traits and physiological traits		
Light Curtain arrays (LCs)	Rapid determination of plant height and leaf area	Maize, barley, rapeseed and tomato
Microsoft Excel-based macro, a tool called "LEAF-E"	Analysing leaf growth parameters	Maize, *Miscanthus* spp. and *Brachypodium distachyon*
Dual-mode microwave resonator	Water content of leaves and the ionic conductivity of the leaf	Potato, maize, canola and wheat
Phenoplant	Chlorophyll fluorescence parameters impacted on leaves by a stress	Arabidopsis
GROWSCREEN FLUORO	Growth and photosynthesis (PSII) efficiency	Arabidopsis
Imaging based methods	Chlorophyll-a fluorescence (ChlF)	Arabidopsis

Reverse phenomics utilizes a suite of new tools applied to a limited set of germplasm to elucidate common strategies responsible for stress tolerance or yield potential. It involves in-depth dissection of physiological traits down to the level of deducing underlying biochemical or biophysical processes. This helps to identify traits like yield components underpinning a superior crop variety through a hypothesis-driven (rather than a descriptive) screening approach. Thus, reverse phenomics can be used, for example, when the phenotype or target trait

is already known and the goal is to determine the mechanism(s) responsible for controlling the trait and identify the responsible gene(s). Reverse phenomics tools and technology are already being used by the Australian Plant Phenomics Facility (http://www.plantphenomics.org.au/) and the Australian National University (http://www.garnetcommunity.org.uk/resources/phenomics). Both forward and reverse phenomics approaches are being used at CIMMYT in wheat to develop advanced lines with complementary physiological traits for drought tolerance as well as yield potential and heat tolerance. In summary, reverse phenomics is used to better understand the trait constellations that contribute to yield. while forward phenomics is used to identify better sources of those traits.

Integrating high-throughput trait phenotyping with genomics for genetic dissection of traits

The effectiveness of genetic dissection and reliability of marker-trait associations identified largely depends on the accuracy of trait data. The evolution of high-throughput phenomics platforms during the last decade has revolutionized trait phenotyping by helping in recording data effectively and cost-efficiently. The data generated was used in trait dissection using a variety of approaches like QTL interval mapping, association mapping, candidate gene association studies, genome-wide association studies, QTLseq and genomic selection leading to discovery of genes/QTLs for important targeted traits. For instance, QTLs/genes/associated markers have been identified for different traits including root traits, seed traits, morphology, biomass, yield (rice), osmotic tolerance (wheat), boron tolerance (barley), biomass (brassica), plant growth traits, and biomass (in maize). The rice automatic phenotyping platform (RAP) was used for high-throughput screening of recombinant inbred line (RIL) mapping population combined with genome-wide association studies (GWAS) that led to the identification of 141 associated loci, 25 of which were previously known genes such as the Green Revolution semi-dwarf gene, SD1. Thus high-throughput phenotyping has the potential to replace traditional phenotyping techniques and can provide valuable for gene identification.

The combination of the multifunctional phenotyping tools HRPF and GWAS provides deep insights into the genetic architecture of important traits. Similarly, in maize by combining the high-throughput maize phenotyping platform and the high-density linkage map, 988 QTLs including three QTL hotspots were identified that provided the opportunity to investigate QTL distribution at the genome wide level.

Summary

In summary, combining the high-throughput phenotyping technology and large-scale QTL analysis not only greatly expanded our knowledge of the maize dynamic development process but also provided a new strategy for breeders to optimize plant architecture toward ideotype breeding in maize. It is important to mention here that the genetic dissection approaches routinely used for trait dissection like genome-wide association studies (GWAS) and linkage mapping typically use measurements at the whole organ or organismal scale that results in generation of too complex to dissect out the biological processes information. Therefore, use of effective phenotyping data with omics approaches including transcriptomics data that changes as a consequence of climate has offered new perspectives for genetic integration of several levels of molecular regulation of phenotypic trait variation.

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Weed Management Strategies in Organic Farming

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Adoption of nutrient-responsive, high yielding crop cultivars together with the indiscriminate use of synthetic agrochemicals like fertilizers and insecticides led to deterioration of soil and environment. Therefore, it is vital to reduce environmental deterioration to the absolute minimum and increase the productivity of damaged soils. The practice of organic farming is one way to achieve this. Weeds generate more losses (34%) to agriculture than any other type of agricultural pest. Moreover, weeds can serve as a home for some plant viruses and host insects. The potential yield of the majority of cultivated crops is decreased by weeds because they naturally expand more quickly, occupy agricultural habitats, and do so. Since the widespread use of agro-chemicals has allegedly led to issues with the environment and human health, there is currently resurgence in interest in organic weed management techniques. Minimizing losses due to weeds, pests and diseases necessities farmers choice of synthetic chemicals usage which has several adverse effects on environment and human health. While herbicides are considered the main means of control in many countries of the world, there is increasing recognition that non chemical methods of weed control have numerous advantages. It's crucial to realize that weeds can never truly be eradicated under an organic system; they can only be managed. The main objective of a weed management strategy in an organic system is to lower weed competition and reproduction to a level that the farmer can tolerate. Non-chemical weed control techniques are to be encouraged for the protection of human health, the environment, and weeds that are resistant to herbicides.

Weed Management Strategies

An integrated weed management (IWM) strategy is to be used to manage weeds on an organic farm. To keep weed populations below the point at which they cause economic harm, and environmental quality preservation is the main objective of IWM.

Preventive Strategies

Prevention is the least expensive technique. This can be accomplished by planting weed-free seed, adopting adequate watering techniques and managing agricultural machines.

Cultural Strategies

1) **Tillage:** Tillage affects weed survival by burying whole plants and weed seed, exposing the root system to drying and cold, and reducing the food reserves of weed plants. Tillage also lessens compaction, prepares seed bed and incorporates fertilizer and wastes. Summer fallow and deep summer ploughing are viable cultural option to stop weed development in organic farming. Summer ploughings aid in managing the *Cyperus rotundus*. Weed occurrence is decreased by puddling in rice. Compared to no tillage and conventional tillage, deep tillage with mould board plough reduced the population of Phalaris *minor* by 13.7% and 8.5%, respectively.

2) **Crop rotation:** Crop rotation is the best cultural strategy for integrated weed management programme in organic farming to disrupt the weed's active growth cycle. Long rotations and diverse cropping systems are frequently followed by organic farmers to improve soil fertility and economic viability. Paddy crop rotation with sugarcane, vegetable crops, sunflower and pulses minimizes the weeds. Rice cultivation can fully eradicate wild oat. Sunflower and cotton encourage *striga* spp. to germinate, but because they are not hosts for this weed, they completely suppress it. Crop rotation is supposed to be an excellent practice for controlling various noxious and mimicry weeds such as *Phalaris minor*.

3) **Cover crops:** Weeds are suppressed by the crop's quick growth and dense ground coverage. Cover crops including defense against soil erosion, enhanced soil structure, increased soil fertility and weed control. Including cover crops into the

cropping system, such as rice bean, groundnut, rye, red clover, buckwheat, winter crops inhibit weed development because its ability to control weed growth, lower weed populations in the next crop. Moreover, cover crops can operate as a living mulch or organic mulch to further control weed growth during the growing season.



Fig 1. Crop rotation

4) **Intercropping:** The weeds can be successfully controlled using intercropping. Fast growing and early maturing intercrops like cowpeas or mung beans between two rows of the primary crop may be taken for this purpose. In addition to providing fodder, intercropping cowpea with maize and harvesting in 40-45 days after seeding effectively controls weeds. The weed problem is significantly reduced when soybean and peanuts are interplanted with upland rice, maize, or sorghum.

5) **Field scouting:** Short-term weed management decisions are made using the knowledge to lessen or prevent financial crop loss. In long- term field scouting is useful in evaluation of success or failures and for making wise decision in future weed management program.

6) **Mulching:** The basic idea behind mulching is to keep the weeds' tops dark until their reserve food supply in the roots runs out and they starve. Clean straw, hay or manure, sawdust, crop stolons and black plastic are examples of mulch. With wheat cultivated after rice, straw management is crucial for weed control.

a) **Living mulch:** Clover is an example of a plant species that typically grows densely and low to the ground and is used as living mulch. Living mulches can be planted either before or after a crop has begun to grow. In order to prevent living mulch from competing with the actual crop, it is crucial to kill it or somehow regulate it. When transplanting broccoli, spread a live mulch made of *Portulaca oleracea* to control weeds without compromising crop output. Living mulch frequently has other goals besides weed control, such as enhancing soil fertility, reducing pest problems, or improving soil structure.



Fig.2 Mulching with Soil

b) **Organic mulch:** Several materials that can be produced on a farm, including as hay, straw, grass mulch, agricultural wastes, and livestock or poultry bedding, are used as organic mulches. There may also off-farm sources for other materials, like leaves, composted municipal trash, bark, and wood chips. Mulching with organic materials can improve soil structure, water infiltration, aggregate stability, and soil biological activity. It can also assist increase soil organic matter.



Fig.3 Mulching with Paddy straw

c) **Degradable plastic mulches:** Plastic mulch that degrade are either photodegradable or biodegradable. After the growing season,

degradable materials do not need to be removed from the field, and some can even be mixed into the soil to hasten the process. In nurseries and with some high-value crops, reusable materials, such as black polypropylene mulch, can be utilized to manage weeds over time.

7) **Stale seed bed preparation:** The steps in this weed control method are to provide a fine seedbed, allow weeds to grow, and then remove weed seedlings directly using light cultivation or flaming. This method aids in giving the crop a chance to emerge and flourish before the subsequent weed flush. This can be done 2-3 times before planting, if time permits.

8) **Soil solarization:** Soil solarization is a unique weed control method that heats the soil for several weeks using solar energy. Due to this polyethylene sheet coating, soil reaches high temperatures of 50-60 °C during the summer. When compared to non-solarized soil, solarized soil exhibits a considerable reduction in weed flora. Solarization involves heating the soil to destroy nuisance organisms like weed seeds, fungi, bacteria and nematodes.

9) **Sanitation and composting:** The introduction and spread of weeds can be minimized by paying special attention to agricultural sanitation and seed sources. When utilized in many locations, equipment and tools should be fully cleaned before being used in another area. Add weed free mulch and compost to field otherwise it may contain seeds that subsequently cause a problem.

10) **Selection of crop cultivars:** Selection of crop cultivars plays an important role in crop weed competition because of morphological features, canopy structures and relative growth rate. The traditional tall growing varieties perform better than modern dwarf varieties under unweeded situations and this is the reason that most of organic growers grow traditional tall varieties. A cultivar that provides early canopy cover and grows quickly outcompetes weeds.

11) **Sowing time:** An essential agronomic practice for managing weeds is changing the sowing window. Crop sowing is scheduled for a time when weed seed germination is unfavourable, but not far enough away to affect crop performance. Wheat seeded in October has less *Phalaris minor* infection.

12) **Seed rate/planting density:** In order to increase the early smothering capability of crop plants on weeds, increasing seed rate or planting density aims to produce more crop plants per unit area. Rice with a higher plant density (44 plants/m^2) has less weed biomass. Higher than usual seed rates can boost crop output and competitiveness, giving the crop the upper hand over weeds.

13) **Water management:** In transplanted rice, weeds can be controlled with a 15-day submergence interval. Due to the soil being wetted only around the plant base, drip irrigation in wider row crops minimizes the intensity of weeds and thus has minimal weed development. In dry areas, the alternate furrow technique also reduces weed intensity. Weed growth in a field is influenced by irrigation timing and technique. Careful irrigation management can lessen weed burden on crops effectively.

Mechanical Strategies

Mechanical method of weed control, such as hand weeding and pulling, include removing weeds using various tools and instruments. In general, hand weeding is most effective in light soils and is less effective when grassy weeds are present.

1) **Manual methods:** Mechanical removal is most efficient way to manage weeds in organic farming. This includes removing weeds by hand and using hand tools or instruments, such as a wheel hoe, to hand-weed. The best mechanical weed management methods involve burying weed seedlings to a depth of 1 cm and cutting them at the soil surface. But this method has a limitation because of manpower shortage. The most successful method for minimizing the buildup of weed dry matter was mechanical weeding performed twice at the 15 and 30 day stages. Due to rising labor costs and labour shortages during the busiest weeding times, mechanical weeding has now largely taken the role of manual weeding.

2) **Flame cultivation:** On the majority of organically grown crops, broadcast flame cultivation before sowing the crop can be employed successfully. It works better on a smooth dirt surface than one that is bumpy or cloddy. Moreover, it works better against broadleaf weeds than grasses, however it loses power as weeds get older. When flaming burns grasses and perennial weeds to the soil's surface, these weeds can occasionally sprout again. During flame cultivation, it is important to carefully seed or transplant crops to avoid disturbing the soil and promoting the germination and establishment of weed seeds.

Biological Strategies

The natural method for weed management in organic agriculture would seem to be biological control.

1) **Allelopathy:** Allelopathy, meaning mutual harm, is an interference mechanism in which a living or dead plant releases allelochemicals exerting an effect on associated plants which plays an important role in natural and managed ecosystems. Several plants express the allelopathic phenomenon through exudation of allelochemicals. For example, rye is among the most important allelopathic crops. Rye can be used to suppress weeds in a cropping system as a rotating crop, cover crop, or mulch, but the most popular way to do so is as a cover crop. Sorghum produces a number of allelochemicals, which are toxic to associated weeds. The most potent allelochemical released by the roots of sorghum is called sorgoleone. In sustainable agriculture, breeding new cultivars with high allelopathic potential may have a significant impact on biological weed management.

2) **Beneficial organisms:** Few studies have been done on the use of predatory, parasitic insects or microorganisms to control weed populations. A weevil for the aquatic weed salvinia, a rust for skeleton weed and possibly the most well-known natural enemy, a caterpillar (*Cactoblastis* sp.) to manage prickly pear have proven effective. Significant research is also being done on microbes and fungus (myco-herbicides) to be more successful in controlling particular weeds. Myco-herbicides are solutions containing pathogenic spores that are sprayed on plants using typical herbicide application tools.

Some biocontrol agents and commercial mycoherbicides used for weed control are indicated below.

Table 1: Fungal, viral and bacterial agents for weed control

Pathogens or agents	Weeds
Alteraria. destruens	*Cuscuta.* spp.
Alteraria. eichhorniae	*Eichhornia crassipes (Mart.) Solms*
Alteraria. helianthi	*Xanthium strumarium* L
Ascochyta caulina Cercospora chenopodii	*Chenopodium album* L.
Bipolaris setariae	*Eleusine indica* (L.) Gaertner
Cochliobolus lunatus	*Echinochloa crus-galli* (L.) P. Beauv.
Crytobagus singularis (weevil)	*Salvinia molesta*
Dichotomophthora indica D. portulacea	*Portulaca oleracea* L.
Exserohilum monoceras	*Echinochloa* spp.
Myrothecium verrucaria	*S. obtusifolia Portulaca* spp. *Euphorbia* spp.
Phoma chenopodicola	*C. album, Cirsium arvense, Setaria viridis*
Phomopsis convolvulus	*Convolvulus arvensis* L.
Phyllachora cyperi	*Cyperus rotundus* L.
Pyricularia sp.	*Digitaria sanguinalis* (L.) Scop.
P. grisea	*E. indica*
Pseudocercospora nigricans	*S. obtusifolia*
Sclerotinia sclerotiorum	Multiple species
Septoria tritici f. sp. *avenae*	*Avena fatua* L.
Pepino mosaic virus	*Solanum nigrum* L.
Araujia mosaic virus	*Araujia hortorum* E. Fourn.
Obuda pepper virus	*S. nigrum*
Pseudomonas syringae pv. *tagetis*	*C. arvense*
P. fluorescens strain WH6	Multiple weeds
P. fluorescens strain D7	*Bromus tectorum* L.
Zygrogramma bicolarata	*Parthenium hysterophorus*
Crocidosema lantana	*Lantana camara*
Dactylopius tomentosus (Cochineal scale)	*Opuntia dilleni*
Neochetina eichhornea N. Bruchi (Hyachinth weevil) *Sameodes alliguttalis* (Hyachinth moth)	*Eichhornea crassipes*

Table 2: Commercial Bio herbicides

Pathogens	Target Weed
Acremonium diospyri	Diospyros Virginian L. trees in rangelands
C. gloeosporioides f. sp. aeschynomene	Aeschynomene virginica (L.) (Northern joint vetch) in soybean and rice
A. cassiae	Cassia obtusifolia L., C. occidentalis L., in soybean & peanut
C. rodmanii	Eichhornia crassipes (Mart.) Solms
P. canaliculata	Cyperus esculentus L. in soybean, potato, corn, and cotton
C. coccodes	Abutilon theophrasti Medik. In corn and soybean
C. gloeosporioides f. sp. Malvae	Malva pusilla Sm. In wheat, lentil, and flax
Chondrostereum purpureum	Prunus serotina (Ehrh.) in forests
Emmalocera sp. stem boring moth	Echinochloa sp.in Rice and wheat
Gastrophysa, Beetle	Rumex sp. in Rice and wheat
Bactra verutana (Shoot boring moth)	*Cyprus rotundus in Rice and wheat*

Organic Herbicides

A limited number of natural substances can serve as herbicides on organic farms.

1) **Corn gluten meal:** Corn gluten meal, a byproduct of the manufacturing of cornflour, is the most extensively used commodity in the country. It is possible to use maize gluten meal as a pre-emergence herbicide. Redroot pigweed, black nightshade (*Solanum nigrum*), curly dock, purslane, common dandelion and smooth crabgrass are among the weeds that are adversely impacted by maize gluten meal. Barnyard grass and velvetleaf are the least susceptible weeds to corn gluten meal among those that have been studied. In general, grasses are less vulnerable to corn gluten meal than broadleaf plants.

Indigenous Practices

These are the indigenous weed management practices which the farmers have been using on their farms.

Calotropis: By maintaining chopped calotropis branches along irrigation channels or entrances, striga populations are reduced.

Cotton shells: Cotton ball shells can be used to suppress the noxious plant *Cyprus rotundus*. Before the rainy season, a 3-inch-thick coating of nutshells is spread around the pitch. Afterwards, to fully absorb it into the soil, the land is cultivated. This causes the weed's root or sedge to burn or die. For around two to three years, the field remains weed-free. Decomposition transforms it into organic manure and aids in boosting crop yield.

Coriander: *Striga asiatica* in sorghum is managed with coriander. The sorghum rows are interspersed with coriander seeds. For every three kg of sorghum seeds, 200 g of coriander seeds are sowed. When the coriander plants reach a certain size, the strands begin to wrap themselves around striga weed, which inhibits its growth.

Conclusion

Reducing the deleterious effects of weeds on crops is the ultimate goal of weed management. Integrated weed management includes all practices that enhance a crop's competitive ability and decrease weeds' ability to reduce yield. Today, there is a renewed interest in organic methods of managing weeds since the widespread use of agro-chemicals has resulted in purported environment and health problems. Therefore, It is important to understand that under an organic system, weeds will never be eliminated but only managed.

Effective weed management is the major challenge for successful organic farming. IWM comprising cultural, mechanical and biological practices are warranted for managing weeds in an eco-friendly way in organic farms. In addition to the growing concern for protection of environment, maintain biodiversity and protection of human and animal health, IWM approaches are also good ways of climate change mitigation. Careful selection of cropping systems (intercropping, crop rotation etc) and controlling weeds during critical period of crop-weed competition are important for sustainable weed management. Research efforts are required to develop location specific bio-herbicides for use in organic farms.

Nano Fertilizers an Emerging and Sustainable Attribute in Aquaculture

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Aquaculture is the culturing of aquatic organisms like fishes, crustaceans, and molluscs under controlled conditions. In aquaculture, fertilizers supply essential macro and micronutrients, which help support phytoplankton growth. The primary producers in the aquatic food chain are the phytoplankton, which carry out photosynthesis. Phytoplankton require many elements, classified either as macronutrients (C, N, P, K, H, O, Ca, Mg, Na, S, Cl) or micronutrients (B, Cu, Co, Fe, Mn, Mo, Si, V, Zn), for growth (Reynolds, 1984; Lin et al., 1997; Boyd and Tucker, 1998). Apart from this, phytoplankton helps maintain optimum culture conditions. Growth of Phytoplankton gets severely affected if nutrients are unavailable in optimum amounts. Hence, the fertilization of ponds is essential to ensure the optimum growth of phytoplankton, thereby increasing overall productivity. The United Nations predicts that the world's population will reach 8.5 billion by 2030, 9.7 billion by 2050, and 11.2 billion by 2100 (UN, 2023), and this will lead to increased pressure on the available cultivable land to feed the world's ever-growing population. To meet the growing human population's demand, using fertilizers to enhance productivity becomes crucial.

Kinds of Fertilizers used in Aquaculture

Primary nutrients supporting phytoplankton growth are N, P, K. Aquaculture applies urea to supplement nitrogen, SSP (Single Super Phosphate) to supplement phosphorus needs, and MOP (Muriate of Potash) to meet potassium needs. Conventionally, chemical fertilizers provide nutrients for phytoplankton growth. Chemical fertilizers regularly increase primary production four to five-fold compared to unfertilized ponds, but when fertilizer nutrients are depleted, primary production returns to that measured in unfertilized ponds (Hepher, 1962). Organic fertilizers increase the primary productivity of aquaculture ponds. Animal manures, litter, agricultural by-products, and fresh or dry plant materials comprise organic fertilizers (Wohlfarth & Schroeder, 1979; Das and Jana, 2003; Kumar et al., 2004). Organic fertilizers are produced naturally compared to chemical fertilizers.

Problems associated with the use of conventional fertilizers

Chemical fertilizers, when used in excess amounts, can reduce soil fertility, and pollute the environment. In the case of conventional fertilizer, half of the applied fertilizer is lost and becomes unavailable to plants. Leaching of nutrients is also a widespread problem encountered with the use of chemical fertilizer. When these fertilizers leach into adjacent water bodies, they can cause eutrophication and disturb the entire ecology of that water body. Repeated use of chemical fertilizers harms beneficial microbes present in soil. Despite having an advantage over chemical fertilizers, organic fertilizers have disadvantages. Farmers need to apply organic fertilizers extensively because of their low concentration of nutrients and the slow release of nutrients. To address these problems, nano fertilizers can provide an effective means to deliver nutrients in optimum amounts. With the application of nano fertilizers, we can also promote precision aquaculture.

Nanotechnology in aquaculture

Nanotechnology offers immense application in diverse areas. Various fields extensively exploit nanotechnology, and its use in aquaculture is growing and will grow exponentially. Nanotechnologies have broad applications in fishery, such as nano filters for water treatment, nano feed, and nano fertilizer. One such area which holds much potential is nano fertilizers as an alternative to conventional chemical fertilizers in aquaculture.

Nano fertilizer

Nano fertilizers contain nanomaterials in the nanoscale range of 1-100nm in the form of nanoparticles containing macro and micronutrients that release nutrients in a controlled manner. Nano fertilizer offers benefits in nutrition management through their strong potential to increase nutrient use efficiency. Nano fertilizers are macronutrient nano fertilizers and micronutrient nano fertilizers. In the

case of the former, macronutrients (such as N, P, K, Mg, S and Ca) are combined with nanomaterial. In contrast, in the latter's case, micronutrients (such as B, Fe, Mn and Cu) combine with nanomaterial.

Classification of nano fertilizer

Nano fertilizers are classified according to several ways. One such is listed below.

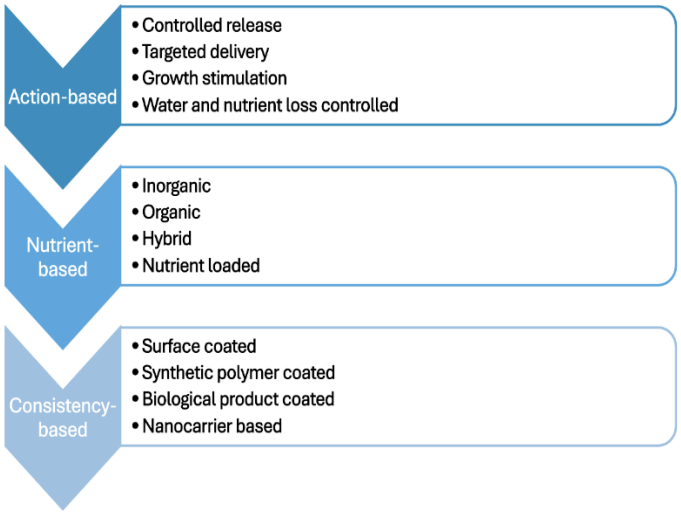


Figure 1: Classification of Nano fertilizer

Synthesis of Nano fertilizers

Nanoparticle formulation uses several approaches: top-down, bottom-up, and biological approaches. The top-down process involves disintegrating larger particles of the bulk materials until they reach the nanometric scale. Bottom-up begins at the atomic or molecular scale to build up nanoparticles using chemical reactions. In most cases bottom-up is the most effective approach used nowadays for nano fertilizer production (Zulqar et al., 2019). On the other hand, the biogenic approach involves natural sources like plants and microorganisms such as fungi and bacteria.

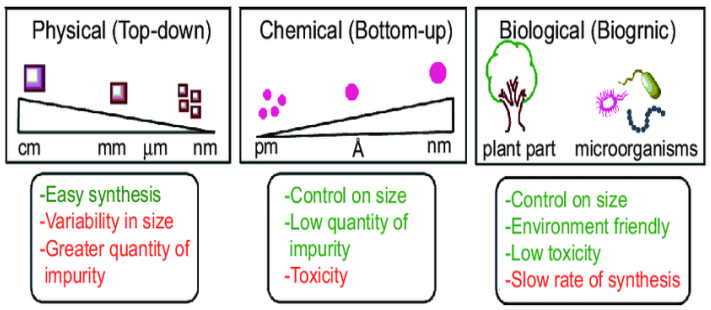


Figure 2: Representation of methods to produce nano fertilizers: physical (top-down), chemical (bottom-up), and biological approaches and advantages and limitations (Bernela et al., 2021).

Table 1: Comparison between Nano fertilizer and conventional chemical fertilizer (Thavaseelan and Priyadarshana, 2021)

Properties	Nano fertilizer	Conventional Chemical Fertilizer
Rate of nutrient loss	Low loss of fertilizer nutrient	High loss rate
Controlled release	The rate of release and release pattern are precisely controlled	Excess release of nutrients leads to high toxicity and imbalance
Solubility	High	Low
Bioavailability	High	Low
Dispersion of mineral micronutrients	Improved dispersion of nutrients	Low solubility due to enormous size particles
Effective duration of release	Effective and extended duration	The plant uses them while changing the rest to insoluble form.
The efficiency of nutrient uptake	Enhanced uptake ratio and saves fertilizer resource	Uptake is low
Soil adsorption and fixation	Reduced	High

Nano fertilizers in the market

IFFCO nano urea is a nano fertilizer approved by the Government of India and included in the Fertilizer control order. It is developed and patented by IFFCO. Applying one bottle of nano urea can effectively replace at least one bag (45kh) of urea (Figure 3) . It contains 4% total N(w/v) evenly dispersed in water. Nano nitrogen particle size varies from 20-50nm. Because of its higher efficiency, it can reduce the requirement of conventional urea by 50% or more. It also helps in conserving soil, air, and water quality. The Department of Biotechnology, Government of India, and OECD international guidelines test nano urea for biosafety and toxicity. Nano urea is nontoxic and safe for the user and safe for flora and fauna. One should use a facemask and gloves when applying. Another nano fertilizer

manufactured by IFFCO is nano DAP, an efficient source of available nitrogen and phosphorus. Nano DAP formulations contain 8% nitrogen (w/v) and 16% phosphorus (w/v). Nano DAP liquid formulation has an advantage regarding surface area to volume as its particle size is less than 100nm. Besides this, through precision and targeted application, nano DAP fulfils the nutritional requirements without harming the environment.



Figure 3: IFFCO nano fertilizer-Nano urea and Nano DAP

Effect of nano fertilizer on Water quality in aquaculture

Nano DAP application to aquatic system will improve the water quality parameters e.g., dissolved oxygen, reduced turbidity and higher electrical conductivity as compared to the control. Among the nano fertilizer available in market Nano DAP reduce the pH and increase the salinity of the system as compared to Nano Urea.

Advantages of Nano fertilizers

Nano fertilizers have a high specific surface area to volume ratio, imparting high reactivity and increasing nutrient bioavailability. Another significant advantage is dosage reduction, as smaller amounts of nano fertilizer are sufficient to meet the nutrient needs. Chemical fertilizers release nutrients faster than nano fertilizers, which regulate the release of nutrients in a controlled manner. Nano fertilizers also help improve soil fertility and develop a feasible environment for microorganisms, causing less environmental harm. Nano fertilizers also help in improving nutrient use efficiency. The frequency of fertilization is crucial as excess fertilizer application leads to poor water quality. As nano fertilizers are readily absorbed, they need to be applied decisively. Researchers use Secchi disc transparency to determine the need to fertilize water bodies.

Disadvantages

Exposure to nano fertilizers can lead to serious health risks due to associated cytotoxicity and genotoxicity. Most studies related to nano fertilizers are carried out on a small scale or on a laboratory scale. Research gaps and a need for long-term environmental studies also exist; industrial manufacturing of nano fertilizers is also challenging.

Conclusion

Nano fertilizers hold vast potential to replace the existing chemical fertilizers used in aquaculture. Nano fertilizers occupy an upper edge due to their numerous advantages. Though applying and using nano fertilizers are at a starting stage, scientists expect positive results from them. Much research needs to be done in this area to explore and uncover the potential of nano fertilizers. Apart from these, nano fertilizers will help achieve precision aquaculture.

