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Soil and water, a source of life

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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 9 of AgriTech Today Magazine. World Soil Day, observed annually on December 5th, serves as a reminder of the critical role soil plays in our lives. This day aims to raise awareness about the importance of soil as a vital resource for food security, climate change adaptation, biodiversity conservation, and sustainable development. Soil is fundamental for agriculture, providing nutrients necessary for plant growth and food production. However, soil degradation, erosion, pollution, and loss of fertility are significant challenges faced globally. Through advocacy, education, and sustainable practices, World Soil Day encourages individuals, communities, and governments to take action in preserving and restoring soil health for the well-being of current and future generations. It highlights the need for responsible land management practices to safeguard this precious natural resource.

It gives me great pleasure to inform you that we have curated and finalized 43 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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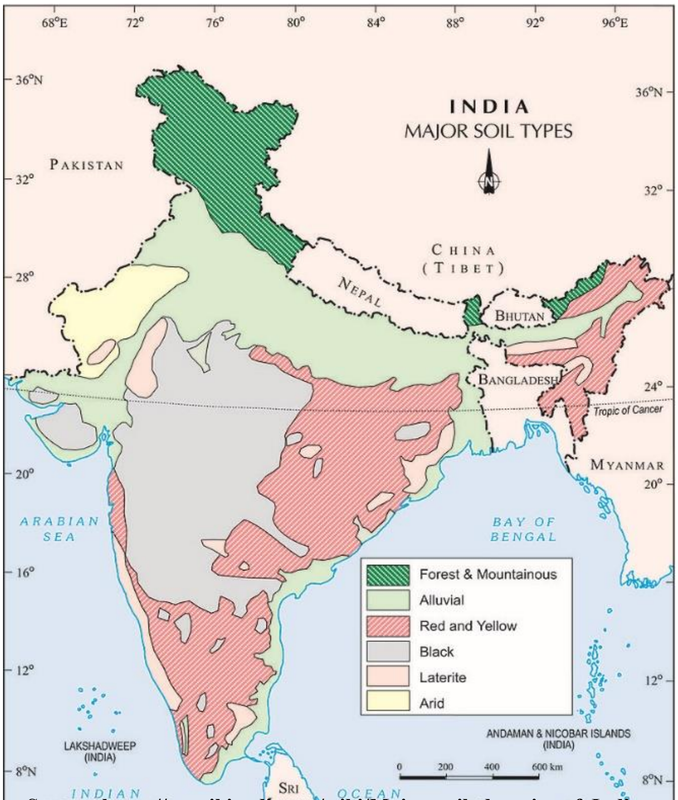
Cover Story

World Soil Day (WSD) is celebrated every year on 5th December worldwide as a means to focus attention on the importance of healthy soil and advocating for the sustainable management of soil resources. An international day to celebrate Soil was recommended by the International Union of Soil Sciences (IUSS) in 2002 under the leadership of the Kingdom of Thailand and within the framework of the Global Soil Partnership. Every year world soil day will be celebrated with a theme to create a awareness on importance of soil in human life. This 2023 year, the theme for celebrating world soil day is Soil & Water: A Source of Life. The basis for ecosystems, human well-being, and food production is provided by soil and water. Since we understand how important they are, we should take proactive steps to protect these resources for coming generations. The ability of soil to store, drain, and filte r water is compromised by soil erosion and compaction, which also increases the risk of landslides, floods, and sand/dust storms. In order for plants to grow and receive the vital nutrients they need to produce food; they need both soil and water. Healthy soil acts as a natural filter, cleaning and storing water as it seeps into the ground. Rainfed agriculture systems account for 80 percent of croplands, contributing to 60 percent of the global food production. These systems rely heavily on effective soil moisture management practices. However, irrigated agriculture systems withdraw 70% of the world's freshwater and account for 20 percent of croplands.

In food production always the healthy soils and their quality and availability of water are interconnected. Adopting sustainable soil management practices could enhances water availability for agriculture. Healthy soils particularly enriched with organic matter plays a crucial role in regulating water retention and availability. Efficient use of quality water, promoting the sustainable use of fertilizers and pesticides, employing appropriate irrigation methods, improving drainage systems, controlling pumping, and monitoring soil and groundwater salinity levels are essential to maintaining sustainable agricultural practices. Sustainable soil management is key to improve water productivity in irrigated systems. In recent days, the improper soil and water management practices affected soil erosion, soil biodiversity, soil fertility, and water quality and quantity across the country. Water scarcity leads to the loss of soil biodiversity, while leaching and eutrophication from agriculture practices

Source: www.fao.org



Source: https://en.wikipedia.org/wiki/Major soil deposits of India

lead to the loss of biodiversity in water bodies. The mismanagement of pesticides and fertilizers not only threated soil and water quality but also possessed significant risks to human health and ecosystems. In many major and minor irrigation project, poor irrigation and drainage practices are some of the main drivers of soil salinization. Rising sea levels contribute to land loss, increasing the risk of soil salinization and sodification, which can negatively impact agricultural productivity. Soil and water conservation contribute to climate change mitigation and adaptation.

In India, the major soils are Alluvial soil (43%), Red soil (18.5%) followed by Black/regur soil (15%) and other soils are Arid / desert soil, Laterite soil, Saline soil, Peaty / marshy soil, Forest soil, Sub-Mountain soil, Snowfields which are feeding for 1.4 billion Indian population. However, about 120.7 mha land is degraded due to soil salination and acid soils because of excess use of fertilizers, unscientific cultivation and industrialization. This degraded land can be converted into cultivable land through adopting the soil quality and nutrient management practices such as:

- Development of soil and land quality indices for major crops.
- Integrated nutrient management and input use efficiency.
- Characterization and prospecting of large soil biodiversity.
- Conservation agriculture.
- Precision agriculture.
- Research on cropping sequence under different soil environmental conditions.
- Land evaluation and agricultural land use planning.
- Benchmark spots (hotspots) for monitoring soil and land quality.

Improved soil and water management technologies such as farm pond, contour bunds & trenches, check dams etc could improve the land's capacity to withstand extreme climate events such as droughts, floods and sand/dust storms. Integrated soil and water management practices provide essential ecosystem services, supporting life on earth and enhancing ecosystem resilience. Healthy soils act as a carbon sink, by sequestering carbon from the atmosphere, thus contributing to both climate change adaptation and mitigation efforts. Now, it is our duty to save this soil by creating awareness on healthy soil, adopting best soil and water conservation practices to cope up with adverse climate change and scientific application of fertilizers through precision agriculture.

"Let's join together for healthy soils"

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Root Culturing in Bareroot Nurseries: Undercutting and Wrenching Technique

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Successful seedling establishment mostly depends on the production of planting stock with a large, robust root system and a shoot to root ratio that fits the requirements of the out-planting location. To increase seedling quality at out planting sites, it is essential to comprehend seedling root physiology and how nursery cultural techniques affect total seedling physiology (Duryea 1984). For the purpose of applying fertilizer, cutting roots, wrenching, and scheduling irrigation, it is crucial to understand the seasonality of root activity and growth in seedling beds. In India, container systems with polybag and root trainers are currently widely employed for the production of forest nursery stock. Nursery production in polybags is a common practice in developing countries, primarily in tree nurseries. Although the polythene containers are convenient and cost-effective, they have an inherent problem with root coiling or spiraling, which has a significant impact on the establishment, growth, and survival of the outplanted seedlings. Root trainer stock has far higher out planting survival and, more crucially, long-term survival; yet, recurrent weeding is necessary in forests to prevent the suppression of slow-growing tree species. Undercutting and wrenching are two more techniques that researchers are experimenting with to promote the growth of fine root systems. When planted in the forest, the wrenched and undercut seedling has a more compact and fibrous root system than the untreated seedling.

Polybag System

Polybags, which are made of polyethylene plastic (typically black), are used all over the world because nursery workers are accustomed to using them, they are lightweight, foldable, affordable (depending on size and seller), and less expensive to ship than contemporary nursery containers. There are several sizes of polybags. When given enough time, nutrients, and water, larger bags typically yield larger seedlings than other types of containers (Abugre and Oti-Boateng, 2011). Furthermore, chemically trimming roots with copper-coated polybags which are accessible in some areas can lessen root deformations (Aldrete et al., 2002). Polybags are smooth on the outside. Because of this, when seedling roots come into contact with the polybag wall, they prefer to concentrate in the bottom of the bag and spiral around. There is reduced overall fibrosity and volume as a result of this malformed root development pattern. Untimely out planting of seedlings can worsen spiraling-related root deformation. Reduced development, a worse ability to withstand stress, and early dieback can result from deformed roots. After planting, seedlings with spiraling roots would not be able to sufficiently anchor the plant and might absorb less water and nutrients.