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Protection of Plant Varieties and Farmers Rights Act in Relation to Plant Breeding

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The improved varieties have contributed significantly in increasing the productivity of crop plants. Both public and private institutions spend huge money and time to develop superior varieties to enhance agricultural production. In the past, free exchange of germplasm across the globe has resulted in a great success in crop improvement. The classical examples are the worldwide use of dwarfing genes in wheat and rice, which have revolutionized the global agricultural production. But with the signing of WTO in 1995 and to recognize the contributions of breeders and farmers, it has become necessary to protect the resultant intellectual property and to grant a license to the sponsors of the research. The legal protection of intellectual property is the only way to accomplish this. In this context, the Plant Patent Act of USA passed on May 12, 1930 was the first legal protection granted to asexually propagated plants and was indeed the first patent in the world to benefit the plant breeders. Later on sexually reproducing plants were also made patentable through Plant Variety Protection Act of 1970 in USA. Initially the protection was not awarded to plants and other living organism, being produced by nature, and was not eligible for patent. But the Plant Protection Act of 1930 recognized that breeders create products that are more than mere product of nature. After this, different forms of Plant Breeders' Rights (PBR) were adopted in Europe, and Netherlands took a lead to adopt PBR by adopting a Plant Breeders' Decree in 1941. On January 1, 1948, a convention known as General Agreement on Trade and Tariffs (GATT) was set up to regulate the world trade and to grant a minimum level of protection to plant varieties. However, the issue of Plant Breeders' Rights became alive only after the establishment of UPOV Convention in 1961 (UPOV is an acronym derived from French, which means, "International Union for the Protection of new varieties of Plants"). In this convention, the role and contribution of the plant breeders was recognized on an international basis. Under this law, the breeder is given the exclusive rights to produce his variety for the purpose of commercial marketing and sale. However, exemption is granted to farmers to use their own saved seed (Farmer's exemption) and breeders for using the variety for research and development of other varieties (Breeder's exemption). The Convention was amended in 1972, 1978, 1991 and 1993 to make additional provision regarding the Plant Breeders' Rights. Arthur Dunkel, the then Director General of General Agreement on Trade and Tariffs (GATT) presented the Dunkle Draft at Uruguay in 1986, which makes it necessary that some form of IPR should be introduced for plants either as patents or an "effective *Sui generis* (of its own kind) system" in line with UPOV. In 1995 World Trade Organization (WTO) replaced GATT.

Protection of Plant Varieties and Farmers Right Act

India has signed an agreement on Trade Related Intellectual Property Rights (TRIPs) under World Trade Organisation in 1995 and has agreed to provide protection to plant varieties either by patenting or by a *Sui-Generis* system or a combination of both. However, the Indian Patent Act of 1970 does not permit the patenting of plants or varieties, whereas in advanced countries like USA and Japan, the patenting of plant varieties is allowed. In India, Plant Variety Protection (PVP) replaces the patents because of the fact that variety development involves the improvement of already existing plants and not *de novo* creation. For this purpose, the Government of

India made an act "Protection of Plant Varieties and Farmers Rights Act (PPV&FR Act) in 2001. The Rules and Regulation to implement this PPV&FR Act were formulated in 2003. For the effective implementation of these rules and regulations, the Government of India established an authority known as "Protection of Plant Varieties and Farmers Rights Authority in 2005. The PPV&FR Authority started functioning from October 2006. The authority consists of a Chairperson and 15 members.

Notable Features of Protection of Plant Varieties and Farmers Rights Act

- To provides an effective system for protection of plant varieties
- To protect the rights of plant breeders to encourage the development of new varieties of plants, stimulate investment for research and development, both in the public and private sector for the development of new plant varieties, and accelerate agricultural development in the country
- To protect the rights of the farmers in respect of their contribution made at any time in conserving, improving and making available plant genetic resources for the development of new plant varieties.
- To facilitate the growth of seed industry in the country which will ensure the availability of high-quality seeds and planting material to the farmers

Under this act, the followings rights of the breeders, researchers and farmers are protected:

Breeders Rights

- It provides an exclusive right to breeder or his successor or his assignee to produce, sell, distribute, import or export the seed of protected varieties
- The breeder can also authorise any person to produce, sell and distribute the seed of protected varieties under certain conditions laid down in the act

Researchers Rights

- The researcher has the right to use the protected variety for research purpose
- He has the right to use the protected variety for the development of new varieties
- However, the authorisation of the concerned breeder will be required for the repeated use of the protected variety for the commercialization of the new variety (e.g. hybrid)

Farmers' Rights

- Right to save, use, exchange, sow, re-sow, share or the sell the product of protected variety, except the sale of branded seed
- Right to benefit sharing from the contribution of his variety or plant materials in the development of new variety
- Right for compensation for low performance of the protected variety: The breeder has to disclose to the farmers the expected performance of the protected variety under the given conditions. If the protected variety does not perform as specified, the farmer has a right for compensation for the low performance.
- Recognition and Reward to the farmers for conservation of land races and development of farmers' varieties.
- Just like breeder, he can register his variety (Farmers variety/traditional variety)
- Farmers are exempted from the payment of registration fee
- Farmers to be protected from the act of innocent infringement. If the farmer who is not aware of the existence of this act and unknowingly breaks the law of protection, then that farmer will be considered as innocent but he has to prove his innocence before the court.

Who can apply for registration

Any person claiming to be the breeder or his successor or assignee or any person authorized by the breeder; any farmer or group of farmers or farming community

Types of varieties, which can be registered with PPVFRA

Three types of varieties namely Extant, New and Essentially Derived Varieties can be registered with the Protection of Plant Varieties and Farmers' Rights Authority.

Extant variety

- A variety which is available in India and notified under section 5 of Seed Act (1966)

- A Farmer's variety (a variety traditionally cultivated and evolved by the farmer at his own field, can be a land race or wild relatives)
- A variety which is of common knowledge
- A variety which is in public domain

New Variety

A variety will be registered as a new variety if its seed has not been offered for sale before one year from the date of application for registration. It should confirm the criteria of Novelty, Distinctness, Uniformity, and Stability. Novelty means the variety to be registered must be new and has not been commercialised before one year from the date of application. The distinctness means that the variety should be clearly distinguishable from the other varieties by at least one essential characteristic. Uniformity means that the variety should be sufficiently uniform in its essential characteristics. Stability means the essential characters should remain unchanged after repeated propagation.

Essentially Derived Variety (EDV)

A variety which is derived through single gene transfer, recurrent back cross derivatives, mutants, soma-clone variants, CMS lines, polyploids, substitution/deletion lines all come under EDV. EDV can be registered, if it differs from the initial variety for at least one character and meets the DUS test.

Varieties which cannot be registered

A variety, which contains any technology that is injurious to the life or health of human beings or animals or plants including terminator technology, shall not be registered.

Crops which can be registered

In the first phase, the Protection of Plant Varieties and Farmers Rights Authority has started the registration of varieties of the following 14 crops: Rice, Bread Wheat, Maize, Sorghum, Pearl millet, Peas, Chickpea, Pigeon pea, Green gram, Black gram, Lentil, Kidney beans, Cotton and Jute

Duration of registration

The varieties are registered initially for a period of six years in case of crops and nine years in case of trees and vines. The registration can be renewed up to a maximum period of 15 years in case of crop varieties and 18 years for trees and vines.

Compulsory licensing

If the seed of the protected variety is not available after three years of registration in adequate quantity at a reasonable price, the PPV&FR Authority may grant a license to a third party to undertake the production of the seed of the protected variety, its distribution and sale with limited royalty to the concerned breeder. The duration of the compulsory licence may vary from case to case keeping in view the gestation period and other relevant factors but it shall not exceed the total remaining period of the protection of that variety.

Benefit sharing

On registration of a variety, any person or a group of people can submit his claim of benefit sharing to the PPVFRA in the prescribed form and with prescribed fee if his/her material has been used in the development of a particular variety. The authority shall take the decision on the matter after considering the following points:

1. The extent and nature of the use of the genetic materials of the claimant in the development of the variety relating to which the benefit sharing has been claimed; and
2. The commercial utility and the demand in the market of the registered variety relating to which the benefit sharing has been claimed

Infringement of the act

Any person will be infringed under PPVFR Act if:

1. Who not being the breeder of the registered variety sells, exports or imports or produces the seed of such variety without the permission of the breeder of that variety;

2. Who sells, exports, imports or produces any other variety giving the denomination similar to the denomination of the registered variety

Penalties for infringement

Any person who applies any false denomination to the registered variety or indicate the false name of the country or false name and address of the breeder of that registered variety shall be punishable with an

imprisonment of three months to two years or a fine of Rs. 50,000 to 5 lakhs or both. Similarly, any person who makes false representation with respect to the denomination of a variety or its propagating material registered under the act shall be punishable with an imprisonment of six months to three years or a fine of Rs. one lakh to five lakhs or both. The subsequent conviction of an offence will be punishable for the second and for every subsequent offence with an imprisonment of one to three years or with a fine of Rs. 2 lakhs to 20 lakhs or both.

Impact of PPVFRA

Genetic improvement of crop plants through conventional breeding or with the help of genetic engineering is a resource and time-consuming process. Development of an improved variety generally takes 8-10 years. Therefore, once a variety is developed, it becomes necessary to protect it from its misuse and to provide incentive to the breeders/ farmers. Once a variety is registered with PPV&FRA, it gives exclusive rights to the breeder for its seed production, distribution and sale. He has the right to authorise any person on mutually agreed terms for the production, sale and distribution of seed of that variety. He will be entitled for his share from the royalty from the sale of that seed. Moreover, it will encourage others (breeders or scientists or farmers) to develop more varieties, which have some commercial value. Since the private seed industry is also involved in the production and sale of seed, it will stimulate both public and private sectors to invest more in the development of new varieties. The registration of a variety with PPV&FRA also ensures the maintenance and availability of high-quality seed or propagating materials of that variety, because once the variety is registered with PPVFRA, it becomes obligatory for the concerned breeder to supply the quality seed in adequate quantity and at reasonable price to the farmers. In addition, the breeder will evaluate the performance of his variety more effectively at farmers' field to avoid any litigation from the farmers for its low performance. Moreover, for protecting a variety, the breeder has to maintain the passport data of the variety and the parental material. On registration of a variety, any person (may be the farmer) or group of persons may submit his claim of benefit sharing if his or their material has been used in the development of that variety. Protection of varieties will lead to lawful acquisition of the research materials with MTA (Materials Transfer Agreement) or authorization from the owner.

Reference:

The Protection of Plant Variety and Farmers' Rights Act, 2001 (53 of 2001)

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Nurturing Sustainable Development: Bamboo's Role in Food, Economic and Ecological Security in North-East India

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Humans have a long and complex relationship with bamboo, an evergreen and adaptable plant. With a growth rate of up to 96 million hectares, it is the fastest-growing plant in India's 63.3-million-hectare forest. Approximately 43% of India's total bamboo wealth is found in North-East India. Particularly in rural regions it plays an important part in the daily activities of the people. The use of young bamboo shoots to be a health food source is less well-known than its commercial utilisation. Due to their high nutritional and medicinal value, shoots can be used to supplement diets deficient in certain nutrients and to feed the world's growing population. The ordinary individuals of the Northeastern region of India enjoy a better socioeconomic status thanks to bamboo, a priceless gift from nature. Bamboo's development habits and organic qualities make it not only a highly valuable investment with a multitude of applications, but it also has a significant potential to mitigate many of the ecological issues the world is currently facing. The role of bamboo in Northeastern India is discussed in this article, along with prospects in terms of environmental security, prosperity in the economy, and food safety.

Introduction

One of Asia's most varied and little-known regions is North East India. With more than 7000 endemic plant species, the Northeast, which is made up of eight states, is recognised as one of the "8 Hottest Biodiversity Hotspots." Because of its varied flora and fauna, this area is ranked sixth among the world's "25 Mega Diversity" hotspots. For a very long time, bamboo has been considered the most significant and prevalent type of vegetation. As a result, this area is also known as the "Indian bamboo paradise." In the Indian context, bamboo is unquestionably a valuable, enduring tropical natural resource with a variety of economic applications. Bamboos, 1575 species in a monocarpic group of non-wood forest plants given to humans by nature, are members of the Bambusoideae subfamily. It is also found in a variety of tropical and subtropical climates. Bamboo is thought to cover 8.96 million hectares, or roughly 63.3 million hectares, of India's total forest area. Of the 136 exotic and native species found in India, the states of Sikkim, Arunachal Pradesh, Mizoram, Nagaland, Manipur, Assam, and Meghalaya, comprise half of the total population of Bambusa sp., followed by West Bengal (Himalayan part). In addition, bamboo's significance has grown significantly because of its ability to be used to create "engineered bamboo" from regular bamboo using contemporary technology. Particularly related to forestry and agriculture, it is capable to cope with the novel difficulties which world is facing. Owing to the numerous uses of bamboo, the people of the Northeastern region are deeply entwined with the plant and its products. As a result, they go by different names depending on where they are. For example, in China, they are referred to as "Friends of the people," in Vietnam, "My brother," and in India, "Green Gold." Bamboos, which our ancestors have long considered to be little marvels, have long been essential for development and prosperity as well as for providing defence against untamed animal attacks. Bamboo is becoming recognised as one of India's most significant renewable natural resources at a slow but steady rate. The young bamboo shoots have many uses, but in the Northeast, they are also eaten. It has new uses in place of depleting wood resources as an alternative to costly construction. The bamboo market is expanding rapidly; estimates place the industry's value at $25 billion. It is now known as "green gold" due to its enormous environmental advantages, which include reducing pressure on tropical forests, which helps to mitigate climate change and stop deforestation. Previously known as "poor man's timber." It is noteworthy to mention that bamboo has countless applications, making it a vital resource for North East India's rural populace. This article provides a glimpse

into the worldwide context of bamboo and its significance in ensuring nutritious food, economic growth, and ecological stability in the North-eastern region of India.

Role of bamboo in food security

The main pillars of food security are transportation, purchasing, and output. Approximately 1.2 billion individuals worldwide, primarily in developing nations, do not have access to sufficient food to fulfil their everyday requirements, and an additional 2 billion people are micronutrients inadequate. With almost twice as many underweight children as sub-Saharan Africa, India has some of the highest rates of underweight children globally. Nutritious crops like bamboo shoots, native rice, buckwheat, flax, and numerous other wild pulses are widely available in the northeastern region. In the past, rural families have met their needs by using underutilised crops. Food and nutritional insecurity and poverty that beset rural as well as urban populations are usually caused by the dependence of farmers on only a handful of very particular crops and the loss of biological diversity in agriculture, which leads to smaller food baskets. Thus, when used appropriately, bamboo shoots, a resource that is often overlooked, can contribute to meeting the growing demand for nutrition, energy, and food, medicine, and industrial needs. Although young bamboo shoots are widely used in industry, it is comparatively less well known that they can also be eaten canned, fresh, fermented, or pickled. The term "shoots" describes the young, edible bamboo plants that have just recently broken ground. They typically weigh about a pound and are 20 to 30 centimetres long, tapering at one end. The shoots are covered in a sheath. Location, rainfall, drainage, fertilisation, soil depth, soil nutrition, pH, and temperature all have a significant impact on their weight. They are abundant in minerals, proteins, carbohydrates, and moisture. In contrast, there is less fat and cholesterol present. Young shoots from species such as D. giganteus have superior organoleptic qualities and are far more nutritious. The edible bamboo shoot is unique among cuisines because of its unmatched flavour and taste. Bamboo shoots are considered a traditional delicacy in many countries, including the US, Japan, Nepal, Thailand, Australia, New Zealand, Bhutan, Korea, Indonesia and Malaysia, in addition to India. Ethnic diversity individuals hailing from Nepal and Bhutan devour it as a pickles or chutneys while in the nation of Indonesia, the shoot is mixed with rich coconut milk and spices to make gulei rebung etc. and Sikkimese like to eat it as non-fermented curry identified as tama. Therefore, it is positively possible to use bamboo shoots to feed the world's growing population. In order to improve global food security, safety, and nutrition, it will be advantageous to supplement diets lacking certain micronutrients due to their therapeutic and nutritional benefits.

Bamboo for economic prosperity

For a living, a sizable portion of North East India's population mainly depends on bamboo. There is an abrupt increase in pressure on our global resources due to the continuous increase in demand for wood that has coincided with global population growth. Therefore, it is essential to use bamboo more in order to keep up with population growth, demands, and the rising cost of other conventional materials. Bamboo has long been employed for a wide range of tasks. The world has taken a fresh interest in it because of its rapid growth and sustainability. Bamboo plays a vital role in economic development due to its high annual yield. It has both conventional and modern applications. Historically, it has supported scaffolding, low-level suspension bridges, extra architectural detail or ornamentation, and split or woven bamboos. In addition, it is an excellent material for furniture, appliances, weapons, food, firewood, fuel, toothpicks, chopsticks, handicrafts, and musical instruments. Bamboo can now be used to produce high-end products like structural beams, flooring, panels, veneers, and decking thanks to recent advancements in processing technology. In modern uses, bamboos are being transformed into manufactured goods such as the bamboo curtain board, laminated bamboo board, bamboo mat board, ply bamboo, etc. Additionally, it has been stated that in practically every performance index, laminated panels outperform wood-based panels. Its value has actually been demonstrated from the top to the

rhizomes. It is a durable and adaptable natural resource with over 1,500 documented uses overall. It is primarily used in Southeast Asia, South Asia, and East Asia, where it has gained prominence due to its economic and cultural significance. Bamboo has a rich history dating back 5,300 years in China, where it was skillfully woven into practical items like mats and baskets. Its widespread use in tropical and sub-tropical regions is attributed to its exceptional weight-to-strength ratio and high-tension strength. With tensile strength of approximately 28,000 lb per square inch—higher than mild steel at 23,000—it proves resilient against forces from earthquakes and strong winds. This construction technique has been employed in seismically active areas of India. Additionally, in the globalized economy, bamboo trade is crucial for a nation's development, expanding external markets and boosting profits.

Bamboo for ecological security

Bamboo, once considered a low-cost alternative to timber, has transcended its status and is now recognized as the "wonder plant" of the twenty-first century. With ecological benefits such as land restoration, soil and moisture preservation, and financial stability, bamboo plays a crucial role in biodiversity conservation and reducing pressure on natural forests. In India, where environmental challenges have historically disrupted communities, bamboo's resilience has been evident in mitigating climate change effects. As a longstanding commercial crop in the Northeast, bamboo demonstrates biogenomic resilience, aiding in the accumulation of organic matter, soil balance, and the reversal of soil degradation in overused landscapes. Bamboo can also be used to control sedimentation and pollution from agricultural runoff, filter waste water, and regulate water flows. Without a doubt, bamboo is essential for fostering ecological security. Bamboo has numerous functions. Because of its biological properties, it is an ideal instrument for lowering atmospheric carbon dioxide levels. It can also slow down the rate of climate change by acting as a carbon sequestration agent. It might be a special and perfect environmentally friendly species for carbon credits. Altogether, it produces more oxygen than comparable tree strands, purifying the air and soil. It also aids in reducing light intensity and offers protection from UV rays. Bamboo, which grows the fastest canopy, can withstand extremely high annual precipitation levels of 30 to 250 inches. Bamboo's large species diversity allows it to grow in a variety of conditions with comparatively little nutrient requirements. Furthermore, it revitalises degraded lands by growing there and reestablishing healthy forest ecosystems. Bamboo roots and rhizomes can spread widely horizontally and grow shallowly into the ground. For example, Bambusa tulda roots can reach 5.2 metres in a horizontal direction. Their tightly woven root mats have a considerable ability to bind the topsoil. The cultivation of the rich volcanic ground on the steep hillsides in the north-central Andes has been going on for thousands of years, made feasible only by the bamboo plantations. It can preserve soil by reducing erosion thanks to its deep root system. Bamboo serves multiple purposes, effectively reducing siltation, managing floods, and conserving water in catchment areas. Its robust nature makes it an ideal material for safeguarding sea banks, canal banks, riverbanks, and dam sites. Planted along streams and rivers, bamboo's rapid growth, facilitated by a consistent water supply, provides effective protection during floods by halting strong currents with its thick culms and stabilizing banks with its fibrous roots. Beyond flood control, bamboo plays a crucial role in preventing landslides, a significant contributor to land degradation. By maintaining river courses, slowing water flow, and countering desertification trends, bamboo emerges as a versatile solution for environmental protection.

Conclusion

Bamboo is a plant species that is used by humans on a daily basis and has many advantages for the economy, ecology, and health. Given the aforementioned considerations, it is imperative that North-Eastern India prioritise the large-scale mass planting of bamboo. Hopefully, this will significantly contribute to reducing the loss of biodiversity, the effects of climate change, nutritional deficiencies, and unstable economies. It will offer plenty of opportunities for the direct or indirect employment of unemployed people through the marketing and

production of raw bamboo and its value-added products, improving the region's ecological, economic, and food security.

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Optimizing Nanofluids Properties Using Artificial Intelligence for Applications in Food Processing Industry

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The term "artificial intelligence" (AI) was coined by researchers at the Massachusetts Institute of Technology (MIT) during the organization of an academic conference in the same year. The inaugural AI program, known as Logic Theorist, was presented at the Dartmouth Conference, showcasing its proficiency in proving mathematical theorems (Shukla et al., 2013). Presently, AI research has diversified across various domains, prominently including expert systems, neural networks, and robotics (Hemmat and Afrand, 2020).

AI encounters intrinsic physical constraints within its operational scale, where governing principles significantly deviate from the macroscopic realm (Bahiraei et al., 2019). The assessment of thermal, kinematic, and physical properties represents a highly intricate, time-consuming, and resource-intensive process. The integration of AI into the food industry has revolutionized conventional approaches to food safety and quality assurance. As technological advancements continue, it is imperative to explore future trends that will define the next frontier of AI in ensuring the safety and quality of our food supply.

Properties of Nanofluids

The nature of nanoparticles (NPs) and base fluids are the key factors that decide the nanofluid (NF) preparation methods to get the desirable properties. There are two methods of NFs preparation, one-step and two-step methods but it is found that the two-step method is more efficient for preparing NFs with metal oxides (Eastman et al., 2001). Although one-step method has benefits of simultaneously producing and dispersing particles in base fluid, due to high cost of production, its applications get constrained to lab-scale production only (Yu and Xie, 2012).

But two-step method is comparatively economical and thereby adopted for large scale production of NFs (Mukherjee and Paria, 2013). In this method of production, NPs are first synthesised in dry powder form and then dispersed in base fluid with the help of homogenization, high shearing, magnetic stirring or ultrasonic agitation. Suitable surfactants can be used to overcome the sedimentation and agglomeration of NPs by creating a repulsive force among NPs.

Machine Learning (ML) Techniques for process optimization

The application of machine learning (ML) techniques becomes pertinent in NF research. Several ML methodologies, including artificial neural networks (ANNs) such as the multi-layer perceptron artificial neural network (MLP-ANN) and radial basis function artificial neural network (RBF-ANN), group method of data handling (GMDH), adaptive neuro-fuzzy inference system (ANFIS), category and regression tree (CART), random forest (RF), and support vector machine (SVM) including the least-square support vector machine (LS-SVM), have been investigated.

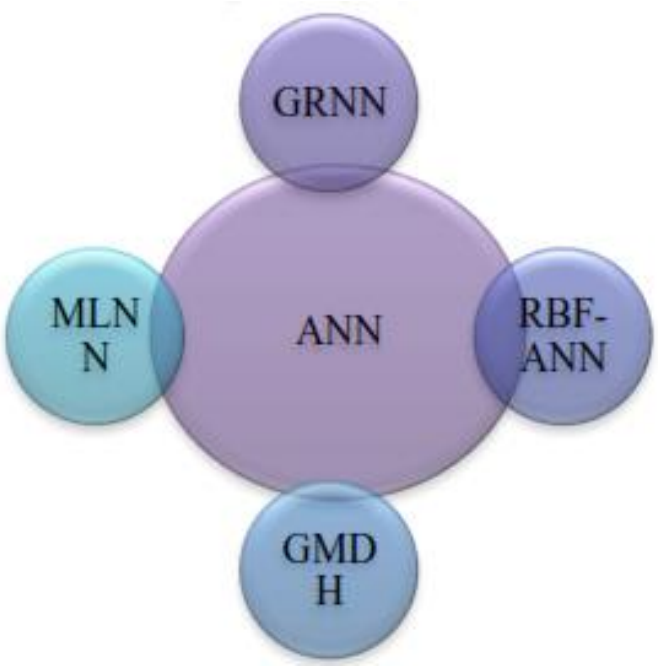


Fig. 1: Algorithms for Artificial Neural Network

Additionally, these ML approaches can be effectively combined with metaheuristic algorithms such as genetic algorithm (GA), particle swarm optimization (PSO), and imperialist competitive algorithm (ICA) to further enhance prediction accuracy and computational efficiency (Ma *et al.*, 2021). Artificial neural network Artificial Neural Networks (ANNs) stand out as the foremost and widely adopted algorithms in the realm of AI (Gao et al., 2018a). ANN has four types of algorithms as shown in figure 1 (Gao *et al.*, 2018b).

Other applications of AI in food industry

Predictive Analytics for Early Risk Detection

One of the key future trends is the widespread adoption of predictive analytics in food safety. AI algorithms can analyse vast datasets to identify patterns and potential risks, allowing for early detection and prevention of food safety issues. This proactive approach minimizes the likelihood of contamination and ensures a swift response to emerging threats.

Blockchain and AI Integration

The synergy between blockchain and AI is anticipated to play a pivotal role in enhancing transparency and traceability in the food supply chain. Blockchain's decentralized and secure nature combined with AI's analytical capabilities will create a robust system for tracking and verifying the journey of food products from farm to fork. This integration is poised to revolutionize accountability and reduce the risk of fraud or contamination.

AI-driven Sensory Evaluation

The future will witness advancements in AI-driven sensory evaluation techniques. Smart sensors and AI algorithms can mimic human sensory capabilities, leading to more accurate and consistent assessments of taste, texture, and overall quality in food products. This technology ensures that consumer preferences are met consistently, contributing to improved product development and customer satisfaction.

Robotics in Quality Control

The introduction of robotics, empowered by AI, will redefine quality control processes in food manufacturing. Robots equipped with advanced vision systems can perform intricate inspections, identifying imperfections or anomalies that may go unnoticed by human inspectors. This automation not only ensures precision but also speeds up the inspection process.

Personalized Nutrition with AI

AI applications will extend into the realm of personalized nutrition, tailoring food products to individual preferences and dietary needs. By analyzing consumer data and health profiles, AI algorithms can recommend or create personalized food options, contributing to healthier choices and catering to the growing demand for personalized diets.

Ethical Considerations and Transparency

As AI becomes more deeply ingrained in the food industry, ethical considerations surrounding privacy, data security, and transparency will come to the forefront. Future trends will focus on developing frameworks and standards that prioritize consumer privacy, ensuring that AI applications adhere to ethical principles and build public trust.

The future of AI in food safety and quality assurance holds immense promise, with innovations ranging from predictive analytics to personalized nutrition. As these technologies evolve, stakeholders in the food industry must navigate the ethical landscape and embrace transparency to harness the full potential of AI in ensuring a safer, more reliable food supply for consumers worldwide.

Conclusion

The utilization of Artificial Neural Networks (ANN) is favoured due to their precision and ease of formulation without requiring complete knowledge of the system. These AI algorithms are simple to apply, adapt, and can overcome lengthy time delays. Among various neural network models, the Multilayer Perceptron (MLP) neural network has been extensively studied and employed in the field of NFs due to its simplicity. In NF research, the most commonly used neural network model is MLP, while the Radial Basis Function Neural Network (RBF-ANN) is the preferred training method. Although MLP is widely employed, RBF neural networks have

also found significant application in the NFs domain. Despite requiring more neurons than standard feed-forward ANNs, RBF-ANN can be developed in a shorter time compared to MLP neural networks. Furthermore, the Generalized Regression Neural Networks (GRNNs) exhibit a simple structure that reduces learning time, making them particularly suitable for NFs modelling when ample training vectors are available. Consequently, for NFs with a large number of samples, the use of RBF-ANN is recommended. However, it is important to acknowledge that despite the efficiency of neural networks in predicting NF characteristics, selecting the appropriate ANN type and determining its configuration still pose challenges. Further research and exploration are needed in this area.

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Status And Scope of Goat Rearing in India with Special Reference to Jharkhand

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The goat is a multi-functional animal and plays a significant role in the economy as well as in nutrition of landless, small and marginal farmers in the district. For this reason, Mahatma Gandhi said that goat as "Poor Man's Cow". Goat rearing can provide part time self-employment without affecting the main occupation for small and marginal farmers. Goat can be readily marketable at any point of time and provided the needy emergency fund to the rural farmers of India. So, goats are fondly called as ATM of rural India. The rural poor who cannot afford to maintain a cow or a buffalo find goat as the best alternative source of supplementary income and milk. The risk involved in goat farming is much lower when compared to other livestock and crop production. Goat is reported to be more economical than cattle and sheep under natural grazing/ browsing.

Status of goat population in India and Jharkhand

- Total Goat Population in the country is 148.88 million according to 20 th livestock census 2019 as presented in table 1.
- Total Goat has increased by 10.14% over previous Livestock Census (2012).
- About 27.8% of the total livestock is contributed by goats as presented in figure 1.

Table -1. Population of goat in 2012 and 2019 livestock census

Population Of Goat (In million) 2012	Population Of Goat (In million) 2019	% growth
135.17	148.88	10.14

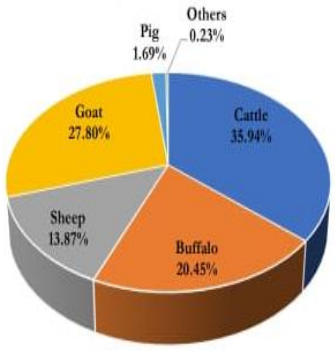


Fig. 1.- Graphical representation of goat population in total livestock population

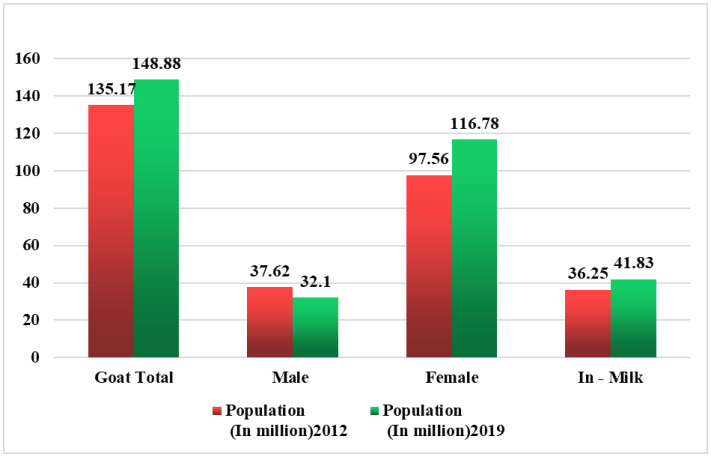


Fig 2. Graphical Representation of Goat Population in 2012 & 2019 (DHAD MF, 2019)

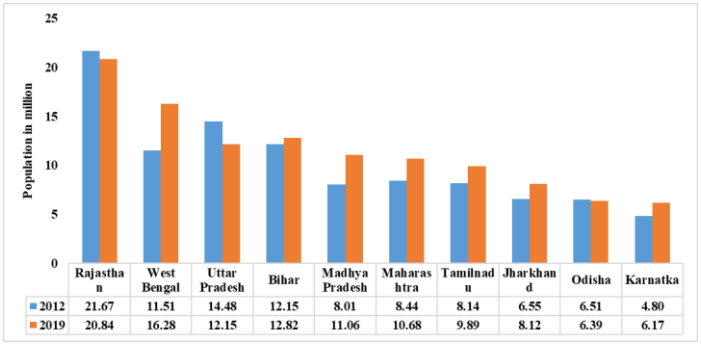


Fig 3. Graphical representation of Goat Population in Major States in 2012 & 2019 (DHAD MF, 2019)

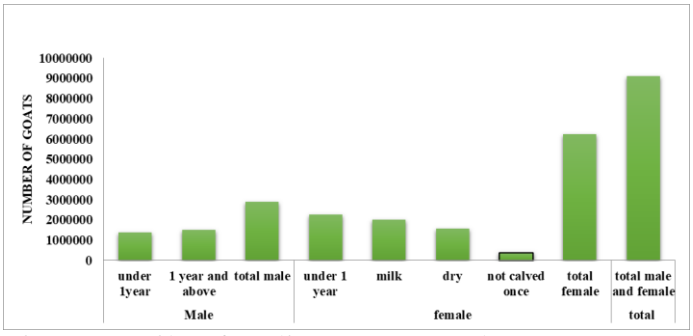


Fig 4. Details of Indigenous Goat by Age, Sex and Use in Jharkhand (DHAD MF, 2019)

Production status of goatery

- The total meat production in India was 7.38MT, 7.65 MT and 8.11 MT, 8.59 MT, 8.79 MT, 9.29MT and 9.76 MT in the year 2016-17, 2017-2018, 2018-19, 2019-20, 2020-21, 2020-21, 2020-21 and 2022-23, respectively. Out of which the contribution of Chevon was 1.04 MT, 1.04 MT, 1.09 MT, 1.21 MT, 1.26 MT, 1.26 MT and 1.41 MT 2016-17, 2017-2018,

2018-19, 2019-20, 2020-21, 2020-21, 2020-21 and 2022-23, respectively as preneted in table 5.

- Jharkhand shares **2.21 percent** in total chevon production of India in year 2021-22.

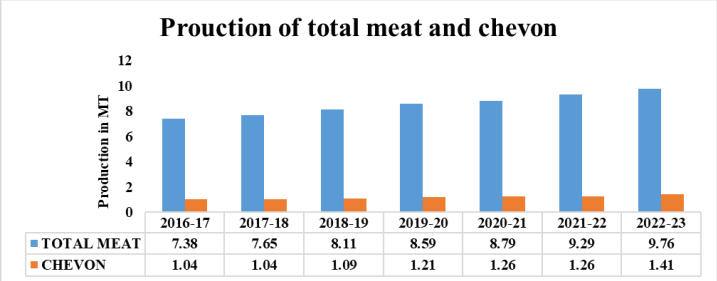


Fig. 5. Production trends of total meat and chevon production in India (BAHS, 2023)

- Per capita availability of meat in India was increased from 5.72 kg in the year 2016-17 to 7.10 kg in the year 2022-23, where as in Jharkhand increased from 1.53 kg in the year 2016-17 to 2.14 kg in the year 2022-23 as presented in table 6, which is far below than Indian Council of Medical Research (ICMR) recommendation of 11 kg/ person/year.

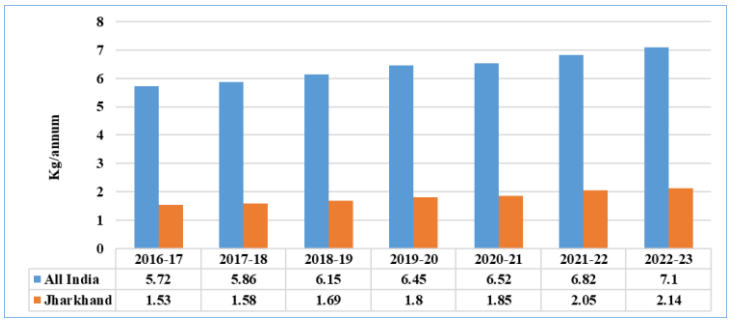


Fig. 6. Per capita availability of meat in India and Jharkhand (BAHS, 2023)

- The total production of goat milk in India in year 2016-17, 2017-18, 2018-19,2019-20,2020-21,2021-22 and 2022-23 was 5.75 MT,6.16 MT, 6.09 MT, 7.35 MT, 6.26 MT, 6.6 MT and 7.59 MT, respectively, out of which the contribution of Jharkhand was 1.3,1.38 MT, 1.49 MT, 1.58 MT, 1.90 MT and 2.29 MT respectively as presented in table 7.
- Jharkhand shares 2.29 MT in total goat milk production of India in year 2022-23.

Role of goatery in rural economy

- Goats play a significant role in providing supplementary income and livelihood to millions of resource poor farmers and landless labourers of rural India.
- Small ruminant rearing ensures self-employment and acts as a cushion in distress situations like drought, etc.
- Goat rearing has distinct economic and managerial advantages over other livestock because of its less initial investment, low input requirement, higher prolificacy, early sexual maturity, multiple product (milk, meat, fibre, skin, manure, etc.) use and ease of marketing.
- The goat husbandry also generates about 4.2% rural employment to the small and marginal farmers and landless labourers.

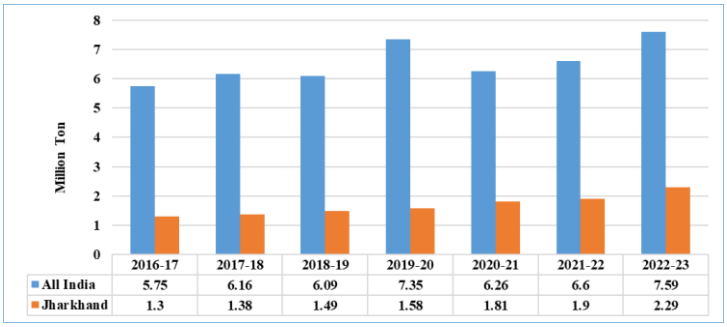


Fig 7. Total goat milk production in India and Jharkhand (BAHS, 2023)

Role of goatery in Indian economy (Lata and Mondal, 2021)

- Goats has tremendous role in providing supplementary income to nearly 70 million farmers in 0.5 million remote villages as well as improvement of socio-economic condition.
- Goats contribute 8.4% of the India's livestock GDP i.e. Rs. 38,590 crores through meat (Rs. 22,625 crores), milk (Rs. 9,564 crores), skin (Rs.1491 crores), manure (Rs.1,535 crores) and others Rs. 3,360 crores.
- India is largest exporters of sheep & goat meat. It has exported 14,128.85 MT of sheep & goat meat worth Rs. 646.69 crores in 2019-20. Major export destinations have been UAE, Qatar, Kuwait, Saudi Arab and Oman.
- Production of chevon increased steadily over the years. Country stands second in goat meat production in the world and has its 12% share.
- India produces 45 MT of pashmina per year from 0.0250 m pashmina goats and is less than 1% of the

total world pashmina production. Indian goats produce around 100-145 g of pashmina per year.

Scope of Goatery

- Goat husbandry provides glimpses of future hope for employment generation, nutritional security and prosperity to the millions of small and marginal farmers in the country.
- Demand for goat milk and milk products for internal consumption and export is expected to rise in coming years.
- Small ruminant rearing ensures self-employment and acts as a cushion in distress situations like drought and famine.
- The demand for meat, milk and fibre is increasing progressively and expected to further rise in future in view of sizable increase in per capita income and health consciousness of people.
- Worldwide consumers are preferring products that are "clean, green and ethical". As such goat producers are shifting to husbandry practices that do not compromise the welfare of animals.
- Medicinal properties of goat milk increased the interest of society to use it as therapeutic health food nutraceutical; moreover, biotechnologists are focusing on designer milk for human health.
- Goat farming involves less investment compared to other species.
- Wide acceptance of chevon all over India without any religious taboo and most preferred after poultry.
- The growing demands of the goat products.
- Low start-up cost.
- With the advent of modernization, urbanization and expanding human population, there will be a greater need for quality food.
- These human needs can only be sufficed by maximizing animal production in future, with global warming. Already we have seen unbelievable growth in poultry sector in the last 3-4 decades.
- The future of world goatery look bright and there are promising opportunities for all. The developed western nations have already attained pinnacle of industrialization, urbanization and modernization, hence there is less or restricted scope for future growth to different agri-businesses. But the developing regions like India which already have the largest goat populations, have true opportunity to become world leaders in goatery.
- There is ample scope for establishing cottage industries based on goat meat and milk products and value addition to skin and fibre.

Government schemes

- National Livestock Mission (NLM)-Entrepreneurship in Sheep/Goat Farming
- National Livestock Mission- Entrepreneurship in Feed & Fodder (Individual entrepreneurs, SHGs, FPOS, Cooperatives, Section 8 companies etc.)
- Animal husbandry infrastructure Development Fund (AHIDF) provided to FPOS, SHGS, Private companies, Individual entrepreneurs, Section 8 companies, MSMEs etc.
- Insurance for the animals under NLM- Livestock insurance (through the State Government)

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The Hidden Benefits of "Weeds": Embracing the Positive Side of Unwanted Plants

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Many people consider weeds to be the worst enemy of farmers and gardeners, since they can compete for resources, cause invasive growth, and require ongoing clearance. But beyond the surface, these plants have an interesting quality that is sometimes disregarded: they have the potential to be useful additions to agriculture and ecosystems. This essay will examine the benefits of so-called "weeds" and highlight the important roles they may play in fostering soil health, biodiversity, and even human well-being.

Biodiversity Support

In contrast to common assumption, a variety of weeds are vital to biodiversity. For numerous insects, the birds, and other species, plants such as these provide essential homes and food sources. For example, dandelion invasions of lawns are well-known, yet they also provide nectar to pollinators like butterflies and bees. By fostering the growth of some weed species, an area's overall biodiversity can be improved, leading to the creation of a more robust and balanced ecosystem.

Soil Health Improvement

Weeds are skilled at adjusting to various circumstances in the soil, and their growth habits can provide important insights into the quality of the soil. Weeds with deep roots, such as burdock or chicory, can aid in loosening compacted soil, enhancing water penetration and aeration. Moreover, taproots on certain weeds can draw nutrients from lower soil layers to the surface, which is advantageous for nearby plants. A few types of weeds also function as dynamic accumulators, drawing necessary minerals from the soil and releasing them for use by other plants once the weeds decay.

Nitrogen Fixation

Legume weeds, such as vetch and clover, have the remarkable ability to fix atmospheric nitrogen, owing to nitrogen-fixing bacteria present in their root nodules. This method not only allows these plants to



thrive in low-nitrogen soils but also increases soil fertility. Other plants may gain benefit by using the nitrogen that these weeds have accumulated by absorbing into the soil, which eliminates the need for synthetic fertilizers.

Medicinal and Culinary Uses

It may surprise you to learn that for millennia, people have used numerous plants that are called weeds for their culinary and medicinal benefits. Purslane, which is frequently found in gardening beds, is a good source of antioxidants and omega-3 fatty acids. Furthermore, another common weed that's edible and a wonderful source of vitamins and minerals is lamb's quarters. Accepting these plants for their therapeutic and nutritional benefits can give communities access to a free and sustainable supply of resources.

Erosion Control

Some weed species are useful means of stopping soil erosion because of their quick development and thick foliage. Even though they are invasive, plants like kudzu have been utilized to stabilize slopes and lower the danger of landslides. Using particular weeds' capacity to reduce erosion can be an economical and sustainable approach to save delicate ecosystems.

Conclusion

In conclusion, although the word "weed" may have a bad connotation, a closer examination exposes the diverse functions these plants provide in

sustaining both agriculture and ecosystems. By comprehending and valuing the advantages of specific weeds, we may create more environmentally friendly and sustainable methods of managing land. Perhaps it's time to change our minds and figure out how to live with the positive features of the plant world—even in the most unlikely places—instead of fighting these plants nonstop. Ultimately, what we may label as a weed may actually be nature's method of providing us with beneficial contributions we hadn't thought about.

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Silent Struggles: The Tragic Tapestry of Women's Lives in the Sundarbans

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In the heart of the vast and mystical Sundarbans Delta, where the tangled roots of mangrove trees intertwine with the ebb and flow of life, unfolds a tragic tale that transcends the beauty of nature and reveals the haunting vulnerabilities of women who call this enigmatic region home. Far removed from the bustling cities and modern conveniences, the women of the Sundarbans grapple with a myriad of challenges that cast a long shadow over their existence. Their vulnerabilities are deeply rooted in the very soil that sustains their communities, and the tale that unfolds is one of struggle, resilience, and an indomitable spirit against the odds.

The Sundarbans, a UNESCO World Heritage Site shared between India and Bangladesh, is a sprawling delta where the Ganges, Brahmaputra, and Meghna rivers converge before emptying into the Bay of Bengal. The beauty of this unique ecosystem belies the harsh realities faced by its inhabitants, particularly the women who navigate a delicate balance between nature's bounty and its unforgiving temperament.



The prologue to this tragic tale is written in the language of natural disasters. The Sundarbans, nestled on the edge of the Bay of Bengal, is a hotbed for cyclones and floods. The women, often the primary caregivers, find themselves at the mercy of these ferocious storms that can strip away their homes, their meagre possessions, and even their loved ones in the blink of an eye. In the aftermath, they are left to piece together shattered lives amid the debris of their once-thriving communities.

As the winds howl and the rivers swell, the economic fabric of the Sundarbans is torn asunder, marking the second chapter of this tale. For the women whose livelihoods are intricately woven into the fabric of agriculture and fishing, the capriciousness of nature means uncertainty and hardship. The salty waters of the Bay of Bengal encroach upon the fertile land, rendering it infertile and unsuitable for cultivation. The once-abundant fish stocks dwindle, leaving the women with empty nets and empty stomachs. The struggle to put food on the table becomes a Sisyphean task, pushing these women deeper into the abyss of poverty.

Education, or the lack thereof, emerges as a central theme in this tale. In the remote corners of the Sundarbans, where the cacophony of wildlife drowns out the sounds of progress, educational opportunities for women are scarce. The ripple effect of illiteracy is profound, limiting their access to information, healthcare, and avenues for economic empowerment. Trapped in a cycle of ignorance, the women of the Sundarbans are further marginalized, their dreams stifled by the oppressive weight of societal norms.

Health, both physical and mental, forms the crux of this tragedy. Sanitation facilities are a luxury, and the absence of proper hygiene exacerbates the vulnerability of women to diseases. The burden of healthcare falls heavily on their shoulders, and the lack of access to medical facilities means that even minor ailments can spiral into life-threatening conditions. The stigma surrounding women's health issues adds another layer of complexity, forcing them to suffer in silence, their pain concealed by the lush greenery that surrounds them.

The next chapter introduces the spectre of gender inequality. In a society where patriarchal norms dictate the roles of men and women; the women of the Sundarbans find themselves shackled by the chains of tradition. Limited decision-making power, restricted access to resources, and a lack of autonomy over their own lives perpetuate a cycle of dependence.

The cries for equality are drowned in the delta's vastness, where the struggle for survival overshadows the fight for basic rights.

Mangrove forests, the lifeblood of the Sundarbans, become both a refuge and a prison. While these unique ecosystems provide sustenance and resources, the conservation policies enacted to protect them sometimes backfire on the very communities that have coexisted with the mangroves for generations. Strict regulations limit access to the forest, depriving the women of the Sundarbans of the resources they depend on for their livelihoods. The delicate dance between conservation and survival becomes a tightrope walk over turbulent waters.

Migration and displacement form the penultimate chapter of this tragic tale. As the challenges mount, families are forced to abandon their ancestral homes in search of a better life. Women, often the pillars of strength in these communities, find themselves uprooted, grappling with the disintegration of familiar bonds and the uncertainty of the unknown. The echoes of their footsteps resonate through the dense mangrove forests as they embark on journeys fraught with hardship and heartbreak.

Yet, in the midst of this tragic tale, there is a glimmer of hope—the resilience of the women of the Sundarbans. As the rivers continue to weave their stories through the labyrinth of mangroves, these women stand tall against the adversities that threaten to engulf them. They form networks of support, sharing the burden of their struggles and drawing strength from the collective spirit that binds them. Their hands, calloused from years of toil, nurture a resilience that refuses to be extinguished.

In the epilogue, the tragic tale of the vulnerabilities of women in the Sundarbans Delta unfolds not as a narrative of despair but as a call to action. It beckons policymakers, activists, and communities to come together and rewrite the script. Empowering women with education, providing access to healthcare, dismantling patriarchal norms, and forging sustainable livelihoods are the keystones of a new narrative—one that transforms tragedy into triumph, vulnerability into strength, and despair into hope amidst the verdant beauty of the Sundarbans Delta.

Upon Summarisation, the potential problems and the respective solutions to these are provided in the table given below:

Problems	Solutions
Limited educational opportunities	Implement educational programmes for women
	Provide access to both formal and non formal education
	Raise awareness about the importance of education
Economic Vulnerability	Introduce skill development programmes
	Promote alternative livelihoods and income generating activities
	Facilitate access to microfinance opportunities
Environmental Challenges	Promote climate resilient agricultural practices
	Diversify livelihoods to decrease environmental dependency
	Integrate conservation policies with community needs
Inadequate Healthcare	Improve healthcare infrastructure in the region
	Establish health clinics and conduct health camps
	Provide access to reproductive healthcare services
Poor sanitation facilities	Develop clean and private sanitation facilities
	Promote awareness about menstrual hygiene
	Ensure the availability of affordable menstrual products
Gender inequality	Implement gender sensitization programmes
	Promote women's empowerment initiatives
	Encourage the active participation of women in decision making
Vulnerability to natural disasters	Establish community-based disaster preparedness programmes
	Create early warning systems and evacuation plans
	Ensure emergency response plans considering the needs of women

Limited access to government schemes	Facilitate access to government schemes through awareness campaigns
	Provide support services to help women avail themselves to benefits
Societal stigma and taboos	Conduct awareness campaigns to challenge societal norms
	Promote gender equality and inclusivity
Lack of infrastructure	Develop infrastructure for sustainable livelihoods
	Ensure access to clean water and energy sources
Migration and displacement	Implement programmes to address the challenges of migration
	Provide support for resettlement and community integration
Lack of empowerment	Encourage women's participation in decision making process
	Foster leadership roles for women in the community
Insufficient monitoring and evaluation	Establish a robust monitoring and evaluation framework
	Assess the impact of interventions and refine strategies accordingly.

The tragic tale of women in the Sundarbans is a haunting chronicle, etched with the vulnerabilities imposed by nature, society, and circumstance. It speaks of the relentless storms that strip away homes, the salt-laden winds that wither crops, and the societal norms that confine these women to the margins of their own stories. In this delta of hardships, the challenges are as vast and tangled as the roots of the mangroves that bear witness to generations of struggles. As we contemplate the conclusion of this tragic tale, it is imperative to recognize that within every tragedy, there lies the potential for transformation. The vulnerabilities faced by the women of the Sundarbans beckon not only sympathy but a call to action—a call to rewrite the narrative and sow the seeds of empowerment.

As we close this chapter of sorrow, let it be with the unwavering belief that within the fertile soils of tragedy, the seeds of resilience take root, and the tragic tale of Sundarbans' women becomes an epic of triumph over adversity—a triumph that resonates not only through the mangrove forests but across the tapestry of time, inspiring generations to come.

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Bad Cholesterol: The Biggest Medical Scam of All Time

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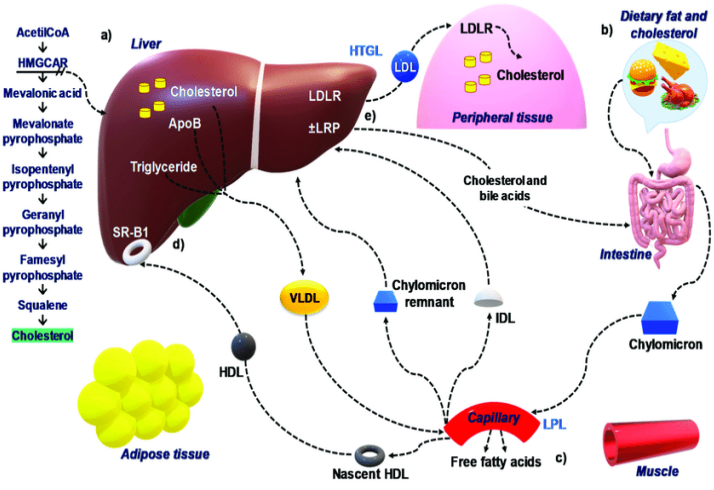
Food myths are the beliefs or perceptions related to nutritional aspects of certain food items having poor justification due to lack of scientific proofs or evidences. Many food products and their nutritive significances are misunderstood by consumers because of no proper nutrition education as well as spreading of some wrong information. The concept of bad and good cholesterol is such a popular food myth which affects the food consumption pattern and dietary habits of people of almost all countries worldwide. The complexity of nutrition science and the lack of definitive research contributed to such confusions and resulted people's avoidance of eggs in their daily diet, especially in USA and other Western countries in fear of catching cardiovascular diseases since 1970s. In present scenario, the cholesterol has been removed from the Naughty List of foods that are believed to harm human beings by being the root cause of any diseases or by provoking the complications of any already prevailing disorder.

The fear of cholesterol leading to CVDs

In almost all countries, most consumers as well as nutrition specialists consider low density lipoprotein (LDL) as 'bad' cholesterol and restrict themselves from consuming eggs, butter, full-fat dairy products, nuts, coconut oil, meat and other fatty food items. These foods being rich in cholesterol are enlisted in 'Nutrients of Concern List'. The cholesterol foods are believed to be of no use and to be the main reason for atherosclerosis and other coronary artery complications. Thus, the rate of consumption of eggs and other full fat dairy products has been declined for more than six decades in Western countries and this myth is now getting widely adapted by the people especially the adolescent girls which is badly affecting their overall health and nutritional status. Around USD 2 trillion fit and healthy people had to pay for this misconception raised due to health professionals' incompetency. Previously, the daily recommended level of dietary cholesterol was less than 300 mg. The USDA in 2015 has updated this guideline and discarded the cholesterol restriction up to 300 mg per day as there is no proper evidence showing any appreciable relationship between the intake of dietary cholesterol and serum cholesterol levels as per the recommendations of American Heart Association or American College of Cardiology.

Real truth or mechanism of cholesterol actions in human body

Cholesterol in body is majorly synthesized by hepatocytes in cytoplasm and endoplasmic reticulum in liver in healthy conditions. The entire central nervous system i.e. brain and spinal cord is primarily composed from cholesterol. Cholesterol is essential for nerve cells to function and for impulse transmission as it provides the base for synthesis of neurotransmitters acetylcholine and epinephrine. Cholesterol acts as precursors for bile salts and vitamin D (7-dehydrocholesterol). Cholesterol helps in maintaining the cellular structure being a part of cell membrane in form of building block lipopolysaccharides. In form of lipoproteins cholesterol is responsible for transport of lipids through chylomicrons, very low density lipoproteins, low density lipoproteins and high density lipoproteins. It serves as the basis for synthesis of steroid hormones such as adrenaline, estrogen, progesterone, testosterone and corticosteroids. Cholesterol helps in body repairing and rejuvenation process.



Recent findings

According to Dr. George V. Mann, saturated fats and cholesterol in the diet are not the actual reason for coronary heart diseases. Human body requires 950 mg per day of cholesterol for metabolic processes, in which the liver contributes 85 per cent and the rest 15 per cent is derived from out diet daily. When we consume more cholesterol rich compounds, by autoregulation, our body itself produces lesser amount of cholesterol. In contrary to that if we restrict ourselves from having food items of high cholesterol, our body will synthesize higher quantity of cholesterol as per its need. If we consume lesser amount of fat than our daily recommended level, our liver will be on more stress as it has to work more to get the optimum amount of cholesterol required for daily metabolism. Hence, high or good amount of cholesterol circulating in body serves as the indicator sign of a healthy, functional liver. It has also been discovered that the majority of people getting heart attacks possess normal cholesterol levels. Moreover, cholesterol has not been found to create any blockage in arterial wall and blood circulation path neither it leads to development of atherosclerosis.

Conclusion

It has now been proved that there is no role of cholesterol in causing any heart disease neither in ceasing heart attack. Hence, after citing the important functions of cholesterol, there should be no fear of consuming cholesterol rich healthy food items such as eggs, nuts, dairy products and meat. People should be aware of such myth as the concept of bad cholesterol is the greatest scam and deception of all time. There is no need of depriving ourselves from any type of cholesterol rich food items, rather we should try to get the proper balanced diet including all food groups to avail the optimum nutritional benefits for a healthy life.

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Integrated Pest Management in Bhendi Crop

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Bhendi (*Abelmoschus esculentus*), also known as okra or lady's finger, is a popular vegetable that is widely grown and consumed in India. 100 grams of bhindi contains 7.03-gram carbohydrates, 2-gram protein, 0.1-gram fat and 9% fiber. Okra is predominantly a crop of tropics and subtropics region. It occupies fifth position, next to tomato in area under vegetables in the country with a production of 33.24 lakh metric tonnes from an area of 3.47 lakh hectares. The crop is cultivated for its young tender fruits, used in curry and soups after cooking. It is a good source of vitamins A and B, protein and minerals. It is also an excellent source of iodine and is useful for the treatment of goiter. Fruit is useful against genitor-urinary disorders, spermetorrhoea and chronic dysentery. Fruits are also dried or frozen for use during off-season. Dried fruit contain 13-22% edible oil and 20-24% protein and is used for refined edible oil. Dry fruit skin and fibres are used in manufacture of paper, card board and fibres. Root and stem are used for clearing cane juice for preparation of jaggery. Okra originated in tropical and subtropical Africa. Existence of a large number of related species with wide variability and dominant characters suggest possible role of India as a secondary centre of origin. India is the largest producer of okra in the world. It is also used as a vegetable in Brazil, West Africa and many other countries. In India, major okra growing states are Uttar Pradesh, Bihar West Bengal and Rajasthan.

The crop is attacked by more than 72 insect pests which infest the crop from seedling to harvest. Amongst them, Melon Thrips (*Thrips palmi*), Leafhopper (*Amarasca biguttula*), Whitefly (*Bemisia tabaci*), Aphids (*Aphis gossypii*), Shoot and fruit borer (*Earias vittela* & *Earias insulana*), Okra fruit borer (*Helicoverpa armigera*) and Red spider mite (*Tetranychus spp.*) are most serious pests from quarantine point of view as these pests may find a place in the pathway of okra fruits export to European Union.

Identification of different Okra pests

Melon Thrips (*Thrips palmi*)

This is polyphagous but mostly found on Cucurbitaceae and Solanaceae crops. Eggs are colourless; bean shaped; turns yellow towards maturation; laid singly inside the plant tissues. Larvae resembles adult in general body form but lacked wings. They usually feed on older leaves. Full fed larvae descend to the soils of leaf litter where it pupates making an earthen chamber. Adult is pale yellow with numerous dark setae. A black line from the juncture of wings runs along the back of the body. Slender fringed wings are pale. Fringe is shorter on the anterior edge than posterior. Body length is 0.8 -1.0 mm. Thrips antenna is seven segmented, Ocelli red pigmented.

Leafhopper (*Amarasca biguttula*)

Adults are greenish yellow, small, wedge shaped 3 mm long having black spot on each forewing and vertex. Lays yellowish eggs in clusters on underside, embedded in the leaf veins. Nymphs and adults feed underside by sucking sap.

Whitefly (*Bemisia tabaci*)

Adults are yellowish dusted with white waxy powder, 1.0- 1.5 mm in length. Female lays stalked eggs singly on underside of leaves. Nymphs and adults suck the sap of leaves. Whitefly Aphids

Aphids (*Aphis gossypii*)

Adults are small soft bodied found in colonies in tender parts. Damage is caused by both nymphs and adults by sucking cell sap. Black shooty molds develop on honey dew secreted by aphids on leaves. Dry condition favours population flair up.

Shoot and fruit borer (*Earias vittela* and *E. insulana*)

Adult of *Earias vittela* is 2.5 cm across the wings and have narrow light green band in the middle of forewings. Whereas *E. insulana* does not have such conspicuous band on forewings. Full grown larvae are dull green, 2 cm long having tiny stout bristles and a

series of black spots on the body. Eggs are laid singly and are of sky blue. Both bores in to shoots resulting in to drooping down of growing points and later on bore in to fruits.

Okra fruit borer (*Helicoverpa armigera*)

Polyphagous, lays spherical yellow eggs singly on tender parts. Eggs are flat at the bottom. Larvae are of varying colour with darker broken lines along side of the body. Body covered with radiating hairs. Pupates inside the soil. Adult is medium sized brownish forewings with dark cross band near outer margin and dark spots near coastal margins. Bore fruits with circular irregular holes comparatively bigger in size. Half portions of larva remain inside the fruit while feeding.