Fig. 1: Spiraling of roots caused by polybags

Container System

Modern containers come in a variety of sizes, shapes, materials, and prices, enabling customization to accommodate a broad range of production variables. They can be purchased as individual cells, free-standing containers, or aggregate blocks. Modern container-grown seedlings grow more uniformly, have more robust roots, and have better root-shoot balance. They can be planted at a much smaller size than seedlings cultivated in polybags. The nursery requires less space, labor, growing media, and other resources because of the smaller size and quicker growth period. Additionally, smaller seedlings are lighter than larger ones, making them simpler to handle, move, and outplant. Modern container-grown seedlings often have higher long-term growth and survival rates than polybag-grown seedlings after planting (Cedamon et al., 2005). Although modern containerized stock has a much greater rate of long-term survival, regular weeding is still required in forests to keep slow-growing tree species from being suppressed.

Fig. 2: Modern container systems consisting of a tray

Undercutting and Wrenching Technique

About this time last century, undercutting was initially employed to enhance the stock of bare-root seedlings. Undercutting was first used to enhance the quality of bare-root seedlings and boost seedling yield in the 1920s. An early nursery strategy that was somewhat successful was the in-situ modification of roots and the removal of inferior seedlings. The practice of root trimming was not being considered as a potential means of "conditioning" seedlings for out planting until the 1950s in nurseries. The undercutting blade needs to be able to cut in the soil in a position that is completely horizontal and adjustable (up to 8 inches). The blade must be sharp and thin, but also stiff. The blade needs to be sharpened on a regular basis to guarantee a sufficient cutting surface. Root-wrenching and undercutting have been reported to be effective pretreatments for a number of tree species (Rook 1971; Kamis Awang 1973). Cutting roots neatly and rapidly with little to no soil disruption should be the goal. Cutting at a shallower depth raises the possibility of seedling mortality due to drought vulnerability and ground-level stem cutting (Aldhous, 1972). Wrenching manually is similar to undercutting, except after cutting the roots, the handle of the spade is forced down, raising the seedlings 3 or 4 cm above the ground rather than withdrawing it. In a current, when the seedlings are about 20 cm high, the roots of line-sown seedlings are undercut at a depth of 8 cm. A tractor is used to perform the undercutting, and a sharp blade is positioned beneath the seedbeds in most of the developed countries. The soil should be rather damp for this procedure, and caution should be used to avoid uprooting the lateral roots. If the treatment is to be effective, the seedling density should not be any closer than 5 cm apart. A few weeks to a month before the seedlings are needed for planting, undercutting is carried out, however, they can be kept in check for a few months without noticeably losing vigor. The use of bare-rooted seedlings would help to reduce nursery cost and those associated with seedling transportation and planting.

Fig. 3: Bareroot seedlings

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A case study: Weed identification and control measure in moisture stress conditions under red-lateritic belt of West Bengal

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Weeds are plants that are undesirable to human activity at a particular time and place, and therefore, weeds will always be associated with human endeavour. Weeds are not only important in agriculture but are also a great nuisance in forestry, pastures and grasslands, wastelands, public amenity areas, aquatic bodies etc. They also affect biodiversity, environment and health of humans and livestock. Unlike other pests, weeds are ubiquitous and affect almost all the crops. Weeds deplete soil moisture and reduce soil water avail- ability in the crop root zone (Saha *et al.*, 2023). Therefore, water stress in agricultural systems depends on crop–weed interactions and the degree to which crops and weeds extract soil water under water-stressed conditions. Among all the biotic stresses, weeds cause the greatest losses amounting to nearly one third Mukherjee, 2021). As the scope for horizontal increase has little possibility in view of the limited area available for cultivation, the only alternative feasible is the vertical increase which can be achieved with better genotypes and providing farmer-friendly input technology. The improved weed management is one such technology which has a tremendous potential in providing a plausible solution to meet the growing demand of food grains, pulses, oilseeds and other crops by the ever-increasing population. Though weeds existed from time immemorial, the modem agriculture, characterized mainly by large scale adoption of dwarf HYV s and hybrids, increased use of irrigation and fertilizers, reduced tillage and globalization of agriculture has severely intensified manifold the weed problems. Low soil moisture increases the competition for water between the weed and the crop, therefore, weed control is even more important when water is scare. Generally, when moisture is limiting, there may be fewer and less vigorous weeds and weed emergence may be delayed until rainfall occurs. Drought tolerant weeds such as thistle a field bind weed develop extensive root systems early and take advantage of limited water, making them more competitive and germination leading to decreased weed abundance. The resulting water-stress conditions negatively affect seed germination, plant growth and development, and seed production of crop particularly in red-latertic belt. For example, water stress can impede or delay germination by constraining water needed for seed hydration and/or during progressive germination and emergence phases. Similarly, water stress impacts plant growth and development, primarily by limiting photosynthetic capacity via stomatal closure and by reducing photosynthate assimilation via limited expansion of leaves.

Table 1: Weed diversity under different cropping system of moisture stress situation

Weed diversity under moisture stress condition		
Broadleave weeds	**Grasses**	***Sedges***
Chenopodium murale, Chenopodium album, Alternanthera sessilis, Cleome viscosa, Euphorbia hirta, Heliotropium indicum, Convolvulus arvensis, Trianthema portulacastrum,Synedrella nodiflora, Euphorbia spp. Argemone maxicana, Tribullus terrestris and *Cirsium arvense*	*Cynodon dactylon, Dactyloctenium aegyptium, Digitaria sanguinalis, Echinochloa colona* and *Eleusine indica*	*Cyperus rotundus, Cyperus esculentus* and *Fimbristylis miliacea*

As per our observation, during last two year 2022-23 at Jhargram block of West Bengal revealed that, our crop field in rainfed are mostly three, rice (*Oryza sativa* L.), oilseeds, wheat (*Triticum species*), corn (*Zea mays* L.),and was followed in importance by a variety of legume species, particularly chickpea (Cicer arietinum L.), dry bean (*Phaseolus vulgaris* L.), lentil (*Lens culinaris* L.), feld pea (*Pisum sativum* L.), broad bean (*Vicia faber* L.), pigeonpea (*Cajanus cajan* L.), cowpea (*Vigna unguiculata* L.) and peanuts (*Arachis hypogea* L.). These are mostly infested several moisture stress weeds (Table 1). Weeds respond under moisture stress by thickening their leaf cuticle and reducing their vegetative growth. Some of important dominant weeds found in rainfed areas as follows:

Paspalum scrobiculaturm - common with direct seeded rice field

Phllanthus amarus - Common weeds with different crop sequence

Tridex Procumbens in association with maize

Infested of direct seeded rice with BLWs

Infestation of groundnut field with sedges

Synedrella nodiflora common weed in different crop sequence

These weeds are able to survive even under extreme drought conditions. Some of special adaptations were observed in these weeds i.e. presence of extensive root system, waxy substance on the leave, thick and fleshy leaves and presence of awn. These weeds can be controlled effectively by intervention of variable option of weed control and weed management measures.

Weed management

Weed "management" implies more than weed "control" and is an important choice of terms and direction. The "ruthless fight to the last weed" is part of the weed control paradigm, whereas a weed management paradigm suggests greater consideration of thresholds, critical periods, environment, and possibly even social outcomes, before weed management methods are imposed. This can be achieved based on suitability of particular technology in appropriate farming system model. Various crop establishment measures significantly reduce weed flora distribution pattern and this become suitable to specific crop (Mukherjee, 219). Therefore, the next logical step is to integrate multiple weed management strategies into Integrated Weed Management systems.

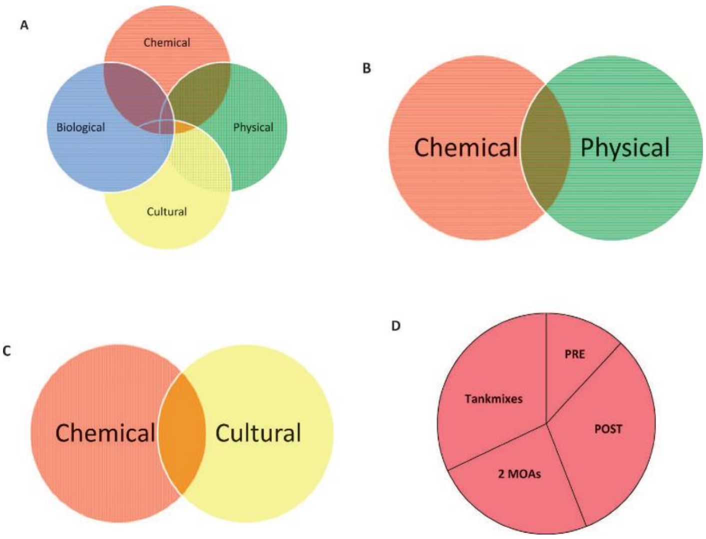

Figure 1. Some forms of true integrated weed management (IWM) (A–C) in contrast to integrated herbicide management (D).