Red spider mite (*Tetranychus spp.*)

Mites are minute in size and vary in colour with two dark spots on the body. Infestation usually observed during warm and dry periods. Damage is done by sucking cell sap, giving grey patches on leaves and leaves become brown and fall. In severe infestation webbing is observed in plants.

Pest Surveillance

Weekly monitoring through pest scouting and with the help of monitoring device like pheromone traps, colored sticky traps should be practiced from germination to harvesting stage. For field scouting 100 plants per acre in a cross-diagonal pattern through zig zag manner is required to be observed for counting of each and every type of insects which may fall in the pathway of okra fruit export. If 95% plants found free from insect pests then the field should be considered fit for export of okra fruits.

Management Practices:

The following Good Agricultural Practices should be adopted for the management of various okra pests:

- Destruction of debris, crop residues, weeds & other alternate hosts
- Deep summer ploughing.
- Adoption of proper crop rotation and avoid growing of malvaceae crops in sequence.
- Use of resistant and tolerant varieties recommended by the State Agricultural Universities of the region.
- Use well decomposed FYM @ 8-10 tonnes per acre or wormi-compost @ 5 tons per acre treated with *Trichoderma sp.* and *Pseudomonas sp.* @ 2 kg per acre as seed / nursery treatment and soil application.
- Apply neem cake @ 100 kg per acre for reducing nematode population.
- Weeding and earthing up in rows should be done 25-30 days after sowing.
- Field should be kept free from weeds.
- Plant tall crops like maize, sorghum and pearl millet on border of the field to reduce white fly population.
- Erection of bird perches @ 10/acre in the field for facilitating bird predation.
- Pheromone traps for two insects' viz. *Helicoverpa armigera* and *Earias sp.* should be installed @ 4-5 traps per acre. Install the traps for each spp. separated by distance of more than 75 feet in the vicinity of selected field. Fix the traps to the supporting poles at a height of one foot above the plant canopy. Change the lures after 2-3 weeks interval.
- Set up yellow/blue traps/ sticky traps 15 cm. above the crop canopy for monitoring and mass trapping of thrips, white fly, aphids, jassids @ 10-20 traps per acre.
- Set up light traps @ one trap per ha.15 cm. above the crop canopy for monitoring and mass trapping of insects between 6 pm to 11 pm.
- Collect and destroy the infested fruits with fruit and shoot borer infestation and larvae of *Heliothis, Spodoptera* and adults of blister beetle.
- Conserve the existing bio-control agents like Spiders, Coccinalids, Syrphid flies etc. in the field by avoiding, delaying and reducing the use of chemical pesticides and promoting the use of bio-pesticides including botanicals and microbial.
- Augment the bio-control agents like egg parasitoids, *Trichogramma chilonis*, *Trichogramma*

achaea, *Trichogrammatoidea sp.*, *Telenomus sp.*, *Encarsia spp.*; larval parasitoid *Bracon sp.*, *Campoletis chlorideae*, *Chelonus blackburni*; predators like *Chrysopa sp.*, *Coccinella sp*. 16. Install bird percher to conserve predatory birds.

- Spray NPV @ 250LE per hectare to control *H. armigera* and *Spodoptera litura*. Spray *Beauveria bassiana* 1% @1500-2000 g in 160-200 l of water/acre.
- Spray *Azadirachtin* 0.03% (300 ppm) neem oil based WSP @1000-2000 ml in 200-400 l of water/ acre or *Azadirachtin* 5% W/W neem extract concentrate @ 80 ml in 160 l of water/acre.
- Apply Need based application of chemical pesticides *viz.,* imidacloprid 17.8 SL @ 150 ml/ha, cypermethrin 25 EC @ 200 g a.i/ha (0.005%), quinalphos 25 EC @ 0.05% or Propargite etc. 57 EC @ 0.1 % for control of leaf hoppers, aphids, white flies, borers and mites.

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Biochar: The Black Gold for Enriching Agriculture

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Abstract

Biochar, often referred to as "black gold," stands at the forefront of sustainable agricultural practices, offering a transformative solution for enhancing soil health and crop productivity. This study delves into the multifaceted role of biochar in enriching agriculture value. By meticulously exploring its impact on soil structure, nutrient retention and microbial activity, we unveil the intricate mechanisms through which biochar contributes to the overall health of agricultural ecosystems. Furthermore, this article highlights the potential economic benefits and environmental advantages of integrating biochar into farming practices, emphasizing its pivotal role as a valuable resource in the pursuit of sustainable and resilient agriculture. As we navigate the complexities of modern agriculture, biochar emerges as a promising avenue for cultivating prosperity and resilience in the fields, truly earning its status as the black gold of agriculture.

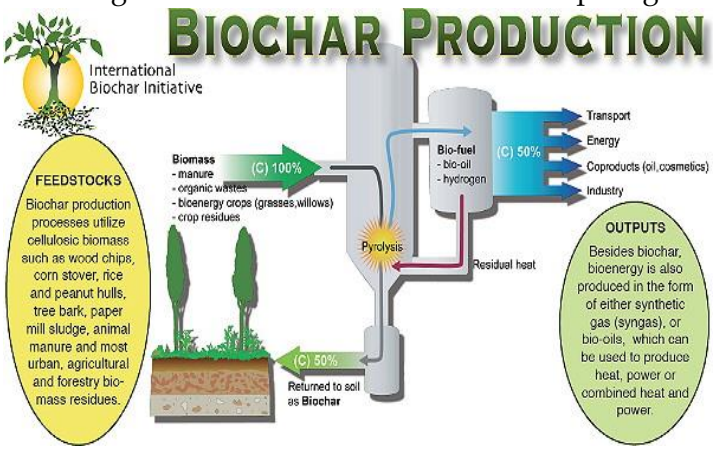
Introduction

Biochar is granular material obtained by heating crop residue at 400°C to 600°C in a kiln-shaped structure in the absence of oxygen. It is used as fertilizer to improve soil health and water-holding capacity of agriculture land. India is the second-largest agro-based economy wherein crop cultivation is taken all around the year, producing a large amount of agricultural waste, including the crop residue otherwise the stubbles. The prime means of disposing of the stubbles, in North India, is being the stubble burning that has popped out as a major issue of environment issue, severely affecting the air quality. This steers to serious health threats and ultimately global warming. Though the GOI had sought to restrict this problem through various measures and campaigns to promote sustainable stubble management, the issue is not yet under control rather alarming rise in air pollution added by the stubble burning is the only result. The burning of stubbles causes various ill effects that are deleterious to human health, soil health, soil-dwelling organisms, ecosystem, and environment.

Biochar can serve as a potential ingredient to remediate the problem caused by the stubble burning. There are many reports available presenting the scope of biochar in improving soil nutrient status, plant productivity and mitigation of greenhouse gases and are discussed in this section. Biochar is a charred, organic, solid, porous, fine-grained, carbon-rich product obtained from the thermochemical conversion, called pyrolysis, under the condition of low or no oxygen. It is a material of comparably higher carbon content than that of its parent material, high stability and surface area of 0.5-450 m^2 g^{-1}. It is reported to contain nutrients such as phosphorus, potassium, calcium, magnesium and micronutrients namely copper, iron, manganese and zinc. The carbon, nitrogen content and the carbon-nitrogen ratio of biochar ranged from 33.0 to 82.7 per cent, 0.10 to 6.0 per cent and 19 to 221, respectively. The biochar can be used as a soil amendment that has been reported to improve soil water, nutrient retention, soil surface area, earthworm and beneficial microorganism population.

What is Biochar and why the hype?

Biochar is charcoal made up of biomass with the process of pyrolysis. Biochar in absence of oxygen can be made from any biological material that used to be alive like logs of wood, bones, sunflower stalks, sugarcane bagasse, rice husk, corn stover, *etc* at around 300-700 Degree Celsius. Every bit of the materials containing cellulose, lignin, and other non-carbon materials vaporize and are consumed with extreme heat leaving behind a porous black structure that makes a clinking sound when smashed or brushed against each other. This left behind black mass possesses a great capacity to reduce the environmental impact of global warming by capturing harmful carbon-dioxide gas. Most areas where Biochar can be made use of is in and as activated carbon helping sequester carbon and nutrients in agriculture. Although Biochar has received quite recognition in recent decades it is, however, quite an old concept. The very first shreds of evidence of the use of Biochar are from the Pre-Colombian era by the Amazonians by burning agricultural wastes in pits or kilns and adding it soil. It is commonly known as Terra Preta (roughly translated into black soil) as most of the tropical soil is poor in nutrients and minerals which is only suitable for the growth of rich rainforests with help of good



sunlight as well as a prosperous amount of rainfall which had led to Amazonians developing the man-made fertile soil with help of Bio-char. Recently, Biochar has been widely used as a versatile material for various applications in agriculture and environmental allied sectors. It has proved to be an effective tool to economically sequester carbon, minimize waste production, and escalate the performance in the circular economy. Its unique



property to lock carbon for hundreds of years is what makes it so valuable and useful. Every year we burn a billion tonnes of biomass be it in form of crop residues, fallen/damaged trees, etc. which produces an intense amount of smoke containing various greenhouse gases such as methane, nitrous oxide along with carbon dioxide and Sulphur oxide which harms our planet as well as our lungs. If instead of open burning, we use this waste in process of making Biochar it will hardly produce any kind of smoke in comparison to when it wreaked havoc whilst open burning. Every year around winter we face intense pollution with a heavy amount of smog-causing difficulty invisibility as well as breathing farmers can easily adapt the process of making Biochar out of the crop waste it will prove to be beneficial for both farmers as well as environment.

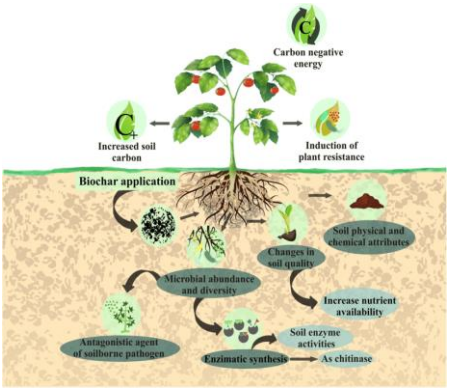
Benefits of biochar to the soil

As a soil amendment, biochar alters the soil surface area, bulk density, pore distribution and water holding capacity adsorb both organic and inorganic contaminants and reduce nutrient leaching. It serves as a slow releasing reservoir of nutrients in the soil. The combined application of biochar and compost had reported increased activities of β-glucosidase, FDA hydrolysis and doubled activities of soil alkali phosphatase, protease, and enzymes involved in carbon, nitrogen and phosphorous cycles. As the soil extracellular enzymes are the proximate agents of organic matter decomposition and nutrient cycling, the increased activities of the above enzymes promote the soil nutrient status. It was reported that the

blended application of biochar, compost and fertilizer increased the soil N-NH4, N-NO_3, P and K to 1.3, 1.8, 1.3, 1.7 folds, respectively.

Benefits of biochar to the plants

In general, the biochar application (exclusive or with compost and fertilizers) to the soil showed numerous positive effects on various plant metabolisms through which increased yields in various crops. Such effects of biochar on the plants were illustrated as a review concerning the vegetable crops. The usage of biochar in the vegetable crops is comparably lower and the vantages of biochar can be explored to maximize the growth and yield of vegetable crops. An increase in the plant available water (PAW) in watermelon and cowpea was noticed which was attributed by the improved available soil moisture (ASM) brought in by the biochar application at 25 t ha^{-1} at a depth of 10 cm. In lettuce, improved leaf traits such as increased number of leaves $plant^{-1}$, length, width and area of leaves were found with combined application of biochar and compost to the unfertilized soil. The total plant biomass increased in cowpea with biochar application at 25 t ha^{-1} at a depth of 10 cm, which was due to improved tap root growth and uptake of water from fine biochar pores. Similarly, an increase in the plant dry weight was reported in lettuce with the exclusive application of biochar. The increased yield with the biochar application in various crops is apparently due to the improved soil fertility and water retention.



Conclusion

Biochar integration in farming enhances crop yields, soil structure, and fertility, positively impacting microbial communities and nutrient retention for lasting benefits in agricultural ecosystems. Amid the challenge of feeding a growing global population and environmental concerns, biochar emerges as a vital force in promoting sustainable agriculture. Its economic advantages, including carbon sequestration, reduced reliance on chemical fertilizers, and improved water retention, highlight its overall cost-effectiveness. Biochar transcends being a mere agricultural amendment, acting as a transformative agent that rejuvenates and enriches the foundation of agriculture. Continued research, education, and widespread adoption are crucial for unlocking biochar's full potential, ensuring a resilient and prosperous agricultural future.

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The Surprising Health Benefits of Ground Cherry (*Physalis Minima*)

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Physalis minima, commonly known as ground cherry, wild cape gooseberry, or dwarf cape gooseberry, is a small and intriguing fruit-bearing plant belonging to the Solanaceae family.

It is native to tropical regions of the Americas. It is found in various countries in Central and South America, including Mexico, Brazil, and Peru. In addition to its native habitat, *Physalis minima* has been introduced and naturalized in other tropical and subtropical regions around the world.



This plant thrives in warm and humid climates, typically growing in open fields, disturbed areas, and along roadsides. *Physalis minima* is adaptable to a range of soil types, and its ability to self-seed and spread easily contributes to its presence in diverse environments. In some regions, it may be considered a weedy or invasive species due to its rapid growth and ability to establish itself in various habitats.

Cultivators and gardening enthusiasts may also grow *Physalis minima* as an ornamental plant or for its small, decorative fruits. The adaptability of this plant makes it suitable for both cultivated gardens and wild landscapes in appropriate climates.

Physalis minima is known for its distinctive orange to yellow fruit enclosed in a papery husk. The plant is characterized by its low-growing stature and delicate, lobed leaves.

The fruit of *Physalis minima* resembles a miniature version of the classic cape gooseberry (*Physalis peruviana*), but it is significantly smaller in size. The husk, known as the calyx, gives the fruit a lantern-like appearance, adding to its visual appeal. The plant is well-adapted to a variety of climates and is often found in both cultivated gardens and the wild.

Culturally, *Physalis minima* has found its place in traditional medicine in some regions, where it has been used to address various health concerns. While the plant's health benefits are appreciated, it is also valued for its ornamental qualities and is sometimes grown for its aesthetic appeal.

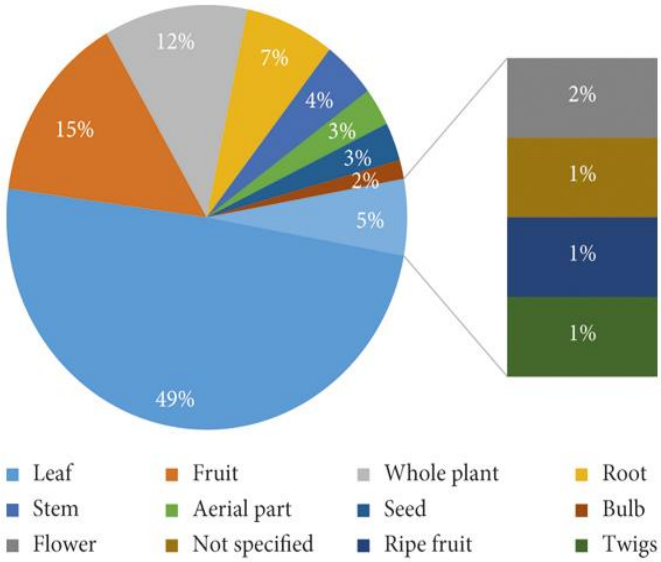


Fig 1. Frequencies of parts used

Physalis minima is a versatile plant with both culinary and potential medicinal applications. As researchers continue to explore its properties, this diminutive fruit is gaining attention for its nutritional content and potential contributions to health and well-being. Whether enjoyed fresh, added to culinary creations, or explored for its potential health benefits, *Physalis minima* stands as a unique and intriguing member of the plant kingdom.

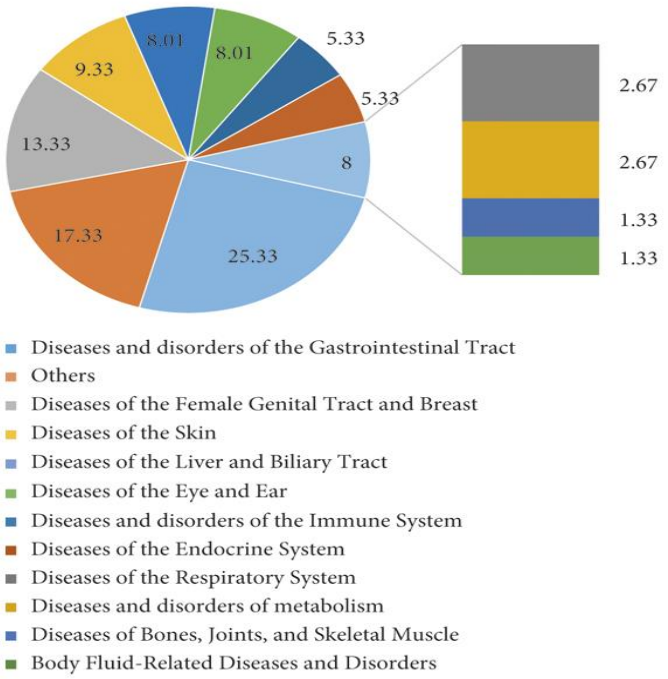


Fig 2. Frequencies of diseases and disorders treated

Potential health benefits of *Physalis minima*

- **Rich in Nutrients:** *Physalis minima* is likely to contain essential nutrients such as vitamins A and C, which are important for immune function, skin health, and overall well-being.
- **Antioxidant Properties:** Like many fruits, *Physalis minima* may possess antioxidants that help neutralize harmful free radicals in the body. Antioxidants contribute to overall cellular health and may have protective effects against chronic diseases.
- **Anti-Inflammatory Effects:** Some members of the Solanaceae family, including Physalis species, have been studied for their potential anti-inflammatory properties. These properties may help reduce inflammation in the body, which is linked to various chronic diseases.
- **Potential Cancer-Fighting Compounds:** Certain compounds found in *Physalis minima* and related plants have been investigated for their potential anti-cancer properties. However, more research is needed to understand the specific mechanisms and effectiveness.
- **Diuretic Properties:** *Physalis minima* may have diuretic effects, promoting the production of urine and aiding in the removal of excess fluids and toxins from the body.
- **Traditional Medicine:** In some traditional medicinal practices, *Physalis minima* has been used to treat various ailments, including respiratory conditions, fever, and digestive issues. However, it's essential to note that scientific evidence supporting these traditional uses may be limited.
- **Weight Management:** The fiber content in *Physalis minima* may contribute to a feeling of fullness, potentially supporting weight management by reducing overall calorie intake.

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Biosafety Issues of Genetically Modified Crops

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For thousands of years, farmers have relied on selective breeding and cross-fertilization to impart desirable traits in plants such as higher yields and resistance to pests. Through trial and error, plant varieties have been developed with altered and stable genetic traits. However, over the past 30 years, the ability to alter life forms has been revolutionized by modern biotechnology. Using sophisticated techniques of genetic engineering or recombinant DNA technology, it is now possible to precisely manipulate the intricate genetic structure of individual living cells by incorporating genes from totally different species. The resulting organisms are known as genetically modified organisms (GMOs) or living modified organisms (LMOs). When the GMO is a crop plant, it is a GM crop or transgenic crop. The emergence of genetically modified crops revolutionized agricultural productivity and nutritional status of several important crops. The genetically engineered traits include insect pests' resistance, herbicide tolerance and virus resistance. Bacterial genes can be used to make insect resistant crops or genes from a cold-water fish can be used to create frost resistant plants.

A transgenic plant contains a gene or genes of a different species artificially inserted in its genome. The inserted gene sequence known as 'transgene,' may come from an unrelated plant or from a completely different species. The first genetically modified crop approved for cultivation is in India is the Bt cotton conferring resistance to bollworm. Bt cotton is a transgenic cotton plant, which incorporates a gene from the bacterium *Bacillus thuringiensis*. It produces crystalline inclusions during sporulation. The biological use of Bt in insect pest control is centered on the exploitation of these crystal proteins especially ∂-endotoxins. These crystalline proteins are found to be highly toxic to agriculturally important pests at very low concentrations.

Conventional plant breeding involves exchange of genes between plants of the same species or from closely related plants to produce a hybrid having desired traits. This crossbreeding however is limited to exchange between the same or closely related species. Therefore, it requires a long time to achieve the desired results as sometimes a related species having the characteristics of interest may not be found and incorporation of undesired characters such as origin of new pest and disease incidences may occur. Genetic engineering enables transfer of genes more easily across taxonomic boundaries. The useful genes can be introduced not just from within the crop species or from closely related plants but even from a wide range of other organisms. This gives a wider range of traits to choose from with the transfer being undertaken in a more controlled and predictable way.

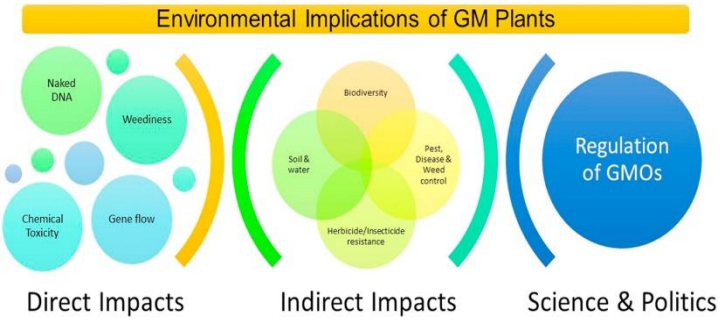


Fig 1: Effect of GMO crops on environment

Source: Aristidis M. T *et al.* 2017

Transgenic crop plants can therefore incorporate the desired traits more quickly and more reliably than through conventional methods. Transgenic crops are produced through genetic engineering in which genes that code for desirable traits are transferred from one organism to another. Although the development of transgenic crops using recombinant DNA techniques is relatively recent, their applications are increasing rapidly because of advantages over the conventional crops. However, as more and more transgenic crops are released for field-testing and commercialization, concerns have been expressed regarding potential risks to both human health and environment. The priorities and parameters of environmental impact assessment of the transgenics should be assessed. These apprehensions arise because transgenic technology crosses the species barrier as compared to classical selection techniques, thereby permitting the gene transfer among microorganisms, plants and animals.

Transgenic crops are not toxic nor are likely to proliferate in the environment. Potential risks from the use of transgenic crops broadly fall under two categories namely Human health and Environment. Consultations on safety in use of GMO's have resulted in a number of National and International recommendations, guidelines and legislation.

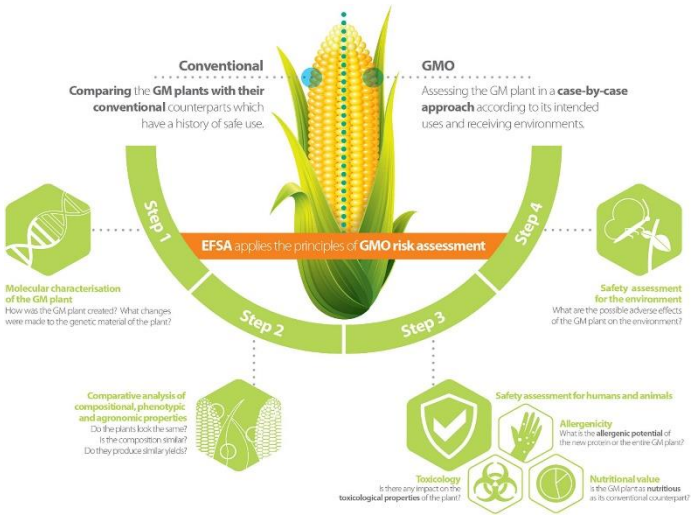


Fig 2: Biosafety Assessment of GMO foods

Source: Nikoletta P *et al*.2020.

India has a well-defined regulatory mechanism for development and evaluation of genetically modified crops as well. The Department of Biotechnology (DBT) and Ministry of Environment &Forests (MoEF) are the two apex bodies. Biosafety issues need to be addressed critically before release of GM crops. Guidelines for safety have been issued by Department of Biotechnology in 1990 covering research in biotechnology, field trails and commercial applications. It also laid separate guidelines for research in transgenic plants. There are six competent authorities for implementation of regulations and guidelines in the country:

1. Recombinant DNA Advisory Committee (RDAC)
2. Review Committee of Genetic Manipulation (RCGM)
3. Genetic Engineering Approval Committee (GEAC), (apex bodies)
4. Institutional Biosafety Committees (IBSC) attached to every organization engaged in rDNA research
5. State Biosafety Coordination Committees (SBCC)
6. District Level Committees (DLC) of the above committees,

The IBSC is constituted by organizations involved in research with GMOs with the approval of DBT. The IBSC is the nodal point for interaction within the institution for implementation of the guidelines.

Risks to human health are related mainly to toxicity, allergenicity and antibiotic resistance. The risk of toxicity may be directly related to the nature of the product whose synthesis. Risks to environment due to release of transgenic crops include impact of imparted traits on other related species, the potential buildup of resistance in insect populations, effect on biodiversity and unintended effects on non-targeted organisms. Accidental cross breeding between transgenic crops and traditional varieties through pollen transfer can contaminate the traditional local varieties with transgenes. The consequences

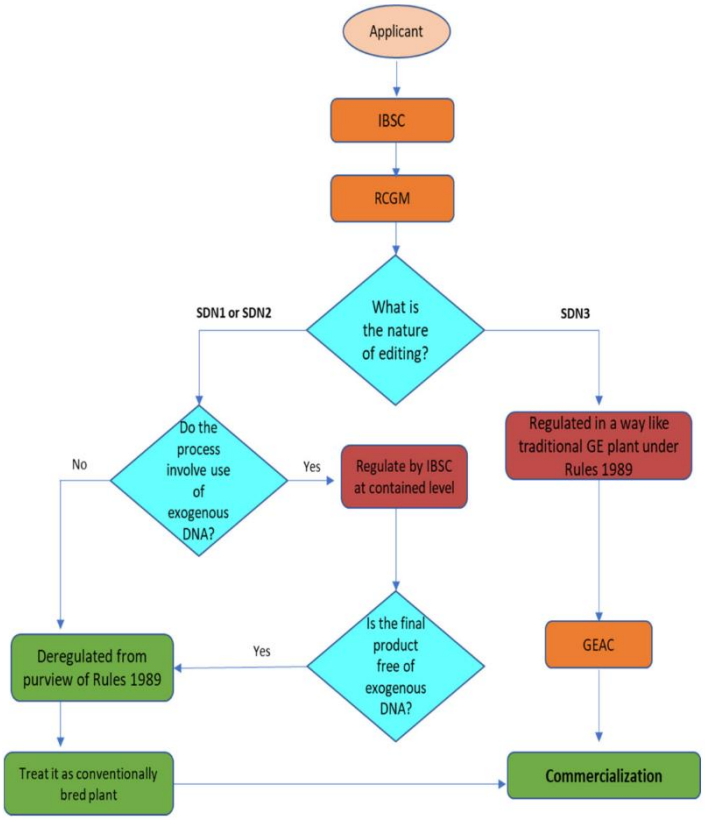


Fig 3: The regulatory pathway for gene-edited plants in India.

Source: Michael G K J *et al*. 2022.

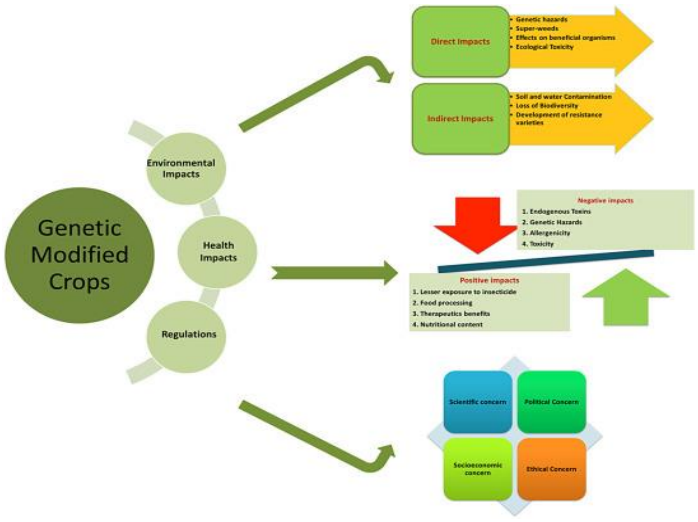


Fig 4: Impacts of GMO crops cultivation

Source : Usha Singh G et al. 2021

associated with such gene transfer may increase weediness if transferred to compatible weedy relatives or lead to extinction endangered varieties of the same genera. There is also fear about the development of super weeds i.e., a weed that has acquired the herbicide tolerant gene due to genetic contamination with a herbicide tolerance GMO crop through cross breeding to related species or by horizontal gene transfer. The gene transferred into plant can actually remain in environment leading to environmental problems. The intentional release of GMOs into the environment has led to interest in possible interactions that occur between other organisms in the environment. Transgenic plants may leak different compounds than conventional plants due to unintended sequence of changed genetic material. This may result in change in ecology of the soil in terms of functional composition and biodiversity. Genetically modified foods can potentially solve many hunger and malnutrition problems across the globe and also protect and preserve environment by increasing yields and reducing dependence on chemical pesticides and herbicides. However, it is important to proceed with caution to avoid unfavorable consequences for the surroundings and our health, considering that genetic engineering technology is very powerful.

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Millets and Their Health Benefits

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Millets have numerous health benefits, including helping to lower blood sugar and cholesterol levels. They're also gluten-free, so people with celiac disease or gluten sensitivities can enjoy them.

Millets are a group of cereal grains that belong to the *Poaceae* family, commonly known as the grass family.

It's widely consumed in developing countries throughout Africa and Asia. While it may look like a seed, millet's nutritional profile is similar to that of sorghum and other cereals.

Millets have gained popularity in the West because they are gluten-free and boasts high protein, fiber, and antioxidant contents.



Fig 1: Different types of millets

Attributes and types of millet

Millets are a group a small, round whole grains grown in India, Nigeria, and other Asian and African countries. Considered an ancient grain, they are used both for human consumption, livestock and bird feed.