(Source: Harker and Donovan, 2013)

The complete weed control through adoption of any single method is highly doubtful. The concept of integrated weed management is more suitable for dry land agriculture to save the cost and get efficient control of weeds. Normal weeding or inter-culture operation required to control weeds are not possible under certain situation (Mukherjee, 2021). Further, initial weeds population which is very small in growth is sometimes ignored for some time to make enough growth. Such very early growth can be effectively controlled by pre or post emergence application of herbicide in cereals as well as legumes. The dose of the herbicide required for spraying varies depending primarily upon the type of herbicide, type and intensity of weed infestation, stage of weed and crop, weed control efficiency. Soil mulching and intercropping with suitable crop become effective to restrict weed density. Other cultural methods like application of high seed rate, pure seed, sowing in rows, high density, stale seed bed preparation, use of well decomposed manures and application of fertilizers in rows, following drip irrigation etc. are effective to reduce the weed competition. Soil solarization can be an effective method for weed control in nursery of various crop.

Many factors including temperature, rainfall, wind, soil type and stage of development of weed species influence our weed management options particularly under rainfed or moisture stress situations. Establishment and maintenance of a weed control programme. is an essential part of effective way under moisture stress condition of Jhargram (West Bengal) like blocks, which completely depend on rain-fall situation. Well-designed need-based programme, rely on a combination of methods and materials, rather than a single strategy should be adapted to combat the vigorous weed problem in crop field.

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Revolutionizing Nutrition with Black Wheat: A Comprehensive Insight into Its Nutraceutical Value

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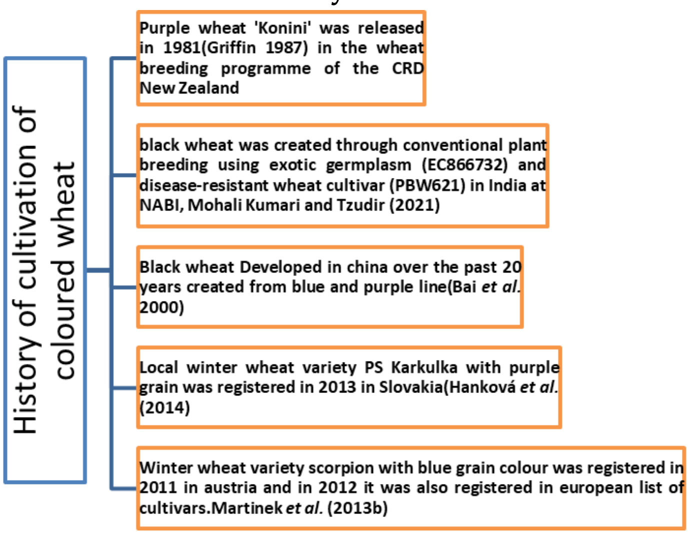
Functional foods are a topic of ongoing industrial use and research. Functional meals can alter a number of bodily processes and boost wellbeing, lowering the risk of diseases linked to a sedentary lifestyle (Monika Garg *et al.* 2016). Widespread interest is currently being shown in functional foods manufactured from pigmented grains (including maize, rice, and wheat) that are high in antioxidant chemicals (Abdel-Aal et al; 2006). Given that healthy people can contribute to both society and the economy, a healthy population is one of the nation's most precious resources. The health of individuals and significant portions of the population, particularly in developing nations, may be threatened by acute diseases and chronic ailments. To suit human needs, food is supplemented with nutrients in many nations.

Cereals are essential among all dietary items and are essential to a balanced diet. Apart from being an important part of diet providing major sources of carbohydrates, proteins, B vitamins and minerals for the world's population and also rich in various health promoting components having health promoting benefits which are often referred to as phytochemicals or plant bioactive substances (Goldberg G 2003). Wheat is an excellent source of carbohydrates, proteins, minerals, and dietary fibre. It also contributes significantly to the daily caloric needs of the wheat-eating population. When it comes to area and production, wheat is next behind rice among food grains. With a 12% share of global wheat production, India is currently the second-largest producer of wheat after China. Wheat accounts for around 21.8% of the entire area covered by food grains and about 35.5% of the overall amount of food grains produced. (Source: http://wheat prod1.dacnet.nic.in/history.htm).

Although wheat is a significant part of the diet in underdeveloped nations, its zinc level is not particularly high. To satisfy the body's needs, wheat grains' zinc concentration must be 45.0 mg/kg (Liu *et al* 2017). Indian bread wheat, also known as aestivum, and pasta wheat, also known as durum wheat, have low levels of iron (27–55 ppm), and zinc (20-50 ppm). Only 28.48 mg/kg of zinc is found on average in wheat grains worldwide, which is much less than the quantity that is generally advised. In India, the average zinc content of wheat cultivars is 28.31 mg/kg. Since the 1960s, the average grain zinc content of wheat has been 31.84 mg/kg with a range of 8.00 to 88.20 mg/kg [Wang *et al.* (2012), Oury *et al.* (2006)].

Fig. 1. Diagrammatic representation of colored wheat history of cultivation



The common wheat variety is amber or white in colour all across the world. Till today there are following three new varieties of wheat registered by Plant Germplasm Registration Committee under National Bureau of Plant Genetic Resources (NBPGR), ICAR New Delhi as given below: Wheat (Triticum aestivum) National ID:IC 0620914 : INGR No.:17001: Blue grain (aleurone) color, IC 0620915 : INGR No.:17002: Wheat Purple grain (pericarp) color and IC 0620916: INGR :17003:Wheat with Black grain colour (Purple pericarp + Blue aleurone). (Source: DARE/ICAR Annual Report 2017–18 Department of Agricultural Research and Education (DARE) and ICAR). Scientists from NABI led by Monika Garg used a hybrid between high-yielding Indian cultivars and colorful wheat imported from Japan and America, which is high in zinc and as rich in anthocyanins and not only developed coloured wheat lines using established biotechnology techniques but also transmitted them to various businesses who have inked agreements with this Department of Biotechnology lab are already growing them (source: https://www.krishijagran.com). (source: https://krishijagran.com 7/05/2019).

The genotypes of wheat that have colorful caryopses, such as purple, blue, black, yellow, and white ones, are currently gaining relevance. Due to the presence of the anthocyanin pigment, numerous studies and research projects are currently being conducted on the use of coloured wheat grains for their health advantages. Currently, coloured grain is being prioritized more in research since it is a source of neutraceutical chemicals. Colored wheat contains higher proportions of phenolic compounds, which are primarily represented by ferulic acid, vanillic acid, and p-coumaric acid (Kequan *et al*. 2005, Liu 2007), in addition to anthocyanins. These compounds may be used as functional foods or as key functional ingredients in products made from wheat (Pasqualone *et al*., 2015; Ficco *et al*., 2014).

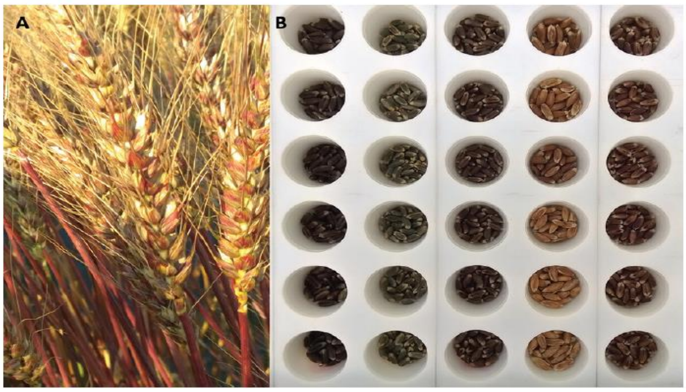


Fig.2 A: Anthocynin Pigmentation wheat (Purple clum and glume) during ripening.B: Pigmented grains of selected single spikes :Left to right: black, blue, deep purple, red and purple grains. (Source: Heinrich Grausgruber *et al*(2018)).

Black wheat (28 times more anthocyanins) may be utilised to generate unique and colourful dishes due to their phytochemical makeup and distinctive colours (Ficco *et al*., 2014) and has the potential to offer extra health advantages over those that standard wheat cultivars typically offer. Consuming black wheat is linked to a number of health advantages, including endothelial cell protection, reducing heart and cardiovascular illnesses (CVD), and acting as anticancer agents (Dykes 2007 and Liu 2007). Additionally, it includes procyanidins and anthocyanins which makes it a possible source of nutraceuticals and functional materials. These bioactive substances are linked to a lower chance of chronic diseases like diabetes, obesity, cancer, and cardiovascular disease from developing (Zhang 2015 and Ma 2017). According to He and Ning (2003), black wheat "Qinhei No. 1" had low sodium and fat content and higher contents of some amino acids, including lysine, methionine, isoleucine, and glutamic acid. It also contains higher contents of iron, zinc, manganese, copper, selenium, magnesium, potassium, and phosphorus. Black wheat has a high zinc concentration of 34.80 mg/kg(Huang *et al* 2018). The organic chromium (trivalent chromium) concentration of the black wheat "03Z4-439" is also around four times higher than that of regular wheat, a property that can be used to cure diabetes. However, there is very little study on the anti-diabetic effects of black grain wheat, and neither human nor animal experimentation is available (Liu 2018). According to mice studies at NABI, black wheat helps to prevent the deposition of fat, enhance insulin tolerance, manage glucose levels, and lower blood cholesterol. The variants contain significant amounts of proteins and important micronutrients like zinc in addition to anthocyanins. As a result, black wheat is an option that may be utilized to fortify wheat flour with high contents of iron, zinc, and micronutrients.

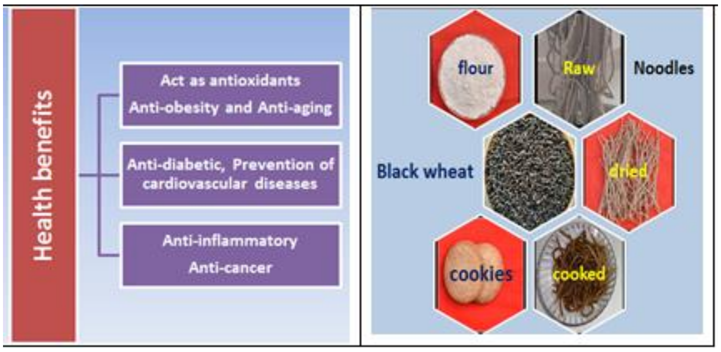


Fig. 3. Diagrammatic representation nutraceutical benefits and value addition of Black wheat

Ensuring food and nutritional security of fast-growing population will pose a huge challenge in future. Black wheat being healthier than white wheat, can be a good alternative in the National Nutrition Mission (NNM) or "Poshan Abhiyaan" for improving the nutritional status of young children, adolescent girls, and women. BGW has to be given more consideration as a substitute source of nutrients and health-protective elements in the human diet due to its valuable compositions.

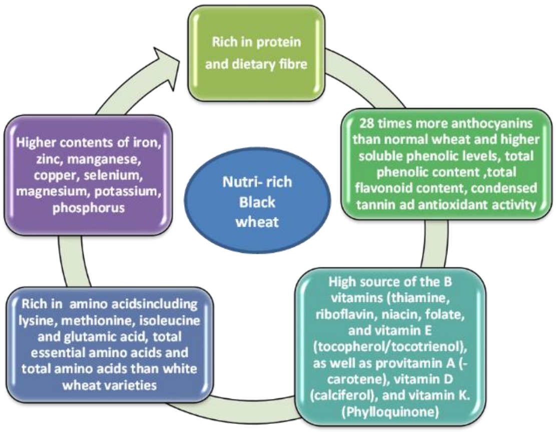


Fig. 4. Diagrammatic representation of nutritional importance of Black wheat

The consumption of foods based on Black wheat would be important step towards alleviating protein malnutrition. Black wheat flour had good functional properties make it useful in different foods formulation. It also implies that it may be worthwhile for industry to take up the production of Black wheat value added products and increasing cultivation by farmers. Such promotion of Black wheat value added products into diet in India could go a long way towards not only alleviating micronutrient deficiencies but also towards the development of functional, nutraceutical foods for preventing or curing of many lifestyles related diseases.

Areas for future research

- Investigation should be carried out to improve the desirable properties of black wheat for food processing and value addition without decreasing its nutrient value.
- The clinical studies with human subjects should be undertaken to investigate Black wheat nutrient bioavailability and the positive effect on immune system.
- The technology should be developed to minimize the processing induced losses in nutrients content in value added products from Black wheat.

This will allow it to be used in a larger range of food products, which will undoubtedly benefit people's health. All of these characteristics, however, are influenced by the wheat grain's genotype, post-harvest treatments, storage conditions (such as temperature), and the environment in which it grows.

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Conservation Agriculture: Nurturing Sustainable Farming Practices

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Conservation Agriculture (CA) is a farming system that can prevent losses of arable land while regenerating degraded lands. It promotes maintenance of a permanent soil cover, minimum soil disturbance, and diversification of plant species. It enhances biodiversity and natural biological processes above and below the ground surface, which contribute to increased water and nutrient use efficiency and to improved and sustained crop production.

CA principles are universally applicable to all agricultural landscapes and land uses with locally adapted practices. Soil interventions such as mechanical soil disturbance are reduced to an absolute minimum or avoided, and external inputs such as agrochemicals and plant nutrients of mineral or organic origin are applied optimally and in ways and quantities that do not interfere with, or disrupt, the biological processes.

CA facilitates good agronomy, such as timely operations, and improves overall land husbandry for rainfed and irrigated production. Complemented by other known good practices, including the use of quality seeds, and integrated pest, nutrient, weed and water management, etc., CA is a base for sustainable agricultural production intensification. It opens increased options for integration of production sectors, such as crop-livestock integration and the integration of trees and pastures into agricultural landscapes.

Principles of Conservation Agriculture

Conservation Agriculture is based on three main principles adapted to reflect local conditions and needs: -

Table 1: Difference between conventional Agriculture Vs Conservation Agriculture

S. No.	Aspects	Conventional Agriculture	Conservation Agriculture
1.	Crop Rotatio-n	Can involve monoculture or limited rotations.	Encourages diversified crop rotations.
2.	Weed and Pest Manag-ement	Relies on chemical inputs and mechanical tillage.	Favour's integrated weed and pest management.
3.	Soil Health and Structu-re	Intensive tillage can lead to soil degradation.	Aims to preserve and improve soil structure.
4.	Water Manag-ement	May result in increased runoff and reduced infiltration.	Emphasizes improved water management.
5.	Erosion Control	Increased risk of soil erosion, especially during heavy rainfall or wind.	Minimizes erosion risk through residue cover.
6.	Enviro n-mental Impact	Can contribute to soil erosion, nutrient runoff, and loss of biodiversity	Designed to be more environmenta lly sustainable.
7.	Philoso -phy	Traditional approach with a focus on tillage and inputs.	Promotes sustainable practices and soil conservation.

Minimum mechanical soil disturbance

Minimum soil disturbance entails practices such as low-disturbance no-tillage and direct seeding. The area subject to disturbance should not exceed 15 cm in width or 25% of the cropped area, whichever is lesser. Any periodic tillage activities should not surpass these specified limits. Strip tillage is permissible as long as the disturbed area remains below the established thresholds.

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Permanent soil organic cover

Three categories are identified based on ground cover percentages: 30-60%, >60-90%, and >90%, with measurements taken immediately after the direct seeding operation. Areas displaying less than 30% ground cover are not classified as Conservation Agriculture (CA).

Species diversification:

Rotation or association must include a minimum of three distinct crop species.

Types of Conservation Agriculture:

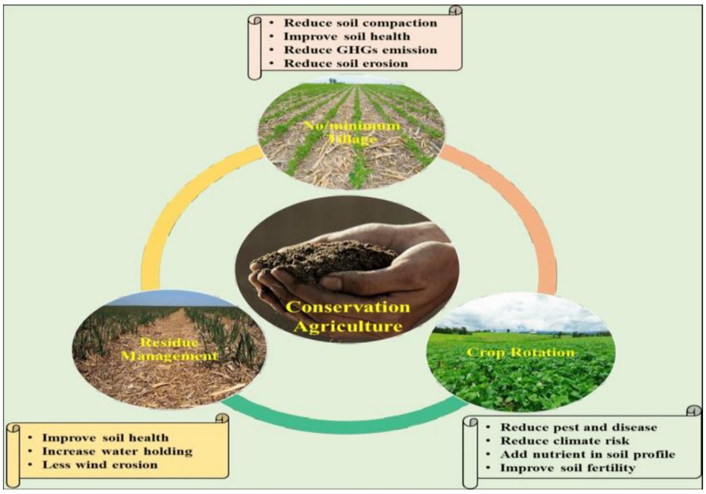
1. Conservation tillage: Conservation tillage is a farming practice that aims to reduce soil erosion, improve soil health, and enhance overall sustainability by minimizing soil disturbance during the preparation of fields for planting. Unlike conventional tillage methods that involve turning over or ploughing the soil, conservation tillage practices disturb the soil to a lesser extent or not at all.

i. No-Till Farming: No-till farming is a form of conservation tillage where the soil is left undisturbed, and crops are planted directly into the residues of the previous crop.