They have multiple advantages over other crops, including drought and pest resistance. They're also able to survive in harsh environments and less fertile soil. These benefits stem from their genetic composition and physical structure - for example, its small size and hardness.

Although all millet varieties belong to the *Poaceae* family, they differ in color, appearance and species.

This crop is also divided into two categories - large and small millets, with major millets being the most popular or commonly cultivated varieties.

Large millets include:

- Pearl
- Foxtail
- Proso
- finger (or Ragi)

Small millets include:

- Kodo
- Barnyard
- Little
- Guinea
- Browntop
- Fonio
- Adlay (or Job's tears)

Pearl millet is the most widely produced variety intended for human consumption. Still, all types are renowned for their high nutritional value and health benefits.

Nutritional profile

Like most cereals, millets are starchy grains - meaning that they're rich in carbohydrates. Notably, they also pack several vitamins and minerals.

One cup (174 grams) of cooked millet packs:

- Calories: 207
- Carbohydrates: 41 grams
- Fiber: 2.2 grams
- Protein: 6 grams
- Fat: 1.7 grams
- Phosphorus: 25% of the Daily Value (DV)
- Magnesium: 19% of the DV
- Folate: 8% of the DV
- Iron: 6% of the DV

Millets provide more essential amino acids than most other cereals. These compounds are the building blocks of protein.

What's more, finger millet boasts the highest calcium content of all cereal grains, providing 13% of the DV per 1 cooked cup (100 grams).

Calcium is necessary to ensure bone health, blood vessel and muscular contractions and proper nerve function.

Benefits of millets

Millets are rich in nutrients and plant compounds. Therefore, they may offer multiple health benefits.

Rich in antioxidants

Millets are rich in phenolic compounds, especially ferulic acid and catechins. These molecules act as antioxidants to protect your body from harmful oxidative stress.

Studies in mice link ferulic acid to rapid wound healing, skin protection, and anti-inflammatory properties.

Meanwhile, catechins bind to heavy metals in your bloodstream to prevent metal poisoning.

While all millet varieties contain antioxidants, those with a darker color - such as finger, proso, and foxtail millet - have more than their white or yellow counterparts.

May help control blood sugar levels

Millets are rich in fiber and non-starchy polysaccharides, two types of undigestible carbohydrates that help control blood sugar levels.

This cereal also has a low glycemic index (GI), meaning that it's unlikely to spike your blood sugar levels. Thus, millets are considered an ideal grain for people with diabetes. For instance, a study in 105 people with type-2 diabetes determined that replacing a rice-based breakfast with a millet-based one lowered blood sugar levels after the meal.

A 12-week study in 64 people with prediabetes gave similar results. After eating 1/3 cup (50 grams) of foxtail millet per day, they experienced a slight reduction in fasting and post-meal blood sugar levels, as well as a decrease in insulin resistance. Insulin resistance is a marker for type 2 diabetes. It occurs when your body stops responding to the hormone insulin, which helps regulate blood sugar. What's more, in a 6-week study in rats with diabetes, a diet containing 20% finger millet led to lower fasting blood sugar levels and a drop in triglyceride and cholesterol levels.

May help lower cholesterol

Millets contain soluble fiber, which produces a viscous substance in your gut. In turn, this traps fats and helps reduce cholesterol levels. One study in 24 rats found that those fed foxtail and proso millet had significantly reduced triglyceride levels, compared with the control group. Additionally, millet protein may help lower cholesterol.

A study in mice with type-2 diabetes fed them a high fat diet with millet protein concentrate. This led to a decrease in triglyceride levels and significant increase in adiponectin and HDL (good) cholesterol levels, compared with the control group. Adiponectin is a hormone with an anti-inflammatory effect that supports heart health and stimulates fatty acid oxidation. Its levels are usually lower in people with obesity and type-2 diabetes.

Fits a gluten-free diet

Millets are a gluten-free grain, making them a viable choice for people with celiac disease or those following a gluten-free diet. Gluten is a protein that occurs naturally in grains like wheat, barley, and rye. People with celiac disease or non-celiac gluten sensitivity must avoid it because it triggers harmful digestive symptoms, such as diarrhea and nutrient malabsorption. When shopping for millets, you should still look for a label that certifies it gluten-free to ensure it hasn't been contaminated with any gluten-containing ingredients.

Potential downsides

Despite millets' multiple health benefits, they also contain antinutrients - compounds that block or reduce your body's absorption of other nutrients and may lead to deficiencies. One of these compounds - phytic acid - interferes with potassium, calcium, iron, zinc, and magnesium uptake. However, a person with a balanced diet isn't likely to experience adverse effects. Other antinutrients called goitrogenic

polyphenols may impair thyroid function, causing goiter - an enlargement of your thyroid gland that results in neck swelling.

Nevertheless, this effect is associated only with excess polyphenol intake. For example, one study determined that goiter was significantly more prevalent when millet provided 74% of a person's daily calories, compared with only 37% of their daily calories. Furthermore, you can lower millet's antinutrient content significantly by soaking it overnight at room temperature, then draining and rinsing it before cooking. Plus, sprouting reduces antinutrient content. Certain health food stores sell sprouted millet, though you can also germinate it on your own. To do so, place-soaked millet in a glass jar and cover it with a cloth that's secured with a rubber band.

Turn the jar upside down, rinsing and draining the millet every 8–12 hours. You'll notice small sprouts beginning to form after 2–3 days. Drain the sprouts and enjoy them right away. If you choose to sprout your millet, be mindful that sprouts have a short shelf life and are more prone to foodborne illness. To ensure safety:

- keep your sprouting container clean
- use filtered or bottled water (NOT tap water)
- rinse sprouts frequently
- empty any remaining water from your sprouts before storing
- store sprouts in a cool, dry location
- wait 8 to 12 hours before refrigerating to ensure they are cool and dry

How to prepare and eat millets

Millets are a versatile ingredient that makes a good rice replacement when cooked whole. To prepare it, just add 2 cups (480 mL) of water or broth per 1 cup (174 grams) of raw millet. Bring it to a boil, then simmer it for 20 minutes. Remember to soak it overnight before cooking to lower its antinutrient content. You may also toast it in a pan before cooking to enhance its nutty taste. Millets are also sold as a flour. In fact, research suggests that making baked goods with millet flour significantly enhances their nutritional profile by increasing their antioxidant content.

Additionally, this grain is processed to make snacks, pasta, and nondairy probiotic beverages. In fact, fermented millet acts as a natural probiotic by providing live microorganisms that benefit your health. You can enjoy millets as a breakfast porridge, side dish, salad add-in, or cookie or cake ingredient.

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Exploring Cutting-Edge Applications of Hydrogels in Post-Harvest Technological Advancements

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The surge in global population and evolving lifestyles has spurred an intensified demand for increased food production, prompting the need for enhanced food processing, logistics, and storage infrastructure to ensure both food safety and security (Sudheer et al. 2023). Hydrogels, intricate three-dimensional hydrophilic networks composed of polymeric chains interconnected through physical or chemical bonds (Batista et al. 2019), play a pivotal role in addressing these challenges. Recognized as colloidal gels, hydrogels disperse in water, exhibiting viscoelastic and structural properties due to the interplay of polymeric chain bonds and solvents integrated into the system (Ullah et al. 2022). The hydrogel's unique three-dimensional structure consists of a liquid phase, typically water or biological fluids, and a solid phase based on polymers or polymeric blends (Sudheer et al. 2023). In their swollen state and under specific pressures, hydrogels facilitate the absorption of target fluids without undergoing structural changes. The water sorption capacity of hydrogels is influenced by factors such as the nature and density of the polymer used and the crosslinking mechanism (Yang et al. 2021). In the creation of hydrogel matrices, synthetic compounds predominate, with chemical crosslinking being the prevalent method. Petroleum derivatives, including polyacrylamide, poly (sodium acrylate), poly (acrylic acid), and polyvinylpyrrolidone, are commonly employed in the formation of hydrogel matrices. Here, the primary objective here is to delineate hydrogels by exploring their classification, preparation, and various aspects of application.

Classification of hydrogel

Hydrogels, diversely classified based on composition and characteristics, include homopolymer hydrogels originating from a single monomer species, ensuring uniformity (Batista et al. 2019). Copolymer hydrogels, synthesized from different monomer species, exhibit block, random, or alternating configurations in the polymeric network chain (Sudheer et al. 2023). Another category is multicomponent hydrogels, formed by crosslinked synthetic, natural, or a combination of polymers, creating a network structure (Pirsa 2021). Homopolymer hydrogels maintain uniform monomer distribution (Cui et al. 2021). Electric charge-based classifications include cationic/anionic, neutral/non-ionic, amphoteric with both basic and acidic groups, and zwitterionic featuring anionic and cationic groups in each repeating unit (Sudheer et al. 2023). Additionally, hydrogels are classified by factors like crosslinking methods (chemical or physical), morphology, gel properties, mechanical capacity, functional attributes, and response modes, providing diverse avenues for categorization (Kaith et al. 2021; Behera and Mahanwar, 2020).

Preparation of hydrogel

Hydrogels, derived from natural polymers like collagen, gelatin, soy, fish proteins, starch, cellulose derivatives, sodium alginate, guar gum, xanthan gum, and chitosan, showcase diverse origins (Sudheer et al. 2023). The γ-polyglutamic acid (γ-PGA) hydrogel is prepared through chemical crosslinking using polyethylene glycol diglycidyl ether (PGDE) as the crosslinking agent, proving effective as a coating on shiitake mushrooms to extend storage life and quality for 30 days at 4 °C with a 1.0% γ-PGA hydrogel coating (Tao et al. 2021). Another innovative approach involves valorizing Carica papaya peel extract in the fabrication of biohydrogels for packaging fresh berries, using Schiff base hydrogels composed of dialdehyde starch and chitosan, incorporating the peel extract into the matrix (Dalei et al. 2023). Additionally, synthetic polymer-based hydrogels, including polyethylene glycol, polyvinyl alcohol,

polyamidoamine, poly(N-isopropylacrylamide), polyacrylamide, and polyacrylic acid, offer versatile applications, while hydrogels derived from biopolymers like hyaluronate, alginate, starch, gelatin, cellulose, chitosan, and their derivatives showcase promising biomaterial applications due to their safety, wettability, and biocompatibility (Behera and Mahanwar 2020).

Uses of hydrogel

Hydrogels, intricate networks formed through chemical or physical crosslinking of hydrophilic polymers (Nath et al. 2023), exhibit remarkable water and fluid absorption capabilities. Cellulose-based hydrogels, known for their structural adaptability and stimuli-responsive properties, have gained attention in food packaging, functional food, safety, and drug delivery (Ullah et al. 2022). Despite continued academic exploration in food processing, commercial adoption lags due to a widespread lack of understanding in the public sector (Warkar and Kumar 2019). Naturally produced hydrogels, prized for biocompatibility, biodegradability, and abundance, emerge as promising materials. Ongoing research suggests that unlocking the full potential of hydrogels could lead to transformative innovations across various industries.

Food packaging

Hydrogels, when formulated with carboxymethylcellulose and polyvinylpyrrolidone, offer promising attributes for efficient packaging materials, boasting durability, biodegradability, and favorable mechanical properties (Gregorova et al. 2015). Employing a solution casting method, PVP–CMC hydrogel films are prepared without chemical crosslinking agents, relying on physical stimuli like heat and temperature, making them suitable for packaging systems with humidity control for water-rich food products (Batista et al. 2019). A novel strategy introduces porous hydrogel-based packaging materials for transporting delicate fruits (Wang et al. 2023b). Hydrogels, like those composed of tamarind polysaccharide and polyvinyl alcohol, designed to maintain seafood freshness, exhibit quick self-healing, good tissue fitting, and freezing tolerance capabilities (Wang et al. 2023a). Molecularly imprinted hydrogels (MIHs) offer a viable alternative to conventional packaging, selectively binding antioxidants and enhancing antioxidant properties in resulting active films (Benito-Peña et al. 2016). Coating shiitake mushrooms with 1.0% γ-PGA hydrogel significantly retards decay, water and weight losses, and vitamin C degradation during storage (Tao et al. 2021). The CMC/NFC/KMnO4 hydrogel extends the shelf life of bananas by simultaneously controlling ethylene and humidity in food packaging, serving as a humidity/ethylene absorbent and ensuring prolonged freshness (Pirsa 2021).

Sensor

Hydrogels have emerged as highly promising materials, garnering significant attention in recent years, particularly in the realms of biosensors and packaging. With exceptional bioactivities, stimuli responsiveness, embedding ability, swelling, biodegradability, non-toxicity, and cost-effectiveness, CH-based hydrogels are meticulously analyzed for their potential applications in intelligent food packaging systems (Yang et al. 2021). In an investigation focusing on PVP-CMC-based hydrogel food packaging, the breathability of the material is assessed for its impact on the preservation of quality and shelf life of "table grapes" (Saha et al. 2015). A practical, cost-effective, and non-destructive sensing strategy is devised to monitor biogenic amines (BAs) in real-time, providing a valuable tool for assessing food spoilage (Luo et al. 2021). The application of a hydrogel biosensor emerges as a rapid, cost-effective, and non-destructive method for assessing the quality of food, particularly in evaluating the freshness of fish (Nath et al. 2023). A functional hydrogel incorporating silver ions, D-glucose pentaacetate, and agarose serves as an effective tool for monitoring the growth of biogenic amines, providing insights into the freshness of fish (Nath et al., 2023).

Antimicrobial

Hydrogels have found recent applications in the food packaging system, primarily due to their commendable antibacterial capacities (Batista et al. 2019). This study introduces an antibacterial packaging material achieved by incorporating methyl-β-cyclodextrin/*Satureja montana L.* essential oil

inclusion complexes into soy soluble polysaccharide hydrogel (Cui et al. 2021). Nanocomposite hydrogels and chitosan films impregnated with nanoparticles exhibit distinct antimicrobial activities, showcasing potential applications in active food packaging (Li et al. 2022). The Hydrogel Film demonstrates the ability to prolong the freshness of strawberries for up to 8, 19, and 48 days at 25.0, 5.0, and 0 °C, respectively, by retarding ripening, dehydration, microbial invasion, and respiration rate (Zhang et al. 2023). The incorporation of antimicrobial agents like Ag, ZnO, and CuO nanoparticles into hydrogels enhances their antimicrobial activities, suggesting a viable strategy to extend the shelf life of packaged foods by encapsulating preservatives, antioxidants, desoxidants, and antibacterial agents within CH-based hydrogels (Restuccia et al., 2010). Among various films, the AgNPs@GT-3/EC film emerges as a standout, exhibiting exceptional UV-light shielding, superior mechanical properties, optimal humidity regulation, oxygen barrier capabilities, enhanced thermal stability, and impressive bacteriostatic rates against S. aureus and E. coli of up to 99% (Shan et al. 2024).

Shelf-life extension

Copper nanoparticles (Cu-NPs) in chitosan-polyvinyl alcohol (Cs-PVA) benefit the preservation of physicochemical quality and increase bioactive compound levels in kidney-shaped tomatoes, extending their storage period (Hernández-Fuentes et al. 2023). The utilization of C. papaya peel extract in the film enhances thickness, moisture content, and opacity, demonstrating versatile performance with antimicrobial and antioxidant activities, water-barrier properties, and biodegradability (Dalei et al. 2023). The developed biohydrogel films extend the shelf life of fresh berries, showcasing potential as sustainable packaging materials. The study on bacterial cellulose and guar gum (BC-GG) based PVP-CMC hydrogel film as an alternative food packaging material highlights superior resistivity to oxygen and water vapor permeability, reducing weight loss and maintaining moisture levels in packed fruits (Bandyopadhyay et al. 2019). Cs-PVA-Cu-NP complexes in jalapeño pepper production improve postharvest quality, while additional studies show their application to tomato plants enhances yield, fruit quality, defensive systems, and increases vitamin C and lycopene contents (Hernández-Hernández et al., 2018; Rivera-Jaramillo et al., 2021).

Conclusion

In conclusion, hydrogels stand at the forefront of innovative materials with versatile applications, driven by their unique properties and diverse compositions. The escalating global demand for enhanced food production and preservation has underscored the importance of advanced technologies, such as hydrogels, in improving food processing, storage, and safety. In essence, the journey through the realm of hydrogels reveals not only their scientific intricacies but also their immense potential in addressing contemporary challenges. As we delve deeper into the crossroads of chemistry, biology, and materials science, hydrogels emerge as a promising frontier, promising advancements that will continue to shape our future in diverse and unexpected ways.

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Millets: The Future Superfood and A Climate Resilient Crops

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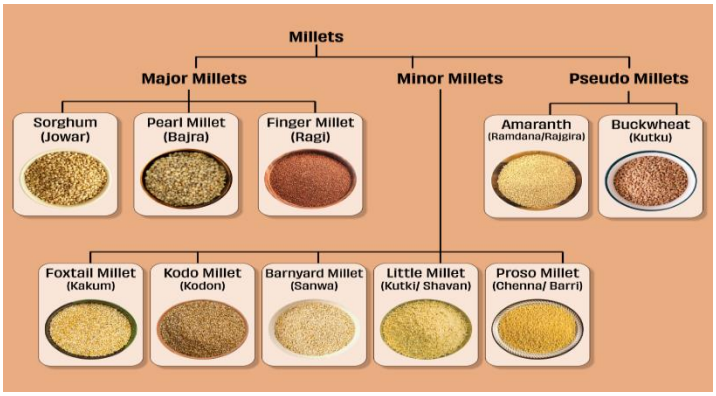
Abstract

Millets are being referred as Nutri-cereals are important crops in the country with higher area coverage as compared to wheat and rice before green revolution period. After decades of negligence, nutri-cereals are making a strong "comeback" in the Indian cereal's production segment.

Introduction

Although, India ranks first in nutria-rich millet production and second in rice and pulses across the globe, it also unfortunately ranks second in child malnutrition incidences. The majority of millets are three to five times more nutritious than most cereals like rice, wheat, maize interms of vitamin, fibre, protein and mineral and are gluten free, hence they are known as superfoods. The nutri-rich millets are the viable solution to reduce the rising incidences of malnutrition and metabolic disorders and can enhance the nutrition and food security of the country. Millets are known as one of the most important cereal grains. Millets are consumed by more than 1/3rd of the world's population. It is the 6th cereal crop in terms of world's agricultural production.

Types of millets



Source: Mehrotra, 2023

Millets are Jowar (Sorghum), Sama (Little millet), Ragi (Finger millet) and Variga (Proso millets). Bajra and Sama are high in fat while ragi has the lowest fat. Millets are used as food and are widely used in rural areas. They have been cultivated for a thousand years and are used throughout the world, in the Middle Ages the Romans and Goals were consuming porridges made of millets eaten than wheat. A majority of the world's commercial millet crop is produced by China, India, Greece, Egypt and Africa (Kimeera and Sucharitha, 2019). Millets are unique among the cereals because of their richness in calcium, dietary fibre, polyphenols and protein (Devisetti, 2015). Millets generally contain significant amounts of essential amino acids particularly the sulphur containing amino acids i.e. methionine and cysteine. They are also higher in fat content than maize, rice and sorghum (Sagar *et al*., 2022). In general, cereal proteins including millets are limited in lysine and tryptophan content and vary with cultivar (Lindseth, 2015)

Conclusion

The aim of this review study is to aware the people to recognize the significance of food and to introduce the millets as a nutritious food, fulfilling the nutritional need of global population and to find a ways to consume the millets nutritionally, effectively and to reduce the problems of malnutrition and other health problems.

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Importance of Calcium and Fortification of Calcium in Milk and Milk Products

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Vitamins and minerals are added to dairy and food products to attract the attention of health-conscious consumers (Weaver, 1998) and responded to public health needs. The fortifying foods with calcium is growing due to the difficulty for individuals to meet calcium requirements with unfortified foods. The deficiency of calcium is causing the diseases osteoporosis, especially in elderly people. Calcium is an essential mineral for human health for bone strength. Indians are more prone to osteoporosis, a debilitating bone disorder resulting from porous bones. Many peoples are suffering from life threatening disease. Major factors responsible for high prevalence of osteoporosis in India are inadequate intake of calcium and vitamin D. The Indian society for bone and mineral research (ISBMR) advised to the authorities and industry to go for calcium fortification of dairy and food products (Hindustan Times, 2002). Calcium requirements is essential an individual's life and for different age groups. Thus, it is imperative that dietary intake of calcium be increased in population groups that have sub – optimal calcium nutritional status. Poor dietary habits are seen in many people for this situation, especially when consumption of fast food or junk food is gaining acceptance. If a calcium supplement is given to a people which already has an adequate supply, this does not affect growth such as height, but increases bone density (Danone, 1999). Cow contains 125 to 150 mg/100 g calcium and buffalo contains 180 to 200 mg/100 g calcium. ICMR (1989) recommends RDA for calcium as 400 to 600 mg (1000 mg in pregnancy/lactation) and NIH (1994) recommends 1200 to 1500 mg of calcium per day. High intake of calcium will possible through formulating calcium enriched dairy and food products. Addition of calcium to milk caused in a new distribution of ions between milk serum and casein micelles, leading to physico-chemical changes in casein micelles.

Fortification with calcium

Calcium is most essential nutrient and it must be provided regularly in the diet. Calcium constitutes about 2 percent of the total body weight and most of calcium is dispersed in the bones. So, an adequate daily intake of calcium is vital for maintaining structural integrity of the body skeleton and strength of the teeth. Apart from the structural role of calcium, it is also equally important in regulating others metabolic processes in the human body. Calcium also plays an important role in the transmission of impulse in nerve cell and in case of injury forms an important component of the blood clotting. Calcium plays an important role in the prevention and treatment of many diseases like osteoporosis, hypertension, colon cancer, kidney stones and lead absorption (National Dairy Council, 1992). The average rate of calcium accumulation in the skeleton between birth and maturity is 60 mg per day but the most rapid deposition occurs during adolescence when the positive balance required rises to about 300 mg or more per day. There is general agreement that extra dietary calcium is required for optimum skeletal growth with recommended intakes at puberty about 1200 mg or more (Vital news, 2000).

Sources of calcium and its bioavailability

Calcium source is present in significant amounts in a limited range of dairy and foods. Some vegetables like green leafy, broccoli provides quite large amounts of calcium intake, others sources include cabbage, beans etc. Milk and dairy products are major source of calcium and proteins. The level of calcium is not reduced when milk is processed like skimmed. The adsorption of calcium is affected by its solubility, chemical forms, and presence of inhibitors in the food or total diet (Allen, 1982).

The bioavailability of calcium mineral has been shown to be reduced in variety of dietary components and capable of forming insoluble complexes with calcium in the intestine. These components include oxalate, phytate and uronic acid and other components of non-starch polysaccharide (NSP) like dietary fibre. Calcium in spinach is less utilized than the calcium obtained from milk or from other green vegetables like broccoli. The high oxalate component of spinach has been reducing the absorption of calcium by forming insoluble calcium complexes in the intestine (Heaney, 1988). Calcium in milk is easily

absorbed by the intestine and it is considered to higher bioavailability than calcium in cereals and vegetables. Two factors in milk – lactose and casein, have been responsible for promoting calcium absorption and leading to apparent higher bioavailability (Miller, 1989).

Lactose delays the precipitation of calcium in vitro by forming calcium-lactose complexes (Charley and Saltman, 1963) and it may also do so in the intestinal lumen. Lactose stimulates passive component of calcium absorption in the illeum and the colon in rats Kansal (1998). Lactose enhances calcium absorption in Vitamin D deficient and Vitamin D adequate in animals. Calcium acts by increasing the proportion of soluble calcium in the intestinal lumen (Lee *et al*., 1979). It is possible that the higher bioavailability of calcium of milk may be due to the absence of many factors, which inhibit the absorption of calcium such as oxalate and phytate. The different type of calcium source did not affect the calcium absorption, but milk components increased the apparent calcium absorption. Milk and milk products are the most important sources of calcium. There is an increasing trend in producing calcium and vitamin D enriched milk, milk products and other drinks. A part of calcium in milk is linked with the casein fraction, where it is associated with phosphorylated serine. The component caseinophosphopeptides (CPP) released in the gastrointestinal (GI) tract during normal digestion can improve passive transport of calcium in the lower portion of small intestine. These CPP forms soluble complexes with calcium phosphate salts and improve calcium absorption (Kansal, 1998). In infants, the protein and calcium requirements are generally met from milk. The micellar form of calcium found in milk is best absorbed and has high bioavailability as compared to that from vegetables and nuts such as sesame seeds, almonds, whole wheat bread, spinach etc. However, regular intake of milk will help in meeting the daily protein intake and calcium requirements (Neelam and Hemalatha, 2001).

Dietary factors affecting calcium bio availability

Optimum bone mineralization requires calcium, but phosphorous must be present for the formation of hydroxyapatite. The dissociation of calcium intake from that of phosphorous may restrict calcium and phosphorus retention. A calcium source with a ratio Ca/P > 1 is a plus. Lactose is reported to stimulate calcium passive absorption (Vital news, 2000) because it is bound to peptides and proteins, milk calcium is more likely to remain in solution when the pH is unfavorable. Milk calcium absorbed in distant intestine in the absence of vitamin D under the effect of lactose. Milk products do not contain anything likely to inhibit the intestinal absorption of calcium such as phytates, oxalates, uronic acids or the polyphenols of certain foods. The hyper calciuric effect of sulfates from the sulphur containing amino acids of milk is offset by the hypocalciuric effect of phosphorous (Vital news, 2000). The uptake of calcium is increased when it is ingested during a meal and combined with protein and lactose as in case of milk products (Danone World News Letter, 1999). The choice of calcium fortification compound may be made more on technological grounds, since there is little variation in the bioavailability of the calcium from different compounds (Couzy, 1996). Only a fraction of about 25 to 35% calcium in the diet is absorbed, most of the dietary calcium stays in the intestinal lumen and contributes to the daily loss of calcium.

Conclusion

Vitamins and minerals are added to dairy and food products to attract the attention of health-conscious consumers. The calcium-fortified milk and dairy products speaks for itself increase the nutrition. Consumers increasingly prefer food with added nutritional value rather than taking nutritional supplements to fill up their calcium needs. Calcium is an essential mineral for human health for bone strength. Milk products are the best source of calcium and it help to fight calcium deficiency; they are further enriched with calcium achieve higher calcium intakes per serving. However, the challenge for Dairy and food manufacturers is to provide a product having high calcium content with good taste and appealing properties.

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Nutritional Rich Millet Pizza

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According to their grain size, millets are categorized as major and minor millets. Finger millet also known as ragi or mandua (*Eleusine coracana*), foxtail millet or kauni (*Setaria italica*), kodo millet or kodo (*Paspalum scrobiculatum*), proso millet or cheena (Panicum miliaceum), barnyard millet or sawan/madira (*Echinochloa frumentacea*) and little millet or kutki (*Panicum miliare*) come under the category of minor millets. In Karnataka, the area under cultivation of foxtail millet is 694.9 ha with the production of 418.8 tonnes (Directorate of economics and statistics, 2015-2016).

Millets are rich in micronutrients especially minerals, B vitamins, nutraceuticals and found to reduce the risk of many chronicdiseases. Carbohydrates of the millets comprise of large proportion of starch (65-70%) and a good amount (16-20%) of non-starchy polysaccharides (NSP). The NSP, which constitute nearly 95% of the dietary fibre content of the grain, are derived not only from bran portion but also from the endosperm cell walls. Foxtail millet is a good source of phosphorous, iron and vitamins like thiamine, riboflavin, folin and niacin (Anon., 2004). Despite being so nutritious these millets visibility waned in recent decades due to the popularity of rice and wheat during the green revolution. The protein content is higher among millets and major cereals also the amount of fiber (as a glucan ; 42.6 per cent). The metabolism of sugar and cholesterol gets increased due to a-glucans resulting in hypoglycemic and hypocholesterolaemic affects, which is beneficial for prevention of diabetes and cardiovascular diseases. Because of this, foxtail millet is used in the preparation of low glycemic index foods for treating diabetics, particularly type 2 diabetes and also cardiovascular diseases. It is rich in dietary fiber6.7 per cent, protein 11 per cent, and low in fat4 per cent. However, with increasing emphasis on diverse grains, and people's quests to find alternatives to rice and wheat, millets are returning to the spotlight. Among the most demand universal food product is pizza. According to Mama Deluca's pizza, Americans eat approximately 100 acres of pizza each day, or about 350 slices per second and approximately three billion pizzas are sold in the United States each year. Pizza consumption has increased 150 per cent between 1977-78 and 1994. Total pizza sales increased 25 per cent from 1991-1995 with a market value of $22.2 billion in 1995. According to USDA, pizza consumption has more than tripled since the 1970's and is likely responsible for the most significant share of sauces and cheese used and purchased in fast food restaurants.

Traditionally, the flattened bread dough of pizza crust is made from wheat flour. The high calorie and low fibre content of pizza makes it unsuitable for consumption by people suffering from diabetes and cardio vascular disease, therefore incorporation of millet flour in the pizza base may enhance its nutritional quality and makes it suitable for the people with above said diseases.

Method of preparation

1. Yeast was dissolved in lukewarm water, sugar was added in it left aside.
2. Flour was sieved. Fermented yeast, salt and bread improver was added and kneaded well with sufficient amount of water.
3. Oil (10 ml) was added and kneaded again till the soft and smooth dough was obtained.
4. Dough was covered and kept in a dry place at approximately 35 ^{o}C for 1 hour to allow it to double its size.
5. After 1 hour, dough was kneaded gently with some oil and divided into portions.
6. On a lightly floured surface, dough was rolled into thin rounds (approximately 4 mm thickness).
7. Thin rounds were covered and kept in a dry, warm place to rise again approximately for half an hour.
8. Vegetables (capsicum, onion, tomato) were cut into thin slices.
9. Pizza sauce was spread evenly in the whole pizza round.