Benefits: No-till helps retain soil structure, reduces soil erosion, conserves moisture, and enhances carbon sequestration in the soil. It also minimizes fuel and labor requirements compared to conventional tillage.

ii. Minimum Tillage: Minimum tillage involves minimal disturbance of the soil, typically limited to the planting row. This can be achieved using specialized equipment that disturbs only a small portion of the soil surface.

Benefits: Minimum tillage combines the benefits of reduced soil disturbance with some weed control. It helps maintain soil structure, reduces erosion, and retains crop residues on the field.



2. Soil Covers

Soil covers, also known as soil coverings or ground covers, refer to materials or vegetation that protect and cover the soil surface. These covers play a crucial role in various aspects of agriculture, landscaping, and environmental conservation. Here are some common types of soil covers:

i. Cover Crops: Cover crops are crops grown not for harvest but to cover the soil during periods when the main cash crop is not growing.

Purpose: Cover crops protect the soil from erosion, improve soil structure, suppress weeds, and contribute organic matter. They also enhance nutrient cycling and provide habitat for beneficial organisms.

ii. Straw or Hay Cover: Straw or hay can be spread over the soil surface as a protective cover.

Purpose: Similar to other mulching materials, straw or hay helps retain soil moisture, suppress weeds, regulate soil temperature, and contribute to soil health.

2. Crop residues: Crop residues refer to the portions of crops that remain in the field after harvesting. These residues include stems, leaves, and other plant material left on the soil surface. Rather than being removed, crop residues are intentionally left in the field as part of sustainable agricultural practices. The management of crop residues has significant implications for soil health, water conservation, and overall ecosystem sustainability.

3. Mulch: Mulch is a layer of material, such as straw, leaves, wood chips, or plastic, spread over the soil surface around plants.

Purpose: Mulch helps conserve soil moisture, suppress weeds, regulate soil temperature, and reduce soil erosion. It also adds organic matter to the soil as it decomposes.

4. Plastic Mulch: Plastic sheets or films laid on the soil surface around plants.

Purpose: Plastic mulch helps control weeds, conserve soil moisture, and regulate soil temperature. It is commonly used in agriculture, especially for crops like tomatoes and strawberries.

Crop diversification: Crop diversification is an agricultural strategy that involves growing a variety of crops on the same farm or in a particular region over time. This practice contrasts with monoculture, where a single crop is cultivated repeatedly on the same land. Crop diversification offers several benefits for farmers, the environment, and overall agricultural sustainability.

i. Crop rotation: Crop rotation is an agricultural practice that involves growing different crops in a planned sequence on the same piece of land over several seasons or years. This systematic rotation of crops offers numerous benefits for soil health, pest and disease management, nutrient cycling, and overall sustainable agriculture.

ii. Crop mix: Crop mix refers to the cultivation of different crops within the same farm or field. In a crop mix, various types of crops are grown in separate areas or plots within the same overall farming space. This practice allows farmers to diversify their agricultural activities and can offer several benefits.

iii. Intercropping: Intercropping is an agricultural practice where two or more crops are cultivated simultaneously in the same field, sharing the available space and resources. Unlike monoculture, where a single crop is grown in a field, intercropping involves growing different crops in close proximity to each other. This practice is designed to optimize resource use, improve yields, and provide ecological benefits.

Advantages of Conservation Agriculture:

1. Soil Health Improvement: CA practices promote soil health by preserving structure, enhancing microbial activity, and increasing organic matter content.

2. Erosion Control: Reduced soil disturbance and permanent soil cover help prevent erosion, preserving valuable topsoil.

3. Water Conservation: Improved water management in CA practices enhances water retention in the soil, reducing the need for irrigation.

4. Enhanced Biodiversity: The diversity in crop rotations and cover crops fosters a healthier agroecosystem, supporting beneficial insects and wildlife.

5. Cost Savings: Conservation agriculture can lead to cost savings for farmers through reduced fuel consumption, less wear on equipment, and lower input costs.

Disadvantages of Conservation Agriculture

1. Transition Challenges: Farmers may face resistance to change and challenges in adapting to new equipment and practices.

2. Initial Costs: The upfront costs of transitioning to conservation agriculture, including new equipment, may be a barrier for some farmers.

3. Weed Management: CA practices may require adjustments in weed management, and effective strategies need to be implemented to control weeds without relying heavily on tillage.

4. Market Access for Diversified Crops: Farmers practicing diversified crop rotations may face challenges in finding markets for less common crops.

5. Climate and Regional Variability: The success of conservation agriculture can depend on local climate and soil conditions, and practices may need to be adapted accordingly.

Conclusion

In conclusion, Conservation Agriculture emerges as a cornerstone for nurturing sustainable farming practices. Through its principles of minimal soil disturbance, permanent soil cover, and diversified crop rotations, Conservation Agriculture not only preserves and enhances soil health but also promotes long-term environmental sustainability. The practice facilitates reduced soil erosion, improved water retention, and efficient nutrient cycling, contributing to the overall resilience of agricultural ecosystems. By embracing Conservation Agriculture, farmers stand at the forefront of sustainable agriculture, fostering a harmonious balance between productivity, environmental conservation, and the well-being of future generations. As we continue to address the challenges of modern agriculture, the adoption and promotion of Conservation Agriculture remain pivotal in ensuring a sustainable and thriving future for global food systems.

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Jalkund: Low-Cost Water Harvesting Structure for Sustainable Livelihood in Rainfed Agroecosystem of the Chandel district of Manipur, India

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The district of Chandel is neighboured by Myanmar on the south, Ukhrul district on the east, Churachandpur district on the south and west, and Thoubal district on the north. It is located at a distance of about 64 km from Imphal, the state capital. The total geographical area of the district is 3,313 square km and it lies between 23.49 degree and 24.28-degree north latitude and 94.09 degree to 94.31-degree east longitude in the south- eastern part of the state of Manipur.

The district is characterized by varying topology that is largely affected by high seepage flow and flash runoff. The dual yet contrasting effect of water in the form of heavy rainfall during monsoon and water scarcity during post monsoon is characteristically severe in this region. The existing typical undulated terrain and dual effects of water are the main limiting constraints in storage as well as availability of runoff water and its later use for irrigation purposes in the district. Of late, there has been an increasing interest in low-cost water harvesting and micro-irrigation system for small scale farming practices.

The age-old traditional farm ponds practiced by the local farmers are vulnerably susceptible to potential losses like infiltration, percolation, seepage flow and evaporation to a great extent. And huge financial requirement for construction/ adoption of concrete pond and optimal irrigation systems makes it almost beyond their reach for the marginal farmers to adopt efficient agricultural techniques/farming systems. Hence, it is essential to identify an economical approach to agricultural techniques so as to uplift the scope for adoption of advanced small scale agricultural techniques/ farming systems for the local tribal farmers of Chandel.

With a purpose to incorporate integrated ways of farming system coupling rainwater harvesting technique, *Jalkund* and micro-irrigation system using gravity system has been put up to demonstrate in Chandel District of Manipur. The use and applicability of the proposed approach in the tough dry terrain of Chandel District of Manipur was assessed for its effectiveness and farmers' satisfaction level.

It was found that adoption of *Jalkund* for harvesting rainwater and its judicious use in agricultural practices can greatly beneficiate the farmers of NEH region of India. The motive was to demonstrate an economical approach to small scale integrated farming system using *Jalkund* and micro-irrigation system as to elevate the socio-economic status of the tribal farming community.