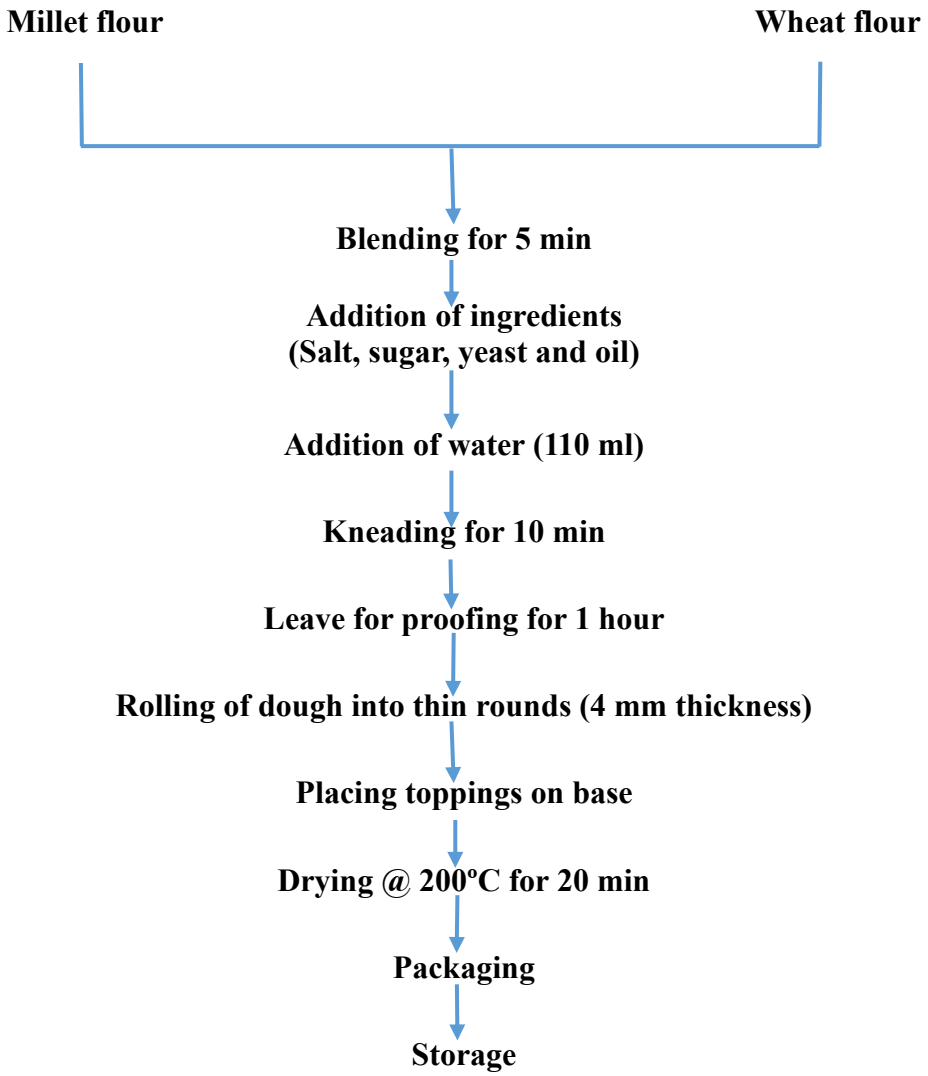
10. Sliced vegetables were placed above the pizza base.
11. Cheese mozzarella was grated evenly on whole pizza.
12. Pizza base was poked with the help of fork (to stop the rising during baking) and baked in an oven at 200°C for 20 minutes.

Pizza ingredients and toppings

- Pizza base
- Capsicum – 50 g
- Onion – 50 g
- Tomato – 25 g
- Mozzarella cheese – 20 g
- Pizza sauce – 1 tbsp.

Foxtail millet and barnyard millet are nutritionally richer than the conventional refined wheat flour used in the bakery products. The high nutrient content of these millet incorporated pizza base make them nutritionally superior than conventional pizza base.

Process flow chart for development of pizza



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The Role of Biomanipulation in Fisheries of Lacustrine Ecosystems

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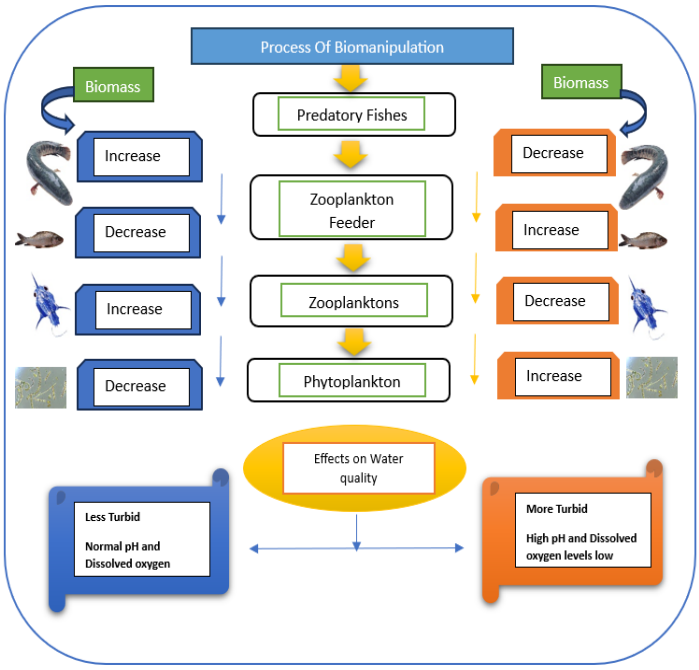
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Abstract

Eutrophication resulting from high nutrient loading has been the paramount environmental problem for lakes world-wide for the past four decades. Efforts are being made in many parts of the world to reduce external nutrient loading via improved wastewater treatment or diversion of nutrient-rich inflows. In that case, biomanipulation technique which is cost-effective technique can be considered as one of the most suitable solutions to overcome the problem of eutrophication and to restore the quality of water in small and shallow eutrophied lakes. Biomanipulation was originally based on the idea that when the number of planktivorous fish are reduced, the density of large cladoceran zooplankton increases, and their grazing during the summer period can reduce certain species of planktonic algae and reduce the algal turbidity of the water. There is a need of more scientific research with respect to the potential bio-manipulation of lake ecosystems with the long-term positive effects.

Introduction

The problem of eutrophication nowadays is greatly affecting the water quality and aesthetic values of the lake ecosystems. In that case, bio-manipulation technique which is cost-effective technique can be considered as one of the most suitable solutions to overcome the problem of chances for success of bio-manipulation technique depends on the approach adopted i.e. whether the removal of fish was partial or complete, if only predatory fish were stocked, size (small lakes are easy to manipulate, Meijer 2000) and depth of the lake but the complete success through bio-manipulation is still debatable. Bio manipulation is generally described as engineering technology." Biomanipulation has become a routine technique for improving water quality of lakes and reservoirs (Hansson *et al.*, 1998; Drenner & Hambright, 1999). Bio manipulation biology is further explained as a management practice adopted by humans to improve degraded water bodies. Wysujack & Mehner (2002) suggested Best bio-manipulation strategy for the fisheries management is the combination of piscivore introduction, manual removal of fish species and its integration with the nutrient management. There is a need of more scientific research with respect to the potential bio-manipulation of lake ecosystems with the long-term positive effects.



Major components behind Bio-manipulation mechanisms

Fish

Fish is an important component of the bio manipulation process. There are two types of approaches we can follow in order to control the population of planktivorous fishes and to increase the zooplankton biomass. First approach to reduce the biomass of planktivorous fish is through kill (using some chemicals like rotenone by following the recommended dose) and removal (capturing the fish directly by netting) whereas secondly, we can go for the stocking of predatory (piscivorous) fishes. A reduction in the biomass of benthivorous fish is also suggested to have a favourable impact on the bio-manipulation process because the benthivorous fish

while feeding will stir-up the bottom causing more turbidity, impairing the colonization & growth of macrophytes and their stability.

Whereas the role of Phyto-planktivorous fish in bio-manipulation process is important as they improve the water quality by actively grazing upon the phytoplankton blooms. Radke and Kahl (2002) carried out an experiment of fish bio-manipulation and concluded that silver carp (Hypophthalmichthys molitrix), a Phyto-planktivorous fish species can more strongly impact the planktonic Cladocera's than phytoplankton, therefore, this fish cannot be considered as a candidate fish species for bio-manipulation in mesotrophic lakes. Starling *et al.* (2002) carried out a study and suggested that introduction of some small-scale commercial fish species targeted against these fishes would not only improve the water quality of the reservoir but also provide the local population with good quality protein. As an alternative to the fish , Roy *et al.* (2010) and Gulati *et al.* (2008), suggested that the introduction of mussels can also create clear water through the filtration of water as they are the filter-feeders and by reducing the nutrient load. In this case, Zebra mussel (Dreissena polymorpha) could be considered as a suitable candidate for bio-manipulation technique as it can reduce the phytoplankton biomass through filter feeding (Caraco *et al.* 1997 and Reeders *et al*. 1993)

Zooplankton

Being a key component of lake ecosystems, zooplanktons have a very important role in the process of bio-manipulation. Cooke (1986) stated that larger zooplanktons can consume a variety of algal blooms more efficiently as compared to smaller ones. Daphnia is recognized as the most significant genus to impact upon algae blooms and major contributor to the success of bio-manipulation. When large Daphnia are absent, zooplankton cannot reduce phytoplankton biomass. Mehner *et al.* (2002) suggested that intensive grazing by Daphnia on phytoplankton leads to the better water quality and also macrophytes becomes the dominant primary producers which would ultimately suppress the phytoplankton biomass. So, the main goal of the bio-manipulation technique is to lower the mortality of Daphnia to achieve the desired results.

Macrophytes

Aquatic macrophytes have been identified as a key component for the long-term success of biomanipulation management. Macrophytes stabilize the sediment preventing re-suspension of nutrients as well as utilizing nutrients for their own growth. The main role of the macrophytic communities of the lake is that they provide refuge to the zooplanktons and create the zone of low-oxygen levels where planktivorous fishes cannot survive well which would result in the prohibited entry of planktivorous fishes to zooplankton refuge (Shapiro 1990). Increased macrophytic population will reduce the algal blooms ((Hosper 1990). Fugl and Myssen (2007) attempted the restoration of lake L. Rogbolle in Denmark with the natural establishment of submerged flora whereas Moore *et al.* (2010) attempted the restoration of Freshwater tidal area in USA by following the artificial or man-made introduction of shoots, seeds and seed pods of Vallisneria americana and protection against grazing.

Purpose of bio manipulation

The key purpose of this technique is to decrease the high concentration of toxic phytoplankton in the water bodies that cause eutrophication. The growth of phytoplankton is controlled by introducing zooplanktons that eventually improve water quality and nutrient cycling.

Importance of bio manipulation

Bio manipulation has significant importance for fisheries. This method is being used by people for decades. Eutrophication has an impact on the diversity of the fish population, this could cause fishermen to lose their source of livelihood. Predator species have been purposefully introduced into the aquatic ecosystem by humans in an effort to control and enhance water quality through a biological process. It is important for the transparency of water in lakes. The habitat is restored for the fish population and aquatic biodiversity.

Advantages of Biomanipulation

1. Natural Process Introduced by Humans, It is a kind of natural/ biological process induced by humans to improve the water quality of the aquatic ecosystem.

2. Reduces Turbidity

3. No Requirement of Chemicals

4. Improves Fisheries

5. Maintain Nutrient Cycling

6. Supports Biodiversity, the decreasing biodiversity due to algal blooms starts increasing as water quality gets better.

Disadvantages of bio manipulation

- ✓ **Management of Lakes:** When using the bio manipulation technology, lakes need to be managed continuously.
- ✓ **Poisoning of Water Bodies:** The water bodies are poisoned by Rotenone application and water is not suitable for human consumption.
- ✓ **Lack of Awareness:** The fishermen are often not aware of the side effects of dominant species. Awareness about the importance of predator species is important for Fishermen.
- ✓ **Expensive Treatment:** The cost of the bio manipulation method is high and it is totally dependent on the method which is being used.

Challenges for bio-manipulation

- ✓ Bio-manipulation can only be used for small, shallow and closed system which means lake system needs to be totally closed (no connection with other water bodies)
- ✓ It is must to remove some fish fauna prior to the introductions of new piscivorous fishes to the lakes to reduce the risk of competition for food, shelter and breeding ground
- ✓ The eutrophication of lakes is being caused by increased worldwide development activities and climate change, which are doing so through increased nutrient influx.
- ✓ Modifications to the lake ecosystems' structure
- ✓ Limited long-term effectiveness

Conclusion

In summary, biomanipulation plays a crucial role in fisheries management in lacustrine ecosystems by influencing fish populations and trophic interactions to restore and maintain ecological balance. It's an approach that requires careful planning, monitoring, and adaptive management to ensure its effectiveness and minimize potential negative impacts on the ecosystem.

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Stress Among College Students and Its Management

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Stress may be defined as a state of psychological and / or physiological imbalance resulting from the disparity between situational demand and the individual's ability and / or motivation to meet those demands. Stress can disrupt both our professional as well as our personal lives. It is the major cause of health problems as 80 percent of all modern diseases have their origins in stress and 75 percent to 90 percent of all visits to primary care practitioners are now known to be stress-related. The World Health Organization (WHO) calls stress "the health epidemic of the 21st century".

Level of stress varies with age and occupation. College years have been deemed as one of the most stressful periods of a person's life. Rajasekar (2013) found that the main cause of stress among management students were faculty pressure (53%) followed by society (50%), parents' expectations (45%) and peer group (2%). Gender also plays a major role in causing stress as a greater number of females (38.1%) are stressed than males (23.3%) (Waghachavare et.al., 2013). Furthermore, employed females are more stressed than unemployed ones due to Overburden of work (mean score 1.04), pleasing others (mean score 0.92), extreme hot weather (mean score 0.86) and decision making (mean score 0.28) (Harshpinder, 2000). To cope up with stress people use different strategies. Some of these strategies are good but some affect negatively to their body. For example, substance abuse by students is mainly due to academic stress. As reported, nearly 5500 children and adolescents in India, begin usage of tobacco products daily, with a majority who initiate substance intake before 18 years and a few as young as 10 years old (Patel & Greydanus 1999).

Stages of stress

When people feel stressed by something going on around them, their bodies react by releasing chemicals into the blood. These chemicals give people more energy and strength, which can be a good thing if their stress is caused by physical danger. But this can also be a bad thing, if their stress is in response to something emotional and there is no outlet for this extra energy and strength. Stress consists of physiological reactions that occur in three stages:

1. Alarm phase: Upon encountering a stressor, body reacts with "fight-or-flight" response and sympathetic nervous system is activated. Hormones such as cortisol and adrenalin released into the blood stream to meet the threat or danger. In this stage the body's resources are mobilized.
2. Resistance phase: Parasympathetic nervous system returns many physiological functions to normal levels while body focuses resources against the stressor. Blood glucose levels remain high, cortisol and adrenalin continue to circulate at elevated levels, but outward appearance of organism seems normal. Heart rate, Blood pressure, breathing increases and body remains on red alert.
3. Exhaustion phase: If stressor continues beyond body's capacity, organism exhausts resource and becomes susceptible to disease and death.

Type of stress

Stress can be both positive and negative. It is our response to stress, how we manage it makes a difference in terms of how it affects us.

i. Eustress: Stress resulting from pleasant events or conditions is called eustress. Eustress can be defined as a pleasant or curative stress. We can't always avoid stress, in fact, sometimes we don't want to. Often, it is controlled stress that gives us our competitive edge in performance related activities like athletics, giving a speech, or acting.

ii. Distress: Stress resulting from unpleasant events or conditions is called distress. It is again subdivided into three parts

   a) Bad stress: If a stimulus we react to is negative, we are actually feeling "distress"

though we label it as stress. e. g. death of a close friend.

b) Acute stress: Acute stress is usually for short time and may be due to work pressure, meeting deadlines pressure or minor accident, over exertion, increased physical activity, searching something but you misplaced it, or similar things.

c) Chronic stress: Chronic stress is a prolonged stress that exists for weeks, months, or even years. This stress is due to poverty, broken or stressed families and marriages, chronic illness and successive failures in life. People suffering from this type of stress get used to it and may even not realize that they are under chronic stress. It is very harmful to their health.

Stressors and their type

Factors that cause stress are called Stressors. In recent times, youngsters encounter different kind of stressors, such as expectation of excelling in academics, vague future, problems associated with adapting into the college environment, stressful surroundings, job expectation, social, emotional, physical and family problems (Lai & Wong 1992, Fish & Nies, 1996, Verma et al. 2002, Chew et al., 2003, Krishnakumar et al. 2005). The most important stressors encountered by youngsters include high individual and external expectations, and stressful surroundings as well as academic motivators such as academic tasks, ranks and college recognition. Students believe that they would practice an improved way of life if these challenges were removed (Maheshwari & Deepa 2013). Stressors can be broadly classified into two groups as follows:

a) External stressors: External stressors are events and situations that happen to cause stress to a person. Some examples of external stressors include major life changes. These changes can be positive, such as a new marriage, a planned pregnancy, a promotion or a new house. Or they can be negative, such as the death of a loved one or a divorce.

b) Internal stressors: Internal Stressors are sources of stress that are coming from within individual's body or mind. They include things like whether they are tired, ill, hungry, hot, cold, nutritional status, emotional state, what thoughts they are preoccupied with, mood, and attitudes.

Symptoms of stress

- Physical symptoms: People in stress may experience changes in sleep pattern, fatigue, digestion problems, loss of sexual drive, headaches, aches and pains, infections, dizziness, fainting, sweating & trembling, tingling hands & feet, breathlessness, palpitations and missed heartbeats.
- Mental symptoms: Stress leads to lack of concentration, memory lapses, difficulty in making decisions, confusion, disorientation, panic attacks.
- Behavioural symptoms: People may experience changes in appetite, eating disorders - anorexia, bulimia, increased intake of alcohol & other drugs, increased smoking, restlessness, fidgeting and nail biting.
- Emotional symptoms: Depression, impatience, extreme anger, tearfulness, deterioration of personal hygiene and appearance are some of the symptoms depicting emotional disturbance that people in stress may experience.

Stress management strategies

i. **A B C technique:** The ABC Technique is an approach developed by Albert Ellis and adapted by Martin Seligman to help us think more optimistically. The technique is based on our explanatory style. That is, how we explain difficult or stressful situations to ourselves, across dimensions of permanence, pervasiveness, and personalization. This strategy has 3 steps, thus the name A-B-C that anyone can follow. The A here is the potentially stressful situation, while B is the beliefs, thoughts, or perceptions about that stressful situation, and C is the consequences,

which results to stress. After knowing the ABC of stress, one can start changing it to avoid stress. Changing A modifies the environment whether it is work place or home. If somebody don't like waiting and sitting in traffic then he/she can leave earlier to avoid rush. If one can't modify the environment, he/she can change B by altering his/her perception. To properly manage stress, one must always focus on how he/she could change the way he/she view things. If modifying the situation or thoughts about the situation can't be done, change C. Learn how to relax and quiet down your mind and body.

ii. **Biofeedback:** Biofeedback is the process of gaining greater awareness of many physiological functions primarily using instruments that provide information on the activity of those same systems, with a goal of being able to manipulate them at will. Some of the processes that can be controlled include brainwaves, muscle tone, skin conductance, heart rate and pain perception. Biofeedback may be used to improve health, performance, and the physiological changes which often occur in conjunction with changes to thoughts, emotions and behaviour. Eventually, these changes may be maintained without the use of extra equipment, even though no equipment is necessarily required to practice biofeedback actually. Biofeedback has been found to be effective for the treatment of headaches and migraines

iii. **Time management:** Time management is the act or process of planning and exercising conscious control over the amount of time spent on specific activities, especially to increase effectiveness, efficiency or productivity. Time management may be aided by a range of skills, tools, and techniques used to manage time when accomplishing specific tasks, projects and goals complying with a due date. This set encompasses a wide scope of activities, and these include planning, allocating, setting goals, delegation, analysis of time spent, monitoring, organizing, scheduling, and prioritizing. Initially, time management referred to just business or work activities, but eventually the term broadened to include personal activities as well. A time management system is a designed combination of processes, tools, techniques, and methods. Usually time management is a necessity in any project development as it determines the project completion time and scope.

iv. **Meditation:** Meditation is a practice in which an individual trains the mind and/or induces a mode of consciousness to realize some benefit, although it can be argued meditation is a goal in and of itself. The term meditation refers to a broad variety of practices (much like the term sports), which range from techniques designed to promote relaxation, contacting spiritual guides, building internal energy, receiving psychic visions, getting closer to a god, seeing past lives, taking astral journeys, and so forth, to more technical exercises targeted at developing compassion, love, patience, generosity, forgiveness and more far-reaching goals such as effortless sustained single-pointed concentration, single- pointed analysis, and an indestructible sense of well-being while engaging in any and all of lifes activities. Thus, it is essential to be specific about the type of meditation practice under investigation.

v. **Cognitive therapy:** Based on the theory that depression is due to distortions in the patients perspectives, such as all-or-none thinking, over-generalization, and selective perception. The therapist initially tries to highlight these distortions, and then encourages the patient to change his or her attitudes.

vi. **Relaxation technique:** A relaxation technique (also known as relaxation training) is any method, process, procedure, or activity that helps a person to relax; to attain a state of increased calmness; or otherwise reduce levels of anxiety, stress or anger. Relaxation

techniques are often employed as one element of a wider stress management program and can decrease muscle tension, lower the blood pressure and slow heart and breathe rates, among other health benefits.

Conclusion

Stress is the major problem among college students. There are several reasons of stress, major being the academic pressure and competition for job. Some amount of stress is necessary to work efficiently but it becomes dangerous if it crosses the resistance level. The person suffering from stress may seem normal but it is very important to identify the symptoms of stress so that the problem could be identified and proper management strategies could be adopted. Some of the symptoms of stress are changes in sleep pattern, changes in appetite, fatigue, digestion problems, dizziness, increased intake of alcohol & other drugs, increased smoking, restlessness, fidgeting and nail biting, tearfulness, deterioration of personal hygiene and appearance. If the person in stress is left unattended, they may adopt some harmful means to overcome their stress. It is the responsibility of peer group, family members and teachers to identify the person in stress and suggest proper stress management strategies like changing their thinking pattern, meditation, time management and using relaxation techniques to overcome their stress.

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The Future of Agriculture: Indoor Vertical Farming

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Globally 54 percent of the world's population residing in urban areas (Zaid et al., 2018), urbanisation, a shortage of farmland, rising greenhouse gas emissions, and the growing concerns of food security underscore the need for vertical farming. In the future, an expanding global population will be able to feed itself because to vertical farming, an environmentally benign, energy-efficient, and a viable substitute for traditional farming. The introduction of indoor vertical farming represents a transformative approach to agricultural practices. This method involves cultivating crops in stacked layers or vertically inclined surfaces within controlled environments, utilizing advanced technologies to optimize growth conditions. Urban areas with limited and expensive land must grow enough food to feed their own people in order to prevent traffic jams, pollution, and soaring food prices.

Advancements in Technology

Indoor vertical farming leverages cutting-edge technologies such as hydroponics, geoponics, and vertical stacking systems. These technological advancements facilitate precise control over environmental factors, including light, temperature, and nutrient levels, thereby maximizing crop yield and minimizing resource usage. In vertical gardening with the help of decorative flowering vines and flowers is increasingly used in interior decoration in shopping malls, areas of public facilities (Xamidov, 2023).

Sustainable Agriculture Practices

One of the key advantages of indoor vertical farming is its inherent sustainability. By reducing the reliance on traditional agricultural land and minimizing water usage, this method offers a more environmentally friendly alternative. The controlled environment also reduces the need for pesticides, further contributing to sustainable and eco-conscious farming practices.

Addressing Food Security

As the global population continues to grow, ensuring food security becomes a paramount concern. Indoor vertical farming has the potential to address this challenge by providing a reliable and efficient means of producing crops year-round, independent of external climate conditions. Vertical home gardens have a distinctive role to play in agriculture, food security, and nutrition (Chadha et al., 2023). Vertical farming has the ability to deliver reliable and sustainable food. This resilience enhances the stability of food supply chains and reduces vulnerability to external factors Soojin & Lu (2023).



Economic Viability

The economic viability of indoor vertical farming is a crucial aspect to consider. While initial setup costs may be high, the long-term benefits, including increased yield per square foot and reduced resource inputs, make it an economically attractive option. Furthermore, the potential for urban farming

can create local job opportunities and stimulate economic growth.

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Challenges and Opportunities

Despite its promising outlook, indoor vertical farming faces challenges such as energy consumption and the need for further research on crop varieties suitable for vertical cultivation. Addressing these challenges presents opportunities for innovation and continuous improvement within the field.

Conclusion

In conclusion, indoor vertical farming emerges as a transformative force shaping the future of agriculture. Its integration of technology, commitment to sustainability, and potential to enhance food security underscore its significance in creating a more resilient and efficient global food production system. As technology continues to advance, indoor vertical farming stands poised to play a pivotal role in ensuring a sustainable and secure future for agriculture.

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Maize Fall Armyworm (*Spodoptera Frugiperda*) and It's Management

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The fall armyworm (FAW) (*Spodoptera frugiperda*) is one of the devastating insect pest belonging to the family Noctuidae and falls in the Lepidoptera order. It is a polyphagous pest causing damage to economically important cultivated cereal crops such as maize, rice, sorghum, cotton and various vegetable crops and eventually impacts on food security. The FAW feeds on leaves, stem and reproductive parts of plant species. It is native to tropical and subtropical regions of the America. FAW, which was first found in America, is one of the common pests of maize in South and North America. In Africa, it was first reported in 2016 and has become one of the major invasive pests reaching over 30 countries across tropical and southern Africa including Madagascar, Seychelles and Cabo Verde at the end of 2017, which later reached over 44 countries. There are 353 plants reported as a host for this pest (Kansiime *et al.*, 2019).

Nature of damage

Caterpillars feed on maize at nearly all stages of growth from when the plant is young and also on the cob. Caterpillar damage on the leaves can sometimes be significant and disrupt the plant's ability to form good grain and healthy cobs

- Leaf feeding causes extensive "window pane" damage on maize.
- Large irregular and elongated holes on the leaves are caused by the big caterpillars while feeding.
- Small caterpillars cause the clear or window-like patches while larger caterpillars cause irregular elongated holes on leaves.
- Bigger caterpillars make larger holes when feeding, causing ragged whorl leaves and producing sawdust-like material called "frass".
- Fresh feeding produces big lumps of frass.
- Badly infested fields will have damage on the leaves similar to that caused by a hailstorm.
- During the day, caterpillars hide deep in the whorls (funnel).
- They feed inside whorls and can destroy silks and developing tassels on older crops, thereby limiting fertilization of the ear and leading to poor grain development.
- Caterpillars move to the ear zone/funnel and start feeding after tassel emergence.
- Damage to cobs may lead to fungal infection, aflatoxin contamination and loss of grain quality.
- Cobs that were attacked in the field will have many of the seeds eaten up by the caterpillar.

Management

Cultural Control

1. Control is largely achieved in the northern range through a winter kill by exposing larvae and pupae within the upper soil surface.
2. Freezing temperatures cause high larval mortality. Therefore, clean cultivation and weeding are recommended.
3. Some locally adaptable methods have also been tried such as soil, charcoal, ash, detergents, paraffin and engine oil.
4. Various plant extracts are often included, such as chilli, neem, *Tephrosia*, *Tithonia*, *Lantana* and garlic.
5. Handpicking egg masses and caterpillars has been tried in Africa. The efficacy of these methods is not well documented.

Biological Control

A large number of parasitic Hymenoptera, acting as larval parasitoids, have been reared from *S. frugiperda*, Natural levels of larval parasitism are often very high (20-70%), mostly by braconid wasps. Some 10-15% of larvae are often killed by pathogens.

The compound N-(17-hydroxylinolenoyl)-L-glutamine called volicitin (A non-essential amino acid present abundantly throughout the body and is involved in many metabolic processes.) was isolated

from oral secretions of *Spodoptera exigua* larvae. When applied to damaged leaves of maize seedlings, volicitin induced the seedlings to emit volatile compounds that attracted females of the parasitoid *Cotesia marginiventris*. Mechanical damage of the leaves, without application of this compound, did not trigger release of the same blend of volatiles. Volicitin appears to regulate tritrophic interactions among plants, insect herbivores and natural enemies of *S. exigua.*

Biopesticides

1. Virus-based insecticides, which are mostly in the Baculovirus group, such as the multiple nucleopolyhedrovirus (SfMNPV) have potential for use in the management of fall armyworm**.**
2. The pest is infected by ingesting the baculovirus. The symptoms of Baculovirus infection include appearance of blemishes, yellowing of the skin, and decline in feeding.
3. *Metarhizium anisopliae* and *Beauveria bassiana* have also shown efficacy against eggs and second-instar larvae of fall armyworm (Komivi *et al*., 2019).
4. *EPN are also used for the control of FAW.-* ***Heterorhabditis.***

Botanicals

1. Azadirachtin (neem) is effective against fall armyworm.
2. Also, extracts from *Synedrella nodiflora* and *Lupinus stipulatus* have shown to have biological effects on mature insects of the genus *Spodoptera*.

Chemical Control

In some areas resistance to insecticides may be widespread and control can be difficult. Recommended insecticides for *Spodoptera* spp. include esfenvalerate,carbaryl, chlorpyrifos, malathion, permethrin, and lamba-cyhalothrin.. Togola *et al.* (2018) showed that five insecticide compounds used against fall armyworm (cypermethrin, deltamethrin, lambda-cyhalothrin, permethrin, and chorpyrifos) remained in the soil.

Pheromonal Control

1. The sex pheromone for *S. frugiperda* contains (Z)-9-Tetradecenyl acetate (Z-9-14:OAca) which is common to *Trichoplusia ni*, *Spodoptera exigua* and *Agrotis ipsilon exigua.*
2. Mating disruption my be possible given the successes observed for S. exigua in which (9Z,12E)- 9,12-tetradecadienyl acetate released at high concentrations, caused mating disruption in tomato, lucerne and cotton fields.

IPM Programmes

1. Integrated control of *S. frugiperda* has been facilitated through cultivation practices to destroy overwintering sites, improved varieties with resistance to leaf feeding through conventional mechanisms or the introduction of Bt crops.
2. Biological controls are prevalent and should be encouraged through reduced spaying of insecticides. CIMMYT (2018) have published a technical guide for IPM of *S. frugiperda* in Africa.

Conclusion

- Use of biopesticides, botanicals and alternating sprays of old and newer insecticides is advocated in the absence of the IPM strategies.
- However, Farmers will need great support through Integrated Pest Management (IPM) to sustainably manage the fall armyworm in their cropping systems.
- There is need to fully elucidate the mechanism of fall armyworm control by CAPP technology to allow its optimization and strategic dissemination as a management tool for this invasive pest.

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Utilization of Renewable Energy Sources in Fisheries Sector

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Fisheries sector is promising way for employment and income generator to huge chunk of the society. The fisheries sector includes fishing, aquaculture, post-harvest processes and product distribution. India is the second largest fish producing country in the world accounting for 6.56% of global production and contributing about 1% to the country's Gross Value Added (GVA) and over 5.37% to the agricultural GVA during 2017-18 (FAO STAT, 2018). Fish, being an important component of the diet for people throughout the world, has high protein content and nutritional value. The consumption of fish is an essential part of a healthy and well-balanced diet (Moya et al. 2008). Potential health benefits related to fish consumption are due to the presence of protein, unsaturated essential fatty acids, minerals, and vitamins (Sidhu, 2003). Additional health benefits from the consumption of fish or fish oil may relate to polyunsaturated fatty acids (PUFAs), especially eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (Sidhu, 2003; Domingo et al. 2007). Fish provide omega-3 fatty acids that could reduce cholesterol levels and the incidence of heart disease, stroke, and preterm delivery (Burger, 2004). It also acts as a mood stabilizer (Silvers and Scott), especially among females (Timonen et al. 2004). The fisheries sector is highly external energy dependent sector which is mainly on fossil fuels. Fossil fuels are dominant form of source of energy used in fishing and these fuels produce CO_2 in the atmosphere which leads to greenhouse effect and other toxic pollutants which are harmful to environment and human kind. Hence, there is need to utilize renewable sources which are inexhaustible in nature and ecofriendly. The depletion of fossil fuel resources and their known adverse effects on the environment have gained the interest in renewable energy resources, such as solar, wind, biomass, wave, and geothermal energy sources. India has set for itself a mitigation of GHG target for 2030.

Fish post-harvest

- It is a highly perishable food product with a very short life span (amount of water contain 80%). During the monsoon season, upto 30% of catch fish would be lost due of lack storage, preservation methods.
- The fish processing refers to the processes associated with fish and fish products between the time fish are caught or harvested, and the time the final product is delivered to the customer.
- The harvested fish should be cleaned and cooled as soon possible due to their strong digestive juices, fish spoil very soon and if not gutted and cleaned promptly may develop off flavor and color.

Application of Solar Energy in fish post-harvest

- Solar drying is used to enhance the effect of the solar radiation.
- Compared to the sun drying, solar dryers can generate higher air temperatures and consequential lower relative humidity, which are conducive to improved drying rates and lower final moisture content of the final products.

Utilization of Fish Processing Waste Materials

The valuable products that would be developed from of these fish processing waste materials are

- Fish waste as a material for enzyme production
- for fish protein hydrolysates (FPH) production
- for fish meal production
- for fish silage production
- for collagen and gelatin production
- for fish oil production – This can be used for production of Bio-oil

Production of biogas using fish waste

Anaerobic digestion is a collection of processes by which micro-organisms breakdown biodegradable materials in the absence of air. Oil-free fish waste (cake) can be used in biogas production. The digestate can be used as fertilizer (Yuvaraj *et al.,* 2019).

Production of biodiesel using fish oil

Transesterification is a chemical reaction used for the conversion of triglycerides contained in oils into usable biodiesel. In transesterification process a glyceride reacts with an alcohol in the presence of a catalyst forming fatty acid alkyl esters and an alcohol. It is the basic step that yields biofuel products.

Conclusion

- An integrated approach to ensure ecosystem integrity and conserve biodiversity
- Use of solar energy or other renewable energy sources for lighting, refrigeration on board the fishing vessels, and other activities.
- Use of solar energy in fish post- harvest can reduce losses (Ex: Solar dryer, solar Refrigeration etc.,)
- Use of renewable energy in aquaculture reduces the production cost and increase the sustainability. & an efficient produced energy can be used for aeration, feed dissension, water pumping, light sources, etc.
- Every year billion tons of fish waste are dumping on land or hauling into the ocean cause emissions so that waste can used for production of biofuels & fertilizers.
- Integrated renewable energy solutions can be used to produce the needed electricity, heat, steam, hot water and cooling/freezing energy in fish processing industries.

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Effect of Climate Change on Food Security, Safety and Nutrition

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Abstract

Climate change can disrupt food production by influencing temperature, precipitation patterns, extreme weather events, sea levels, and the degradation of agricultural land. The vulnerability to these changes varies across regions, populations, and genders. The impacts of climate change extend to pasture, crop, and livestock production, leading to a reduction in the nutritional value of certain crops. Additionally, fisheries, aquaculture, food manufacturing, logistics, and trade are all susceptible to climate-induced challenges. All four dimensions of food security—availability, stability, access, and utilization are affected by climate change. Changes in availability can contribute to a rise in food prices. Climate change also affects human health and nutrition by influencing the absorption and utilization of nutrients. The incidence of foodborne diseases, influenced by climate change, increases nutritional requirements while simultaneously hindering absorption. Contamination risks in food include microorganisms, animal disease pathogens, fungal toxins, harmful algae by-products, chemicals, pesticides, and veterinary drugs. Environmental factors play a role in the abundance, survival, and virulence of pathogens, leading to an increase in morbidity and mortality from diarrheal diseases due to contaminated food and water. The spatial and temporal distribution of disease vectors and animal reservoirs expand due to climate change, resulting in the wider distribution of vector-borne and zoonotic diseases. Climate change influences the emergence and re-emergence of infectious diseases. It encourages the infection of crops with toxigenic fungi, leading to the production of mycotoxins such as aflatoxin, which can reach humans through the ingestion of contaminated crops. The impact of climate change on the marine environment enhances the formation of harmful algal blooms and the production of algal toxins.

Keywords: Climate change, Food security, Toxigenic fungi, algal toxin, mycotoxin.

Introduction

Undernutrition persists as a severe global socio-economic and health challenge. In 2010, 925 million people were grappling with hunger, and the convergence of undernutrition with infectious diseases led to an estimated annual toll of 3.5 million preventable maternal and child deaths (UN System, Standing Committee on Nutrition, 2010). The IPCC's Fourth Assessment Report (2007) underscores that climate change and its variability will significantly impact both food security and malnutrition. Projections suggest a future characterized by more intense, frequent, and prolonged extreme weather events, including extended periods of drought, heavy precipitation, heat waves, and tropical cyclones. These climatic shifts will directly impact food and nutrition availability, particularly in vulnerable communities. Climate change consequences extend to disruptions in sewage, drainage, and water systems, resulting in increased issues like flooding and sea-level rise. This contributes to water and agricultural land contamination, with more people exposed to diarrheal and infectious diseases, worsening undernutrition challenges, and limiting effective food resource utilization. The intricate relationship between climate change and undernutrition heightens the vulnerabilities of marginalized communities, highlighting the pressing need for comprehensive global interventions.

Climate Change

- By 2050, the global average temperature is projected to increase by 2-4 °C above pre-industrial levels due to climate change, with land experiencing more substantial temperature rises than oceans.
- Generally, rising temperatures will lead to a more dynamic hydrological cycle, resulting in increased overall rainfall. However, certain regions may experience reduced rainfall, and alterations in the timing and intensity of rainfall events could have significant localized impacts.

- Droughts have adverse effects on both the quantity and quality of agricultural yields, diminishing dietary diversity and overall food consumption. This can result in undernutrition, protein-energy malnutrition, and/or micronutrient deficiencies, along with substantial economic losses.
- Climate change contributes to sea-level rise, particularly affecting low-lying coastal zones and river deltas. This leads to salination and the destruction of agricultural land, with significant repercussions on livelihoods and food security due to crop and livelihood asset losses.
- Tropical cyclones pose a threat by destroying crops, agricultural land, infrastructure, and crucial livelihood assets.
- Temperature variations and water scarcity will influence the physiology of both animals and plants.
- Climate change results in compromised sustainability and can contribute to socio-economic and political conflicts.

Disparities in Susceptibility to Climate Change Effects

Climate change stands as a global environmental threat to human health and the environment, affecting hydrological systems, freshwater supplies, land degradation, and putting stress on food production systems (World Health Organization, 2005). Additionally, extreme events have the potential to devastate human settlements.

The impact of climate change exhibits variations across regions, among diverse populations, and is influenced by gender.

Regions at Risk

Areas most prone to negative impacts from climate change are those already facing heightened vulnerability to food insecurity and malnutrition, potentially experiencing substantial losses in agricultural land. Arid and semi-arid regions, especially susceptible to droughts, face reduced crop productivity and diminished food availability due to even minor increases in local temperatures and heightened water stress.

Certain regions heavily reliant on low-lying coastal areas with high population densities, such as mega-deltas and small island states, encounter significant threats from rising sea levels and salt intrusion. Floods in these regions pose risks of destroying crops, livelihood assets, and agricultural land. Coastal conditions may also degrade through beach erosion, impacting fisheries. The adaptation process is particularly challenging for impoverished communities.

At-Risk Population Groups

Climate change heightens vulnerability to food insecurity among groups like smallholders, subsistence farmers, and coastal populations. Individuals with limited adaptive capacities, influenced by factors like age and socio-economic disadvantages, face negative impacts on crop yields and food resources. Climate change has caused over 160,000 deaths and 5 million Disability-Adjusted Life Years (DALY) from malaria, diarrhea, malnutrition, and flooding (McMichael et al., 2004). Projected effects include increased malnutrition, respiratory diseases, and diarrheal diseases, impacting vulnerable individuals and agricultural labor supply. Climate-related extreme weather events force poor families into negative coping strategies, elevating undernutrition risk (UN System, Standing Committee on Nutrition, 2010).

Gender Disparities in Climate Vulnerability

Throughout all stages of climate change-related extreme weather events, including exposure, risk perception, preparedness behavior, warning communication, response, and recovery, men and women experience differential impacts (Fothergill, 1998). Climate change, particularly through its effects on water and food security, has the potential to intensify women's workloads.

Aspects of Food Security

The four essential dimensions of food security include:

1. Availability: Ensuring a sufficient quantity of food is accessible for consumption.

2. Stability: Guaranteeing the regular availability of resources necessary for food consumption.

3. Access: The ability of individuals to obtain food consistently, either through personal production or purchase.

4. Utilization: Involves the quality and safety of food, nutritional aspects, and the body's ability to absorb adequate amounts of nutrients.

It's noteworthy that climate change significantly impacts all these dimensions (The MET Office and World Food Program's Office for Climate Change, Environment, and Risk Reduction, 2012).

I. Climate Change's Impact on Food Security (Cohen et al., 2009 and FAO, 2008)

a. Pasture, Crops, and Livestock Production: Global warming's repercussions on food production vary regionally due to factors like reduced water availability, sea-level rise, and extreme weather events. Developing countries may see a 10-20% decline in agricultural output by 2080. Recurrent droughts impact crops and livestock, affecting food and water availability. A moderate local temperature increase alongside elevated CO2 can have modest positive effects, but CO2 concentration rise may lower nutritional value, impacting staple crop prices (UN System, SC on Nutrition, 2010). Climate change affects farm animal growth, health, reproduction, and dairy production, contributing to increased zoonotic diseases.

b. Fisheries & Aquaculture: Fish are sensitive to temperature changes and ocean acidification, known as "the Evil Twin of Global Warming." Higher water temperatures harm crustaceans and shrimp, and fish distribution shifts risk species extinction. Increased CO2 and ocean acidity impact aquatic organisms and disrupt the food web. Climate factors affect fisheries, impacting productivity and increasing disease vulnerability. Extreme weather events may lead to farmed stock escapes, impacting genetic diversity. Warmer ocean temperatures worsen eutrophication, causing toxic algal blooms. Elevated ocean temperatures promote cholera, increasing the risk of diarrheal diseases (FAO, 2008, McMichael et al., 1996).

II. Climate Change's Impact on Food Availability, Stability, and Access (Cohen et al., 2009)

Extreme weather events pose challenges to the stability and access of food supplies. The exacerbation of food insecurity is evident in the loss of cultivable land and nursery areas for fisheries in low-lying regions. Climate-related issues, including animal and plant pests, diseases, and invasive aquatic species, contribute to crop and animal losses, diminishing aquatic populations and impacting the stability of production systems. These factors also reduce access to food by lowering income from food crops and animal production, altering aquatic populations, and increasing the cost of disease and pest control. The escalation of food prices can further impact the access to food for households. Extreme weather events also play a role in water and food contamination with chemicals, potentially affecting food stability, access, and utilization. In situations where food supplies are insecure, individuals tend to shift towards less healthy diets and consume more "unsafe foods," exposing themselves to various chemical, microbiological, and other health hazards. Without climate change, 640 million people are anticipated to be at risk of hunger by 2060. Climate change is projected to add 40-300 million people to the at-risk category (McMichael et al., 1996).

III. Climate Change Impact on Health and Food Utilization: Food Safety Hazards

Climate change is a significant global health threat, impacting disease burden and mortality (Costello et al., 2009). It affects food safety throughout the production chain, exacerbating nutritional needs. Contaminated food, laden with bacteria, viruses, or chemicals, causes over 200 diseases, straining healthcare and economies (WHO, 2014). Pathogens like bacteria, viruses, and protozoa are influenced by climate change, with water temperature affecting cholera peaks and extreme events impacting disease emergence. Vector-borne diseases like malaria face altered distribution dynamics, with regions contracting or expanding. Climate-sensitive diseases like Rift Valley Fever are influenced by precipitation changes (FAO, 2008; McMichael et al., 1996; The National Institutes of Health, 2014).

Zoonoses and Other Animal Diseases

Zoonotic diseases, transmitted to humans through vectors, direct contact with infected animals, animal products or wastes, or the consumption of contaminated food or water, pose an increased risk as the incidence of such diseases in animals rises. Climate change is a key factor contributing to the emergence and spread of diseases in livestock, facilitating the transfer of pathogens to humans. While many aspects of the impact of climate change on bacteria, viruses, and protozoa are relevant to zoonotic diseases, specific factors include:

- Augmentation of animals' susceptibility to diseases,
- Expansion of the range or abundance of vectors/animal reservoirs, and
- Prolongation of the transmission cycle of vectors.

Increase in the Susceptibility of Animals to Disease

Extreme weather conditions such as intense cold, drought, excessive humidity, or heat can heighten animals' susceptibility to specific pathogens. These conditions increase the chances of disease transmission among animals, elevate livestock exposure to vectors and wildlife, and amplify disease transmission to humans.

Increase in the Range or Abundance of Vectors/Animal Reservoirs

Climate change alters the dynamics of zoonotic diseases by affecting vector sensitivities, leading to shifts in range, seasonality, and abundance. Droughts followed by heavy rainfall create breeding grounds for disease-carrying mosquitoes, impacting outbreaks of vector-borne livestock diseases. Changes in precipitation patterns influence arthropod vector distribution. Examples include Rift Valley fever and tick-borne diseases. Climate change also affects the ecology of animal hosts, prolonging transmission cycles of vectors and increasing the incidence of human infections.

Influence of Climate Change on Molds and Mycotoxin Contamination

Climate change factors such as temperature, humidity, and precipitation can favor the growth of toxigenic molds. Adverse conditions for plants may encourage increased fungal growth and higher mycotoxin production. Indirect triggers, including insect and pest attacks, soil characteristics influenced by climate change, fertilizer usage, droughts, nutrient deficiencies, and excess toxic elements, contribute to fungal colonization and mycotoxin production.

Control measures for fungal development and mycotoxin production involve post-harvest handling techniques, cleaning, drying, and storage, where maintaining suitable humidity levels is crucial for stability. Climate change could potentially impact this aspect of the food chain.

Environmental Contamination, Flooding, and Chemical Residues in the Food Chain

Climate-related events, like increased floods, are linked to agricultural and pastureland contamination with metals, chemicals, and toxicants. Soil contamination arises from mobilized river sediment or pollutants released upstream, affecting areas like industrial sites and landfills. Grazing on flooded pastureland can transfer contaminants to milk and the food chain. Higher temperatures and intensified precipitation contribute to water pollution, carrying pathogens, pesticides, and pollutants into water bodies. Hurricane Katrina's aftermath in 2005 showed floodwaters contaminated with various chemicals, posing risks to water quality. Warming ocean temperatures increase mercury methylation, impacting fish and potentially affecting women and their offspring (EPA, 2005; Booth and Zeller, 2005).

Climate Change Mitigation and Food Security

Climate change mitigation is vital for food security, safety, and nutrition in low- and middle-income countries. However, concerns arise with biofuel production, as burning forests for biofuels can exacerbate climate change. While biofuels contribute to mitigation, policies promoting their use may challenge food security. Bioenergy sources divert resources from food crop cultivation, resulting in lower food production, market shortages, and increased food prices. This leads to reduced access to nutritious foods, impacting health and productivity, especially among the poor (United Nations System, 2010; Cohen et al., 2009).

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Habitat Management: The Eco-Friendly Plant Health Management to Play Down Insecticide Resistance Against Insect Pests

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Insect pests infestation is one of the major biotic stress for the lower productivity of crops. Pests problem have increased due to monoculture, over reliance on nitrogenous fertilizer, dense cropping and availability of preferred host. Entomologists have been developed several crop and even pest-wise integrated pest management (IPM) to minimize the use of insecticides and to conserve, increase and encourage the action of defenders (natural enemies of pests) for eco-friendly pest management. Habitat management is the first line of defense against insect pest, however chemical insecticides are still front-line defense and due to misuse, over use and use of insecticides at sub lethal doses there is development of pest resistance, resurgence, secondary pest outbreak, destruction of natural enemies and environmental pollution. The habitat manipulation tactics creates a suitable microhabitat within agricultural ecosystem which supplies the resources such as food and shelter to natural enemies in a pesticide free zone for their better survival and increase predation efficiency.

Habitat manipulation by growing of attractant plants to attract the natural enemies, repellent plants to repel the pests, trap plants to attract and trap the crop pests, barrier/guard plants to prevent the entry of pests. It also includes trap crops that divert pests away from crops and changing monocultures to polycultures in agro-ecosystem. Enhancing plant diversity to increase the fitness of natural enemies in a conservation biological control system. Changes in landscape diversity due to monoculture have led to more insect outbreaks, because of the removal of natural vegetation and decreased habitat diversity.

Habitat management or manipulation is an important agro-ecological approach, which can be used to minimize pest pressure in the agro-ecosystem through improving natural enemies' fitness by the presence of plant functional diversity. Habitat can be managed within crop, within farm or at the landscape level. The habitat management is influenced by the landscape composition, nature of plants, flower color, longevity of flowers, non-crop habitats such as weedy lots, hedgerow, field margins.

Habitat manipulation by growing insectary plant/flowering plant species provides a suitable microhabitat within agricultural ecosystem that attract or accumulate natural enemies or pests by providing shelter, nectar, pollen, alternate host, physical refugia, and lekking sites and/or by releasing volatile compounds. Nectar in flowers is an important source of carbohydrates that natural enemies use to maintain their activity and metabolism. Pollen is an important source of proteins, minerals, and vitamins that enhance fecundity, survival and abundance of natural enemies. Natural enemies' fitness in agro-ecosystems is influenced by floral traits such as quality and availability of nectar and pollen, flower color, shape, size and morphology of the corolla, and plant volatiles. Insectary flowering plants around field also attracts different kinds of pollinator that helps in natural cross pollination and increases yield.

The key concept of the habitat management is conserving and enhancing entomophages by increase

plant biodiversity and growing of flowering plants that provides nectar and pollens to natural enemies to promote biological control for a sustainable agriculture under zero insecticide condition.

Conclusion

Habitat management for pest management is the environmentally sustainable plant health management practices to maintain pest population below ETL by enhance pest: defender ratio and that reduce over reliance on chemical pesticides to avoid the development of pesticide resistance on insect pests. It is not a 'high-tech' approach, but simple, eco-friendly and practical method for all farmers to implement, which fits with the popular perception that diversity leads to stability and productivity.

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Plant Microbiome Engineering: A Sustainable Management Approach for Plant Growth and Disease Management in Temperate Fruits

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Abstract

The plant microbiome is an integral part of the host and increasingly recognised as playing fundamental roles in plant growth and health. Plant microbiome engineering, or phytomicrobiome engineering (PME), is potentially useful, but as-yet-unexplored new approach that could be used to improve plant productivity, health, and growth in a variety of environmental settings. The capacity of the plant microbiome in limited environmental conditions and the idea of enhancing microbial functions may promote plant development vis-a-visproduction and productivity.

Introduction

Temperate fruit trees are adapted to the temperate zone climate in mid-latitudes grown in a variety of climates across the globe to high latitudes. In temperate regions of the world, pome, stone, and nut fruits are major commercial fruit tree crops. These fruits belong to the Rosaceae family, which also includes species of pome (apple, quince, and pear) and stone fruits (apricot, peach, plum, almond, and cherry).Total 48% of the world's fruit production comes from temperate fruit trees. However, China, Turkey, USA, Brazil, Italy, South Africa, and Spain cultivate about 50% of the world's temperate fruit crop in various climatic zones. Almost 10% of the world's word fruit is produced in India. Temperate fruits have a strong export orientation and a significant potential for foreign exchange earnings. Himachal Pradesh, Jammu & Kashmir, Uttaranchal, and other eastern hilly states of India are the growing regions for temperate fruits such as apple, pear, peach, plum, apricot, almond, walnut, etc. Temperate fruit are susceptible to several biotic and abiotic stresses and among them diseases caused by various pathogens are of great economic importance. Scab, early leaf fall, powdery mildew, Alternaria leaf spots, collar and root rots, cankers, leaf curl, leaf spots and viruses are prevalent diseases in temperate fruits. Chemical pesticides are frequently sprayed on crops with the primary objective of eliminating or reducing disease invasion, infection, or severity in order to prevent crop losses caused by diseases. But it's becoming more and more obvious that using chemical pesticides over an extended period of time has a number of negative effects on both the environment and human health. Wide range of pesticides can be hazardous to people in both acute and chronic forms, and it is increasingly becoming clear that these chemicals also harm non-target organisms including pollinator species, pollute water and soil, and cause extensive harm to the larger ecosystem. Plant-associated microbiome plays crucial roles in enhancing the uptake of nutrients by plants and provides defence against both biotic and abiotic stresses. Furthermore, these various microbial communities that make up the plant microbiome carry out a variety of tasks, including nitrogen fixation, nutrient solubilization, defence against harmful plant pathogens, and the synthesis of phytohormones, such as indole acetic acid, auxin, gibberellin, abscisic acid, aminocyclopropane-1-carboxylate deaminase, and antibiotics. They also help plants develop induced resistance to pathogens and encourage the growth of other beneficial microorganisms.

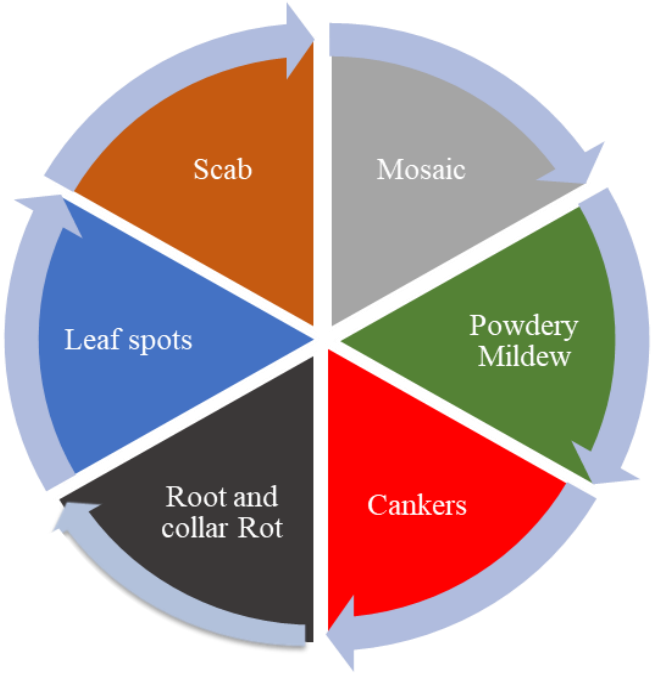


Figure 1. Different diseases of temperate fruits

Microbiome and Engineering

The "microbiome" as all of the microorganisms in a community, and specifically, as the microbial communities connected to a plant that are able to survive, grow, and interact with various plant tissues, including roots, shoots, leaves, flowers, and seeds. Plant microbiomes have the potential to be advantageous; offering plants an adaptive edge while simultaneously protecting them from possible pathogens and promoting growth, health, and productivity. Among the various groups of species, the bacterial microbiome has garnered increased attention due to its beneficial interactions and importance for sustainable agriculture. This can influence beneficial plant activities like growth limitations, phytopathogen activity, and the improvement of plant growth and health through influence of the bacterial microbiome and the creation of bioinoculants. This could potentially reduce the need for chemical fertilisers. Plant growth-promoting bacteria (PGPB) are rhizospheric or endophytic bacteria that stimulate plant growth. In certain instances, the microbiome plays a fundamental role in basic processes like plant development or the growth of vital organs like the root, which facilitates the plant's better uptake of water and nutrients. In order to improve diagnoses and treatments in plants that can eventually be applied to animals and humans, it may be more beneficial to manipulate the phytomicrobiome. Nonetheless, the phytomicrobiome is typically linked to a variety of microbes that are important components of agricultural output and serve a vital role. A major global proposition, sustainability in agriculture has been realised with the use of several microorganisms. The globe is moving towards economically viable and environmentally safe methods that could be applied to increase agricultural productivity. For Earth to survive, an appropriate farming system is therefore essential. To meet the need for food, crop production per area of agricultural land must be increased in this regard. Recommendations state that different approaches could lead to a comparable improvement in plant health. The microbiome of plants has a significant impact on both the host's growth and development and the availability of nutrients. As a result, plants "engineer" and recruit a local microbiome based on natural exudate, adapting this habitat to support their existence. Plant microbiomes offer significant health benefits in addition to protection, including enhanced plant growth and productivity and environmental adaption. The majority of microorganisms are located in biomes where they frequently modify plant physiology and help plants withstand harmful incursions. These microorganisms are grouped together inside the microbiome on the tissues and surface of the host plants. As a result, the bimodal connection permits nutrient uptake, supporting the host's development and resistance to environmental stressors. Microbial compositions can be changed to enhance host phenotypes and beneficial effects ecosystems through microbiome engineering. The three main associations—the rhizosphere (root-attached soil), endosphere (internal tissue), and phyllosphere (aboveground parts)—plants are linked to a diverse array of microbes, including bacteria, oomycetes, fungi, viruses, and archaea. These microbes carry out important functions that affect host health and fitness and are found in a specific region of the plant microbiome. The rhizosphere is the most intricate and varied microbial community niche among them. Through evolution, plants have developed intricate, mutually advantageous connections with the microbes in their environment. Most studies have concentrated on the fungal and bacterial communities within the plant microbiome, despite the fact that archaea, protists, viruses, and bacteria are all present. Therefore, core microorganisms have a high potential to organise microbiomes through methods that are beneficial to host plants, while hub microbiomes include more specialised microorganisms created solely based on their location inside a network structure with a specific function. The various ways of microbiome engineering are as under:

Enhancing mechanisms that promote plant growth

Protozoa, viruses, fungi, bacteria, and archaea are some of the various organism types that make up the microbiome. Due to its impact on plant physiology and development, this variety of microbial

communities is essential to plant functioning. Plant microbiomes have the potential to be advantageous, shielding the plant from possible pathogens, enhancing plant fitness and growth, and fostering tolerance to abiotic stresses. Inevitably, transmitted by soil plant pathogens that colonise the roots of plants and successfully subvert plant innate defences by breaching the protective microbial protect of beneficial organisms and causing disease are also passed down to the rhizosphere microbiome.

Improving the phytoremediation process

An affordable, solar-powered, and ecologically benign method of soil remediation is called phytoremediation. This technology addresses the pre-existing contamination in the system biome by utilising plant abilities to intercept, take up, accumulate, and translocate contaminants. The efficiency of phytoremediation depends on plants contaminant concentration, soil pH, nutrients and oxidoreduction as well as those microorganisms that are associated with soil and plants, respectively.

Promoting bio control and antagonistic behaviours

Worldwide plant diseases are the primary source of significant financial losses for farmers. According to FAO estimates, pests and diseases account for about 25% of crop loss. There have been reports of regional variations: in more developed nations, diseases are thought to reduce crop yields by 10% annually on average, but in less developed regions, yield loss from diseases frequently surpasses 20%. Chemical pesticides are frequently sprayed on crops with the primary objective of eliminating or reducing the disease invasion, infection, or severity in order to prevent crop losses caused by diseases. But it's becoming more and more obvious that using chemical pesticides over an extended period of time has a number of negative effects on both the environment and human health. In this regard, there are many biological control traits that are present in an array of microbes, including colonisation and competition for food space, antibiosis, hyperparasitism and the generation of degradative enzymes. Furthermore, these plant-associated microorganisms form a mutual association that influences the host plant-associated microbiome and supports a vast array of bacterial taxa, many of which enhance plant growth and tolerance to biotic and abiotic stresses, inhibit plant diseases, break down xenobiotic compounds, and increase yields. By using artificial microbial consortia, it is possible to manipulate this enormous diversity of microorganisms, opening up new synergistic possibilities for improving disease management.

Exploiting Host-Mediated Microbiota Engineering for Protection of Plants against Diseases

Using cyclic differentiation and propagation, the host phenotype is used in host-mediated microbiota engineering (HMME), a biological technique that indirectly selects microbiota. By fostering microbial communities for positive effects on plant development and health, HMME is a promising strategy to enhance host performance. By observing phenotypic alterations in host plants following multiple generations of growth in the same location, this technique allows the selection of a specific microbiome. Therefore, the microbiome functions that affect host fitness are selected and manipulated through changes in host phenotypes.