Low-cost rainwater harvesting structure, *Jalkund*: *Jalkund*, an economical rainwater harvesting structure restricts the potential losses like infiltration, percolation, seepage flow and evaporation to great extent. (Saha *et al.*, 2007) ICAR, Barapani, Meghalaya has successfully developed *Jalkund* integrating lining of the inner wall and bed of the pond using Low Density Polyethylene (LDPE) of 250- or 500-micron films. The lining film is a revolutionary concept in water management which dramatically restricts the seepage losses at a reasonable cost. Installation of *Jalkund* involves excavation of kund (Pond), for a total capacity of 30,000 liters with a dimension of 5m x 4 m x 1.5 m. Once excavation is done plastering of the inner walls of the pond with a mixture of clay and cow dung in the ratio of 5:1 followed by a 3 – 5 cm thick cushioning with dry pine leaf or thatch grass @ 2 to 3 and ultimately laying down of lining material (LDPE black agri-film of 250 or 500 micron). The collected water can be covered with locally available materials like bamboo, grasses, etc. as to avoid the evaporation loss of water particularly during off season (November to March). The adoption and installation of *Jalkund* is simple.

With proper lining and roofing, the potential water losses may be restricted allowing storing of water for later uses. Harvesting of rainwater using *Jalkund* and integration of micro-irrigation system for irrigating the farmer's farm may uplift the applicability of small-scale integrated farming system.

Methodologies

***Jalkund* construction mechanism**

a) Excavation of the pit of the 7.5 x 4.5 x 1.2 m on selected site (preferably at hill top/uplands) before the onset of monsoon.

b) The bed and sides of the *kund* should be levelled by removing rocks, stones or other projections, which otherwise might damage the lining material.

c) The inner walls, including the bottom of the *kund*, to be properly smoothened by plastering with a mixture of clay and cow dung in the ratio of 5 : 1

d) After clay-plastering, about 3–5 cm thick cushioning should be done with locally and easily available dry pine leaf (@ 2–3 kg/sq. m) on the walls and bottom, to avoid any kind of damage to the lining material from any sharp or conical gravel, etc.

d) This should be followed by laying down of 250 µ LDPE black agri-film or Silpauline sheet. The agri-film sheet should be laid down in the *kund* in such a way that it touches the bottom and walls loosely and uniformly, and stretches out to a width of about 50 cm all around the length and width of the *kund*. A 25 x 25 cm trench should be dug out all around the *kund* and

25 cm outer edge of agri-film may be buried in the soil, so that the film is tightly bound from all around. At the same time, side channels all along the periphery of the *kund*, helps to divert the surface run-off and drain out excess rainwater flow. This is to minimize siltation effect in the *kund* by allowing only direct precipitation. Silpaulin sheet 250 GSM can be also used for longer duration in place of LDPE black agri-film.

e) *Jalkund* is to be covered with thatch (5-8cm thick) made of locally available bamboo and grass. Neem oil (10ml/sq.m.) is also advocated to reduce evaporation in off season.

Outcome

Traditionally the farmers of the district practiced mono cropping due to lack of water in rabi season. The sustainable water availability round the year through the Jal Kund will certainly enhance the income of the farmers crops like tomato, king chilli, cabbage, etc. and also from the extra income expected from rearing of fish and ducks.

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Low Tunnel Technology for Vegetable Crops

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Vegetables are a rich source of vitamins, carbohydrates, salts and proteins. Due to increased health awareness, high population growth rate, change in diet patterns, there is a year-round high demand for fresh vegetables in the country in domestic and export market. Due to unfavourable climatic conditions, there is a flood of vegetables in the season and high-priced vegetables in off-season. With the introduction of greenhouses, low and high poly tunnel technology with controlled temperature and humidity, vegetables can be cultivated in off season also. Low tunnels also known as plastic tunnels are miniature structures producing greenhouse like effect. Launched in 1999, as a pilot project by the Agricultural Technology Management Agency, the low tunnel technique is catching up among the farmers. They facilitate the entrapment of carbon dioxide which enhances the photosynthetic activities of the plant that helps to increase yield. Among the different types of covers available to use with LTs, spunbonded row covers of various thicknesses are most popular. They are semi-transparent porous fabrics that allows airflow and ventilation, hence helps to avoid condensation that may damage the foliage in contact with water.

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History

- Hoop houses or poly tunnels have been existed since 1940s. With each passing decade their design continues to evolve.
- The first use of plastic film in agriculture has been done by Professor. E. M. Emmert in 1948 when he built the first plastic greenhouse, a wooden structure covered with cellulose acetate film. Later, he replaced that film with more effective polyethylene film due to unstable behaviour of cellulose acetate film on exposure to temperature and moisture.
- After this, introduction of plastic film in agriculture began on a wider scale and in 1950s, it replaces paper for mulching vegetables. The first plastic tunnels were used in Fresno County by Mr. Richard Espinoza to grow Japanese eggplants and Chinese long beans in 1981. He was introduced to this technique when he was on a tour to San Diego vegetable growers in 1981. Later on, he built the first tunnel laying machine followed by building many low tunnels for the local vegetable growers.
- Walk in tunnels, low plastic tunnels etc. were evaluated for cultivation during normal and off – season at Indo- Israel Project in IARI, New Delhi during the year 1999- 2000 to 2000- 2003. In India, the low tunnel technique was launched in 1999, in Punjab as a pilot project by Agricultural Technology Management Agency (ATMA).
- This technique has proved a boon for vegetable growers, especially those with small land holdings.

Principle Behind

Low tunnel farming works one the same principle as that of a greenhouse. It helps to create conditions during winter equivalent to those in summers. Therefore, the vegetables that are sown in summer can easily be cultivated in winters inside these low poly tunnels.

- In general, low tunnels allow shortwave solar radiation to pass through during the day and the plastic material slows longwave radiation from the surface at night It converts the light energy from the sun into heat energy which provides warmth to the plants grown inside it and promote early growth of plants. The interior of tunnel heats up faster from the incoming solar radiations as it passes through the transparent polythene sheet and is absorbed by black polythene sheet spread over the soil.

- The plastic sheet on the surface serves three purposes- 1) it traps heat 2) it reduces evaporation or conserves moisture 3) it eliminates the growth of weeds.

Advantages and Disadvantages:

1. **For raising healthy seedlings-** it is done by modifying the microclimate inside low tunnels which helps the grower to raise healthy and early nursery. This can be an extra source of income for a farmer by selling those seedlings to another village.

Fig 1: Growth difference in cucumbers grown under low tunnel as compare to open field

2. **Enhances nutrient uptake by the plants-** the plants grown inside low tunnels have stronger root development in comparison with the plants in open field. Therefore, it enhances the uptake of nutrients.
3. **Maintain optimum temperature-** every crop requires certain temperature to grow like cool season crops require around 21˚ C and warm season crops requires temperature as high as 32˚ C. Low poly tunnels are capable of maintaining an optimum temperature for summer sowing crops if cultivate in winter season.
4. **Reduces Evapotranspiration-** the use of mulching technique inside low tunnels reduces the water loss from the plants and soil. So, it takes longer for a plant to dry.
5. **Provides protection-** the plants that are cultivated under low poly tunnels have a protection against wind, frost, rain and snow.
6. **Dissembled easily-** this technique is light in structure and therefore can be dissembled easily and relocate to another place after cultivation has been done.

Disadvantages

1. Less production of vegetables in comparison to high tunnels.
2. Crop management operations are difficult like spraying, hoeing, fertilizer management become quite tough for a grower to do in low poly tunnels.
3. Temperature maintenance is difficult and it requires regular monitoring by the grower because for some temperature sensitive crops like – tomato and pepper, if they grow too tall and touches the row cover sheet, it will get deteriorate.
4. Dismantling must be done manually and therefore labour intensive.
5. Repair and support are significant obstacles.

Conclusion

The growing population, rapid industrialization and urbanization is gradually decreasing the cultivated land area and so the demand of fresh vegetable under shrinking land area forces the policy makers to think beyond open field cultivation. Therefore, these low-cost poly tunnels offer an immense scope for the farming community of India.

A low cost and low maintenance technique, low tunnel technology ensures supply of vegetable during scarcity and help the grower to obtain reasonable and profitable return of their produce. By increasing air temperature, reducing wind damage and providing a degree of frost protection, the low tunnels accelerate crop production and extend the growing season. There is a need of efforts to minimize the initial investment for establishment of protected structures. Government support as well as intervention of NGOs for financial help and arrangement for skill development programme on protected cultivation will help to increase the area under protected cultivation. The further refinement in existing technology will definitely go a long way to harness the full potential of low-cost poly tunnels in vegetable production in the hilly regions.

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Success Story: The Journey of a Rural Youth Farmer to a Millionaire Through Integrated Farming System

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Shri Shivanagouda Patil from Haletegur village, Dharwad Taluk, Dharwad District, Karnataka state who completed his SSLC and get into farming in joint family size of 20 members. Earlier he was following only mono cropping pattern mainly sugarcane and having mango orchard in 61 acres of land with annual net income of Rs. 5,65,000/- in the year 2014.

Nature of farm activities and technologies adopted

He visited KVK Dharwad in the year 2018 for consultancy. On regular consultancy and trainings by scientists of KVK, Dharwad he started growing

intercropping of soybean and maize in mango orchard in 25 acres of land with integrated crop management practices. He started mulberry cultivation in 2 acres for sericulture activity. KVK introduced short duration sugarcane variety CO-9004 under FLD and soybean variety DSb-21 in his field. He attended training on scientific sheep and goat farming from KVK and established integrated goat cum poultry unit.

Also took consultancy on fishery activity in farm pond. Then iintroduced composite fish farming with Rohu, Catla, Common carp breeds in farm pond.Improved green fodder varieties like African tall maize, CoFS-29, CoBN-5 and DHN-6 were introduced in his farm. He planted mahogany trees within this field taking intercropping of mulberry for sericulture activities and teak plantation along the bunds.

Entrepreneurship and business to generate annual income

From 30 acres of sugarcane (CO-9004) getting an income of Rs. 24.30 lakh. Rs. 1.5 lakh from 4 acres of sole soybean (DSb-21) cultivation, Rs. 5.0 lakh from intercropping of soybean and maize in mango and Rs. 8.0 lakh from the mango orchard. Running 5 cycles per year and getting Rs. 4.5 lakh from sericulture activity and Rs. 1.0 lakh from fishery activity in farm pond.

Successfully established dairy farming with HF, indigenous cows (8 Nos.) and Murrah Buffaloes (10 Nos.) and selling 100 L of milk daily and overall, from the dairy unit earning Rs. 9.5 lakh annually. Established the integrated goat cum poultry shed with capacity of 20 Beetal, 10 Tellicherry goats and 80 desi poultry birds and earning Rs. 3.5 lakh from this unit. In future he is expecting income from mahogany (500 Nos.) and teak (400 Nos.) plantation. Now he is earning total annual net income of Rs. Rs. 37, 30,000/- per year. He was honoured and recognised with many awards like taluka level Shreshta Krishika Award from UAS, Dharwad, Incentive award from CRI pumps Pvt. Ltd, also received millionaire farmer of India (MFOI) award from ICAR, Pusa, New Delhi sponsored by Mahindra Tractor in 2023.

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Advances in Methods for Estimating Greenhouse Gas Emissions from Rice Soil

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Agriculture contributes significantly to greenhouse gas emissions and plays an important role in climate change. As the world's population grows and demand for food increases, it is imperative to accurately assess and mitigate greenhouse gas emissions from agricultural practices. In recent years, there have been remarkable advances in methods for estimating these emissions that allow scientists, policy makers, and farmers to gain a better understanding of their environmental impact. These advances include a wide range of technologies, from improved measurement techniques and remote sensing to sophisticated modelling tools and the use of Big Data and machine learning. Using these innovative approaches, researchers can evaluate the effectiveness of mitigation strategies, identify emissions hotspots, and develop sustainable agricultural practices. In recent years, there have been significant advances in methods for estimating greenhouse ga emissions from agriculture. Accurately quantifying these emissions is crucial for understanding their contribution to climate change and developing effective mitigation strategies. In addition, standardization and harmonization efforts are providing consistent estimates of emissions, facilitating global comparisons and informed decision-making. This article reviews recent advances in methodologies for estimating greenhouse gas emissions from agriculture and highlights their importance in combating climate change and promoting sustainable agricultural systems. Here are some notable advancements:

Monitoring climate change in rice-agroecosystem

Climate change monitoring in the rice agro-ecosystem aims to understand and respond to the complex interactions between climate variables and rice production. Monitoring involves the systematic collection and analysis of climate data, including temperature, precipitation, humidity, and extreme weather events, to assess how changing conditions affect rice growth, yield, and quality. Remote sensing technologies such as satellites and drones provide valuable insights into crop health, water availability, and land use changes. Data collected through monitoring contributes to early warning systems that help farmers prepare for climate-related challenges such as droughts, floods and pest infestations. In addition, monitoring facilitates the identification of climate-resilient rice varieties and the development of adaptation strategies, including modified planting dates, modified irrigation practices, and improved pest management.

Greenhouse gas measurement at field level

Traditional methods of measuring greenhouse gas emissions in agriculture, such as manual chamber measurements, are labour-intensive and time-consuming. Newer technologies such as automated chamber systems, eddy covariance, open-path gas analyzers and laser-based spectroscopy enable continuous measurements of greenhouse gas fluxes in real time. These advancements provide more accurate and detailed data on emissions from agricultural systems.

Manual chamber method: Greenhouse gasses can be measured using the closed chamber method, in which the gasses are collected at the experimental site in a chamber made of acrylic plates and then analyzed using a gas chromatograph. However, the data obtained with this method is not real-time data and has its own limitations. The basic idea of this technique is to enclose a given volume of soil in a closed chamber that allows gaseous exchange between the chamber head and the soil below.

The greenhouse gas flux from the soil was assessed using closed chambers by taking regular gas samples from the chambers and measuring the change in gas concentration over the period of linear concentration change. Subsequently, the analysis was performed using a gas chromatography system equipped with a flame ionization detector (FID) as well as a methanizer for CO_2, an FID for CH_4 and an electron capture detector (ECD) for N_2O (Nayak et al. 2017).

Errors

- Disturbances of the physical and biological systems caused by the measurement procedures.

- The error regarding the volume of the chamber has been taken into account.
- Sample handling errors, improper chamber design, problems in sample analysis and inappropriate procedures for calculating the flux.

Advantages

- Inexpensive and can be used in remote locations because it does not require a power source.
- Used for large-scale greenhouse gas estimation for measuring emissions at the field and farm level.
- The chambers are simple, affordable, and easy to make and chamber's dimensions and size are adjustable.
- Even in small plots, treatment differences and even very small flux variations could be detected.
- Minimal disturbance to the crop during sampling.

Disadvantages

- Time-consuming process that requires a significant amount of manual labour.
- In other hand, limited in the sample volume that can be analysed at a time with limited accuracy, which can lead to variability in the results obtained.
- Also, limited in its ability to detect and count microorganisms that are smaller in size or present in low concentrations.
- Gas concentrations in the chamber may rise to the point of preventing normal emissions. However, short collection times can reduce this problem.
- Because of the turbulence of air flow that naturally exists at the ground surface, closed chambers alter atmospheric pressure variations. Therefore, an enclosed chamber may exaggerate gas flux. An appropriately designed vent that allows pressure equalisation inside and outside the chamber can solve this problem.
- Temperature fluctuations are possible both inside the chamber and in the soil. However, temperature fluctuations can be minimised by insulating the chamber and coating it with a reflective substance.

Ecosystem level measurements of greenhouse gas

Measurements of greenhouse gases at the ecosystem level are typically made using a range of methods, including direct and indirect methods. While indirect methods make estimates of GHG fluxes based on associated variables or processes, direct methods measure greenhouse gas fluxes at the ecosystem level. Direct methods include eddy covariance measurements of greenhouse gas fluxes and the measurement of ecosystem respiration. Modelling approaches including remote sensing that use satellite data to predict greenhouse gas fluxes based on ecosystem characteristics such as temperature, vegetation cover and moisture are some examples of indirect methods for estimating greenhouse gas fluxes at the ecosystem level.

Eddy Covariance: The eddy covariance method is based on a sensor-based real-time measurement of greenhouse gases (**Figure 1**). Basically, the air flow in the atmospheric boundary layer can be viewed as a horizontal flow of numerous rotating eddies containing the greenhouse gases, each of which has a 3-D component (Ux, Uy and Uz). The covariance between the concentration of a particular greenhouse gas or heat and the vertical wind component (Uz) is the flux of that greenhouse gas or heat. The EC measurements are based on high-frequency (10-20 Hz) data of wind speed, wind direction and CO_2, CH_4 and water vapour concentrations at a certain height above the canopy, obtained with a triaxial sonic anemometer and an infrared gas analyzer. Assuming perfect turbulent mixing, all high-frequency data are accumulated over half an hour to calculate carbon, water and heat balances on a daily to annual basis (Chatterjee et al. 2021).

Regional level measurements of GHG

There are several regional-level measurements of greenhouse gas emissions from agriculture, which can vary depending on factors such as climate, land use and agricultural practices. The development and improvement of a globally recognized methodology and software for the calculation and reporting of national greenhouse gas emissions and removals is the responsibility of the IPCC's Task Force on National Greenhouse Gas Inventories.