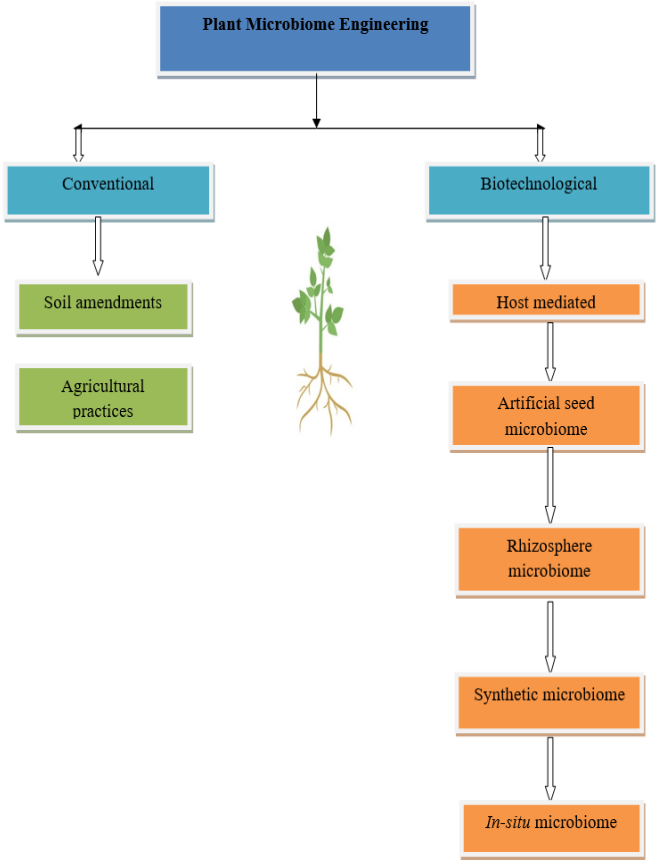


Figure 2. Engineering plant microbiome through conventional and biotechnological methods.

Limitations

The intricacy and dynamic character of plant-microbe interactions present a number of difficulties for plant microbiome engineering. A thorough knowledge of the roles and interactions of microbes is hampered by the complex and diverse structure of the plant the microbiome, which is impacted by environmental influences. There are many challenges in developing delivery systems to introduce and maintain the persistence of synthetic microorganisms in the plant rhizosphere. The field is further complicated by unintended ecological implications, possible disturbances to native ecosystems, and concerns about the long-term effects of modified plant microbiome on the plant and its surroundings. Plant microbiome engineering is made more complex by ethical issues relating to environmental sustainability and ecosystem integrity. These issues highlight the necessity of responsible methods and thorough analysis in order to fully realise the intriguing possibilities of this technology.

Conclusion

Over the past few decades, advances in our comprehension of the plant microbiome and rhizobiomes have made it possible to create integrated strategies that improve plant fitness. The host-mediated selection to engineer the plant microbiome can improve plant health. The co-evolution process that takes place in advantageous to suppressive soils (multigenerational generation) can be used as a model for this process. By employing this model, plants are able to choose their own "individualised" microbiome to mitigate the adverse impacts of a particular soil borne pathogen. The creation of the upcoming generation of bio inoculants is probably going to result from the use of this natural technology that controls the plant microbiome to regulate host health.

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Bioformulations: The Path to Sustainable Agriculture

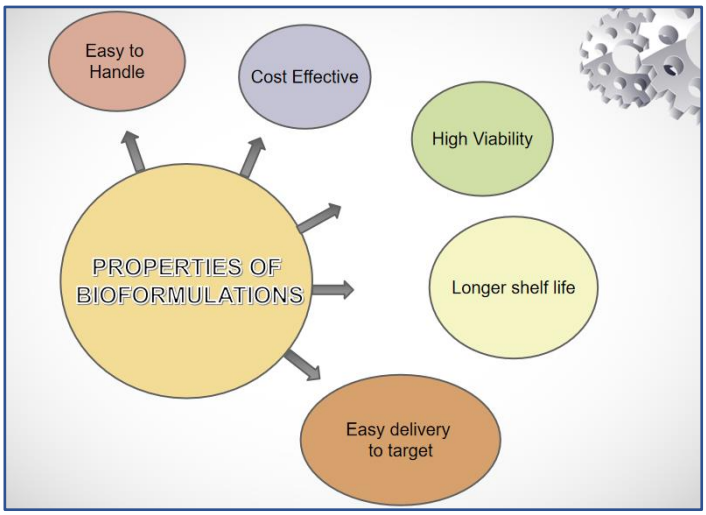
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The increasing awareness of the public regarding the environment is causing them to feel concerned about the chemical substances utilized in producing food, leading to a greater preference for organic food. Globally, chemical pesticides and fertilizers have been extensively employed to enhance agricultural productivity and safeguard plants and their harvests from diseases. However, environmentalists are now taking a closer look at the significant negative impacts linked to these methods. Thankfully today, we have options available for replacing or at least minimizing the use of these chemicals. Another option as a substitute is the use of bio-formulations, which are comprised of living microorganisms such as fungi and bacteria. These bio-formulations are available for purchase globally, and can be used as alternatives to chemical pesticides, fungicides, and fertilizers. They can be used either on their own or in conjunction with chemical fertilizers. This information has provided fresh perspectives in the field of agricultural economics, as researchers have recently created microbial bio-inoculants to enhance plant growth and eliminate disease as a new alternative. However, this environmentally friendly method is facing challenges because the bio-formulations currently available for certain crops do not consistently yield results that are similar to those achieved in controlled laboratory conditions. Scientists across the globe are continuously working hard to develop formulations that are easier for users, possess enhanced abilities to combat plant diseases, and potentially protect a wider variety of crops. It is important to thoroughly examine the entire process of bio-formulation development, including screening microorganisms, developing and executing products, to ensure they are used in the most effective way.

Scientifically bio-formulations refer to the products derived from microbial sources, which can include whole microorganisms or their byproducts (metabolites), designed to enhance plant growth, nutrient acquisition, and disease control in an environmentally friendly manner. These formulations could be mixed solutions containing many bio-inoculants (microbial strains), sticking agents and nutrients which can leverage the beneficial interactions between plants and specific microorganisms to improve agricultural sustainability.

Fig.1. Properties of Bio-formulations



Different types of bio-formulations include bio-fertilizers and bio-pesticides which comprise of bacteria and fungi as its main components (Fig. 2). Additionally, these bio-formulations contain fungus and bacteria, either alone or in combination. These can be applied similarly as chemicals, for example, as seed dressing, soil treatment or foliar spray. Those bio-formulations that do not possess any living organism have been focused majorly via this article. However, the formulation procedure may differ based on many factors like inoculant type, soil type, available resources and type of application etc.

Another bio-formulation of biochar acts as a potential inoculant carrier for sustainable agriculture. Understanding how biochar affects agriculture and the potential for increasing cell immobilization can shed light on how biochar functions as an effective inoculant carrier. It found its application in improving maize productivity and soil fertility.

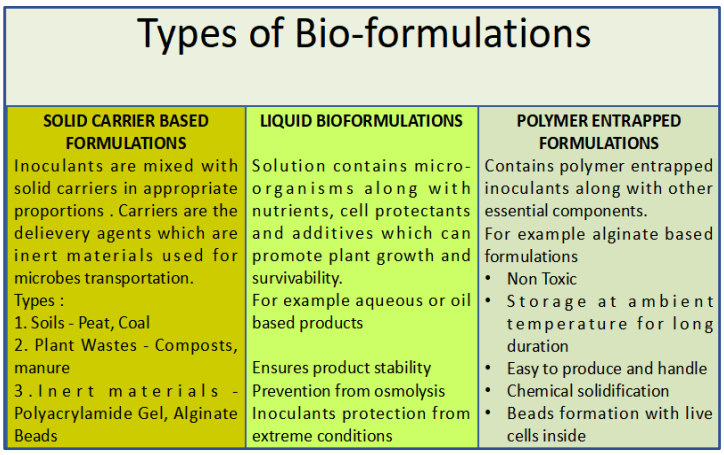


Fig. 2. Types of Bio-formulations

Nano-formulations, a new addition to the realm of bio-formulation in high-tech "smart" farming, involve combining nanoparticles with biofertilizers to create nano-biofertilizers (NBFs). The introduction of NBFs into plants holds the potential to enhance their growth and increase their ability to withstand external pressures. By utilizing microbe-driven environmentally-friendly production, metallic nanoparticles and organic substances like polysaccharide and chitosan can be enclosed in order to create these formulations e.g. improving the effectiveness of insecticide by using a nano-bio-formulation of etofenprox

Among other foliar chemical bio-formulations, it is found that effect of proline has been studied on almost all the abiotic stresses like salinity, temperature, drought, osmotic etc. for different crops like common beans, chickpea, wheat cultivars etc (Fig. 3).

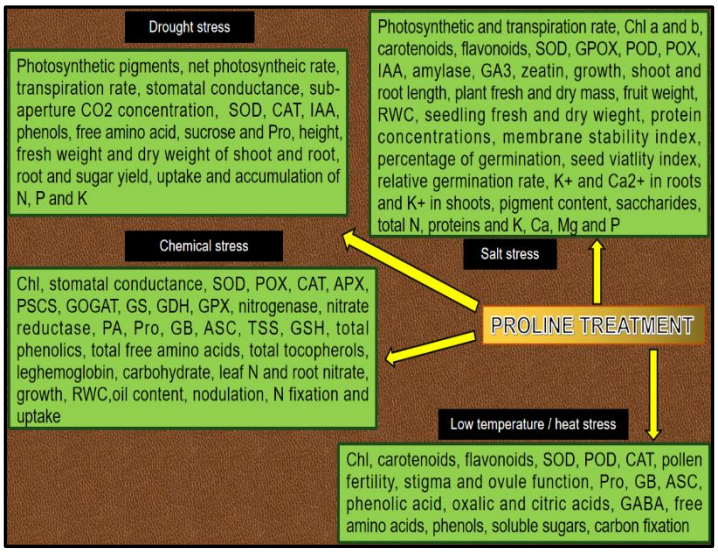


Fig. 3. The summarized physiological and biochemical changes observed under the influence of exogenous proline in plants (Up-regulated processes and/or biochemicals are marked in green)

Table 1: Different types of bioformulations and their mode of action

S. No.	Spray	Bio-formulation applied	Crop	Improved trait	Mechanism of action
1	Foliar spray	Silica	Rice (*Oryza sativa* L.)	Water stress tolerance	Regulates stress through mantaining RWC, net photosynthetic ratio, intercellular CO_2 level, stomatal conductance, and transpiration rate. In addition, silica plays a vital role in improving the physiological activities and enhancing the cellular metabolic rates in plants in response to drought stress, thus enhancing water use efficiency, growth, and biomass
2	Foliar spray	Melatonin	Strawberry (*Fragaria × ananassa Duch.*)	Salinity stress tolerance and enhance fruit yield and quality	Increases yield of strawberry fruit and quality, in plants grown under salinity. Melatonin is associated with boost in leaf antioxidant enzymes and abscisic acid

3	Foliar spray	Naphthyl acetic acid	Maize (*Zea Mays* L.)	Drought stress tolerance	Increased Seed vigor index, root–shoot ratio, leaf area index, leaf area ratio, Total biomass, chlorophyll 'a', chlorophyll 'b', carotenoid content, peroxidase and Superoxide dismutases content under high drought stress
4	Foliar spray	Calcium	Maize (*Zea Mays* L.)	Drought stress tolerance	Increased plant growth, water relations, proline content and hydrogen peroxide activity
5	Foliar spray	HBL (28-homobrassinol)	Rapeseed (*Brassica napus*)	salinity stress tolerance	Lowers the concentrations of NH_4+ and NO_3^- ions significantly, and the consequent enhancement in photosynthesis, efficient utilization of nitrogen
6	Foliar spray on the shoots	Proline	Lettuce (*Lactuca sativa*)	Temperature stress tolerance	Effective foliar application of proline up to 5 µM improves lettuce yield in response to temperature and salinity stress
7	Foliar spray	Proline	Quinoa (*Chenopodium quinoa*)	Drought stress tolerance	Increased proline content, total phenolic compounds, and antioxidant enzyme activity
8	Foliar spray	Proline	Common beans (*Phaseolus vulgaris*)		Increased the concentrations of carotenoids, ascorbic acid, endogenous proline, phosphorus and potassium in plants exposed to stress
9	Foliar spray	Proline	Wheat (*Triticum aestivum*)		Reduces the Na^+:K^+ ratio and oxidative stress and increasing the content of the internal proline improve growth and yield
10	Foliar application	Proline	Chickpea (*Cicer arietinum*)	Heavy metal stress tolerance	Increased nodulation, hemoglobin, carbohydrate content, leaf and root nitrogen content, the enzymatic activity of enzymes related to nitrogen fixation
11	Foliar spraying and root application	Melatonin	Soybean (*Glycine max* (L.) Merrill)	Water deficit stress tolerance	Improved PSII efficiency, improved the leaf area index and the accumulation of dry matter, slowed down oxidative stress and damage to leaves by increasing the activity of antioxidant enzymes, reduced the content of malondialdehyde
12	Foliar spray	Spermidine	Oat Seedlings	Reduces the negative effects of salt stress	Increased the activities of superoxide dismutase, peroxidase catalase, and ascorbate peroxidase, and

					reduced the rate of O_2 production and the accumulation of H_2O_2 and malondialdehyde
13	Foliar spray	Myo-inositol	Creeping bent grass (*Agrostis stolonifera* L.)	Enhances drought tolerance	Protected plants from drought damage by improving OA and water use efficiency, the decline in chl loss for photosynthetic maintenance, and improvement in antioxidant enzymes activity and gene expression contributing to less oxidative damage under drought stress and contributed to better plant water status
14	Foliar spray	Glycine betaine and potassium	Wheat	Enhances drought tolerance	Improved spike length, number of grain per spike and grain yields, leaf water potential, osmotic potential and turgor potential to maintain plant water potential gradient under stress.
15	Foliar spray	Trinexapac-ethyl	Creeping Bent grass (*Agrostis stolonifera* L.)	Enhances drought tolerance	Higher soil water content, lower evapo-transpiration rates, and higher leaf relative water content, greater osmotic adjustment, which was associated with increased accumulation of soluble sugars and inorganic ions (Ca and K) in leaves of TE-treated plants. TE-treated plants maintained significantly higher turf quality and leaf photochemical efficiency under stress
16	A label-free nano-liquid chromatography-mass spectrometry	Nitric oxide	Banana (*Musa acuminate*)	Osmotic stress	Antioxidant enzyme activities, such as superoxide dismutase and ascorbate peroxidase

Conclusion

The use of bio-formulations as a solution to reduce crop yield losses has become a more sustainable option compared to chemicals. However, the formulation of these bio-pesticides is often inadequate and does not meet the necessary regulatory standards, thus hindering their successful commercialization. Compiled information on bio-formulations as common bio-fertilizers and bio-pesticides with their mode of action is available in the researched texts but until now not much research is done to compile the information present on chemical bio-formulations. Only after thorough research can globally available bio-formulations that are "in use", would be considered for the process of commercialization. In this article, we propose creating a framework for methods to achieve better

formulations. This framework could be valuable for developing more effective products.

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3D Printing: Printing Future Food

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The early origin of 3D printing technique was limited to develop photo-hardened polymers for manufacturing metal and ceramic parts. It was in 2007, when researchers at Cornell University developed an extrusion-based printer named Fab@home for printing food (Malone and Lipson, 2007). Three-dimensional printing or 3D printing is the 'additive manufacturing' technique used to create three-dimensional items by application of consecutive layers of materials (Waseem et al., 2023). This method allows the industries to formulate customised products based on the needs of target population. Food industries can now produce customised meals with specific nutrient content and can tailor meals with specific dietary supplements through 3D printing (Varvara et al., 2021). 3D printing is the amalgamation of material science, culinary art and engineering. With the use of this technology, food industry can be transformed through efficient food manufacturing, customized nutrition and distinctive culinary experience (Waseem et al., 2023). This technology also can help in the waste reduction and food contamination. The first 3D printer was developed by Hull in 1986 (Hull, 1986). Typically, there are seven techniques of 3D printing as per American Society of Testing and Materials (ASTM) which are for non-food materials (Standard ASTM, 2012):

1. Power bed fusion
2. Directed energy deposition
3. Material extrusion
4. Binder jetting
5. Material jetting
6. Sheet lamination
7. Vat polymerization

Following are different categories of 3D printing for food applications which are briefed further. Out of these four techniques, extrusion printing is the most common one.

1. Selective sintering
2. Extrusion method
3. Inkjet printing
4. Binder jetting

Selective sintering

In this process, powdered materials are bonded together forming a solid 3D structure with the help of laser or hot air as power source. Powdered material like starch, sugar and fat is used for sintering process and the unfused powder can be reused. The powder bed principle is used for selective sintering where solid powdered particles are consolidated selectively in a specific area as per the design to construct a finished 3D product (Andharamakrishnan et al., 2022). The laser scans the cross-sections and selectively fuses the powder. After scanning, the powder bed is dropped and a fresh layer of powder is applied on top. Until the final desired structure is achieved, this process is repeated while the unfused powder is restored and re-used (Liu et al., 2017). The process is affected by different parameters like particle size, melting temperature, flowability, glass transition temperature, bulk density, wettability, type of laser, power, energy, etc. (Sandhu and Singh, 2022). Figure 1. shows the selective sintering technique.

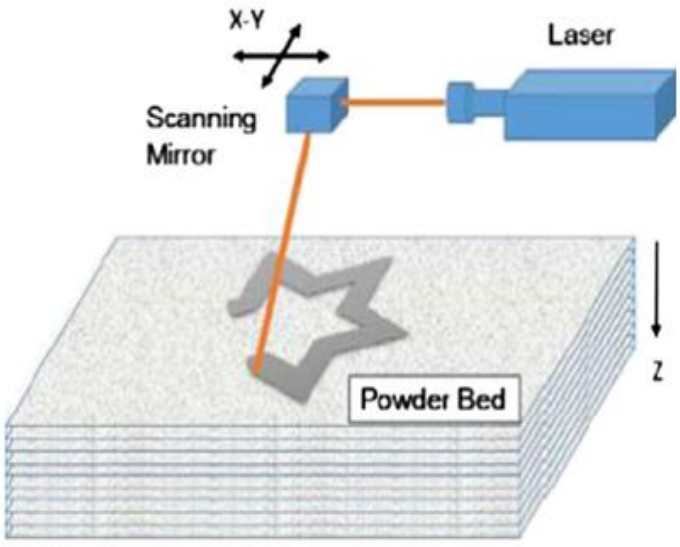


Fig. 1. Selective sintering printing (Sun et al., 2015)

Extrusion printing

This method is based on extruding the food through a nozzle under a constant pressure where the raw material could be either solid or liquid having low consistency or viscosity. The material is loaded into the extruder cartridge and then drawn through the nozzle with the help of ram pressure, layer-by-layer shape of food is created (Pitayachaval et al., 2018). During extrusion, the raw material can be heated before being depositing into layers onto platform of printer. The shape is made by horizontal movement of nozzle and vertical movement of platform. Optimum heating of the material is required to control the final viscosity (Varvara et al., 2021). Extrusion 3D printing has various applications in food, pharma, plastic and medical industries. Pre-tempering of chocolate, puree of food and its by-products, meat purees, cheese and dough have been commonly employed for extrusion process (Liu Z et al., 2017). In some cases, like meat or sea food extrusion, temperature needs to be maintained below 4°C to prevent microbial growth through all phases. Food additives like starch, xanthan gum, pectin etc. are added in purees to help sustain the shape of extruded product and improve printability, flowability and solidification (Mantilal S et al., 2020). The characteristics of end product is dependent upon nozzle diameter and pressure. The stable range of pressure inside nozzle ranges between 20-50 KPa for soft foods (fish, egg white foam, etc.) 100-170 KPa for stiffer pastes (Marmite, Vegemite, etc.), 300-600 KPa for thicker consistency foods (protein rich foods, fibres, multicomponent foods, etc.) (Varvara et al., 2021). Figure 2. depicts the hot-melt extrusion printing technique.

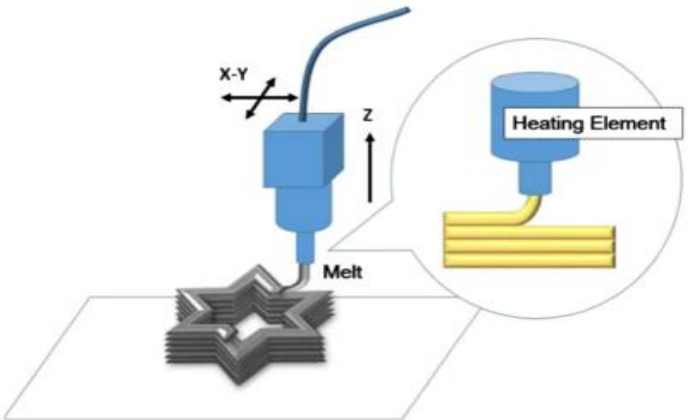


Fig. 2 Extrusion printing (Sun et al., 2015)

Inkjet printing

This technique uses the conventional inkjet technique where edible materials in liquid form are used instead of inks (Waseem et al., 2023). Stream of droplets of material is dispensed form a thermal or piezoelectric head to specific areas where thermal head is heated electrically to generate pulses that force droplets out of the nozzle (Pitayachaval et al., 2018). This method is commonly used for decorating or surface filling operations in cake, cookie, or candy. The process is completely non-contact method and thus prevents the contamination of food (Varvara et al., 2021). The surface tension and wettability of printing substrate regulates the droplet placement and spreading (Waseem et al., 2023). There are usually two types on inkjet printing, namely, continuous and drop-on-demand printing. In continuous type, the printer injects ink from a piezoelectric crystal at a constant frequency. While in drop-on-demand printer, the ink is released from the head by means of a valve that applies pressure. Despite being slower process than continuous method, it gives higher resolution and precision of final product. This method is used for low-viscosity materials for surface filling or image decoration (Godoi et al., 2018). Figure 3. shows the inkjet printing technique.

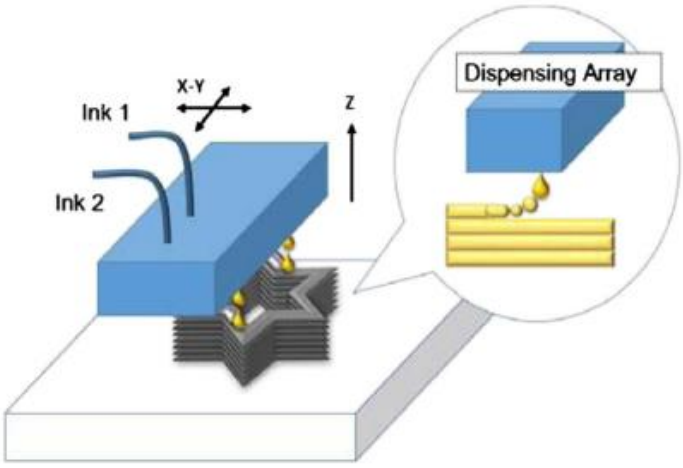


Fig. 3. Inkjet printing (Sun et al., 2015)

Binder jetting

This process, also known as liquid binding, involves layer-by-layer deposition of powdered material and selective liquid binder dispensing according to a 3D data file. This technique aids in the creation of many colourful structures. The build plate is sprayed with a mist of water onto which powdered

material of appropriate thickness is sprayed. To this, liquid binder is ejected followed by next layer of powder. This process is repeated until a pre-determined structure is produced. Due to spray of liquid binder over food substrate, the created 3D build would require an extra drying process for removing the leftover moisture. Drying enhances mechanical integrity and structural stability. limited to materials that are powdered (Anandharamakrishnan et al., 2022). To ensure strong bonding and structural integrity various binders are examined for their interactions with food powders (Waseem et al., 2023). The properties of binder and powdered material decide the processing factors. Binder should have suitable viscosity, surface tensions, density etc. Powder should be flowable i.e. angle of repose should be less than 30 degrees. Also, it should have good wettability to promote interactions with binder (Godoi et al., 2018). Figure 4. shows the binder jetting printing technique.

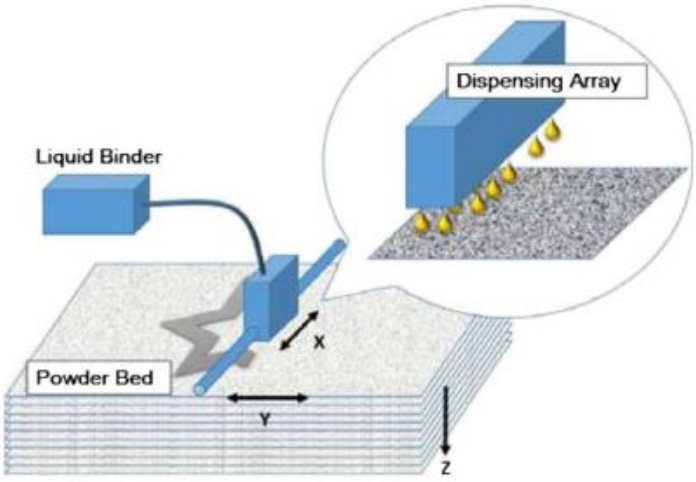


Fig. 4. Binder jetting printing (Sun et al., 2015)

Recent applications of 3D printing in food industry

3D printing is nowadays being by NASA for allowing astronauts to create their own space foods. Hershey, a chocolate company, collaborated with 3D printing company to develop 3D printing product (ChocoJet 3D) that allows astronauts to print their own customized chocolates in space (Kim et al., 2017). A German venture, Biozoon, developed 'Smoothfood' in form of jelly and sauce like grilled chicken which enhance the texture of dish for people with dysphagia or elder people having reduced masticatory function. This is serving as a 'Personalized Nutrition for Elderly' in Europe (Kim et al., 2017). London based students invented GumJet 3D printer which prints gum resin with flavouring layer by layer. Wacker, designed chewing gum 3D printer to create gums with coconut, fruit juice and plant extracts. They also invented Candy2Gum to convert candy into gum which handles water-based and fat-based ingredients (Liu et al., 2017). Barcelona based startup 'Novameat' has been printing plant-based meat analogue to combat unsustainable and insufficient global agricultural system to solve world's food supply problem. An American start-up, Modern Meadow, is working on 3D printing of stem cells that can mitigate meat-like matrix which will be identical to 'conventional-meat'. US Army is also interested in printing need-based foods depending on soldier's nutrition at the battlefield. They are working on ultrasonic agglomeration technology to offer variety of meals to soldiers (Davide and Xavier, 2015). Hans Fouche developed Cheetah Chocolate 3D printer with 8 nozzles which is based on extrusion printing to make different kinds of chocolates (Victor, 2015). ChefJet Pro 3D System prints visually appealing sweets and food decorations which are made from sugar, chocolate, cheese and other food materials. Interlocking sweets, wedding cakes and multi-colour cocktail decorations and sugar sculptures are being developed using ChefJet Pro (iReviews, 2014).

Conclusion

3D printing has evolved to a vast extent with its applications in military foods, space foods, customized foods for special dietary needs for elderly and people with dysphagia, confectionary, sweets, gums and chocolates. Though its application has been expanding in food sector, there are still some challenges regarding the printing precision and accuracy, printing speed, quality food production and nutritional requirements. Also, the composition of raw material, its properties, process parameters and post-processing treatments will also decide the printed structure's precision and accuracy. A lot of work is to be done on the limited addition of additives in food material, selecting those materials which give more cohesion in between layers. The need to ensuring food safety by considering the microbiological quality is

also needed. Despite these challenges, the progressive innovative research in 3D printing technology will bring new solutions for food industries that will help in producing customized health foods which will be much more attractive and appealing to consumers. We can push the boundaries of food and design a future where precision, personalisation, and sustainability are key components of our eating experiences by utilising the most recent technological developments.

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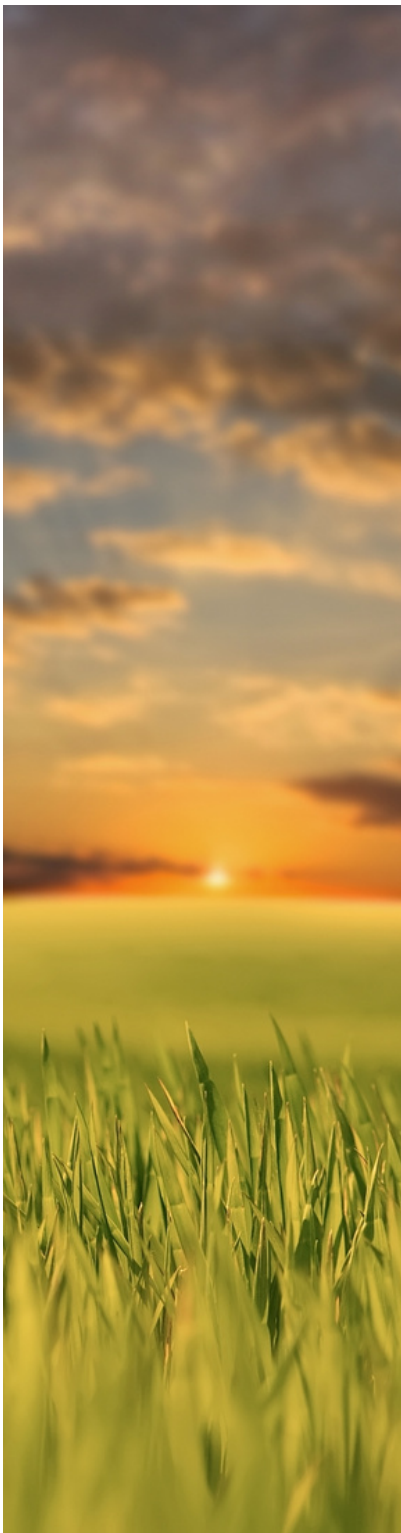
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