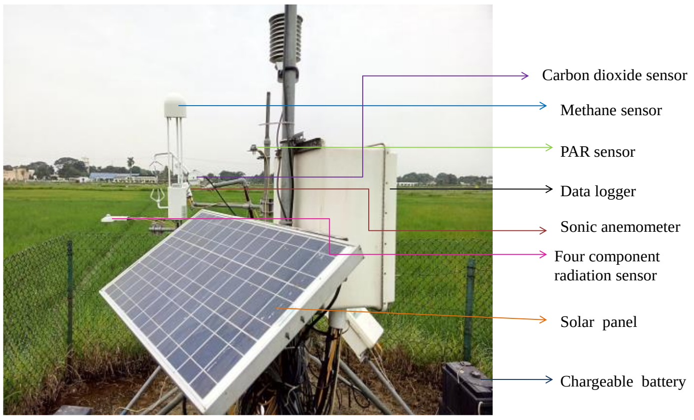

Fig. 1. Open path eddy covariance system

Life cycle assessment (LCA): Life cycle assessment is a method used to evaluate the environmental impact of a product or system throughout its entire life cycle. LCA has been applied to agriculture to estimate the greenhouse gas emissions associated with various agricultural activities, including crop cultivation, livestock farming and food processing. By accounting for emissions from inputs such as fertilizers, energy consumption and transportation, LCA provides a holistic view of the emissions associated with agricultural practices.

Global level measurements of GHG

Remote sensing and satellite imagery: Remote sensing technologies, including satellite-based sensors, offer a broader perspective on agricultural GHG emissions. These tools can be used to detect and measure various indicators such as vegetation condition, soil moisture and changes in land use, which are crucial for estimating emissions. The combination of satellite data with ground-based measurements and modelling techniques enables a more comprehensive assessment of agricultural emissions on a regional and global scale.

Modelling and simulation tools: Computer models and simulation tools are increasingly used to estimate GHG emissions from agriculture. These models integrate data on factors like soil properties, climate conditions, crop types, and management practices to estimate emissions. They can be used to explore different scenarios and assess the effectiveness of mitigation strategies. Improved models provide estimations that are more accurate and enable policymakers and farmers to make informed decisions to reduce emissions. Models such as CENTURY, DNDC, DayCent, DSSAT, TechnoGAS, ECOSSE, EPIC are widely used and validated globally for estimation greenhouse gas emission.

Climate change monitoring in the rice agroecosystem aims to understand and respond to the complex interactions between climate variables and rice production. Monitoring involves the systematic collection and analysis of climate data, including temperature, precipitation, humidity, and extreme weather events, to assess how changing conditions affect rice growth, yield, and quality. Data collected through monitoring contributes to early warning systems that help farmers prepare for climate-related challenges such as droughts, floods and pest infestations. In addition, monitoring facilitates the identification of climate-resilient rice varieties and the development of adaptation strategies, including modified planting dates, altered irrigation practices, and improved pest management. These advances in methods for estimating greenhouse gas emissions from rice soil have enhanced our understanding of the sector's contribution to climate change. They provide valuable insights for policymakers, researchers, and farmers to develop and implement sustainable practices and reduce emissions from agricultural systems.

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Seaweed Extract: A Potential Biostimulator, Biodegradable and Eco-Friendly Resource for Plant Defense

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A rapidly growing world population has highlighted the need to significantly increase food production in the context of a world with accelerating soil and water shortages as well as climatic stressors. This situation has generated new interest in the application of seaweed extracts because of their potent plant growth enhancing properties through metabolic benefits, triggering disease response pathways and increasing stress tolerance. The basis for these benefits is complex and poorly understood. Seaweed extracts are complex and have been demonstrated to possess novel mechanisms for increasing crop productivity.

Plants incessantly encounter abiotic and biotic stresses that limit the growth and productivity. However, conversely, plant growth can also be induced by treatments with various abiotic and biotic elicitors. This situation has generated new interest in the application of seaweed extracts because of their potent plant growth enhancing properties through metabolic benefits, triggering disease response pathways and increasing stress tolerance. The major constraints in rice production are biotic and abiotic stresses (Ansari et al., 2015). Each year, these stresses cause large-scale crop losses, which are expected to escalate as climate change is projected. Fungicides are crucial strategies for managing fungal diseases in rice since they are the most destructive worldwide. The excessive use of fungicides causes fungicidal stress.

Besides, fungicide application also has more significant impact on the residual levels in the crop. Reducing pesticides in agriculture is essential to minimize the environmental impact and improve the sustainability of agricultural systems (Van Oosten et al., 2017). As a result, agricultural practices have evolved towards organic, sustainable, or environmentally friendly practices. Organic molecules such as seaweeds may be used as one of the strategies to minimize pesticide use. Unlike pesticides, these organic compounds are non-toxic and non-polluting (Pal et al., 2015).

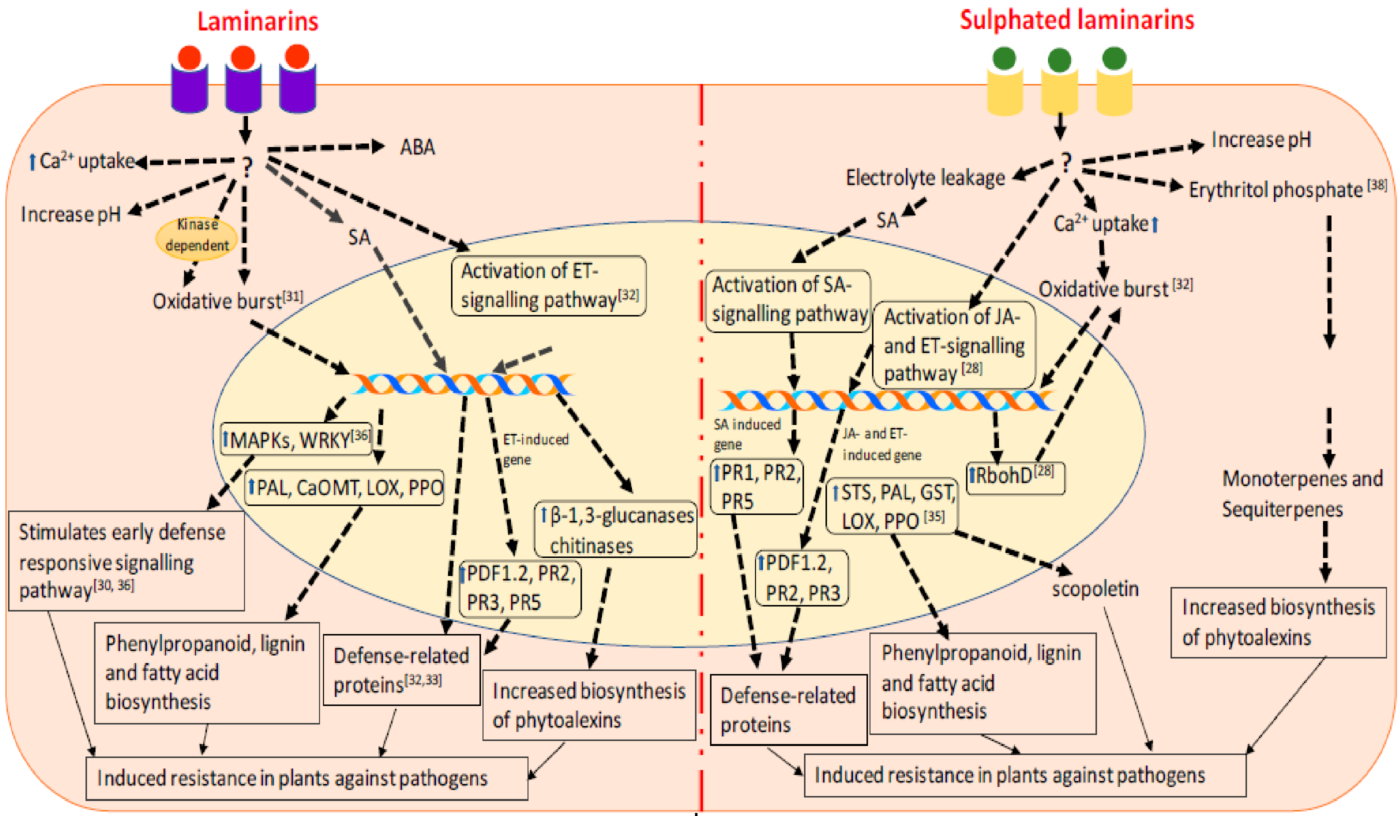

Fig. 1: Schematic representation of the cellular functions and signalling pathways involved in defense mechanism elicited in laminarin and sulphated laminarin (Shukla et al., 2021).

Seaweed extracts have been shown to promote plant growth, minimize abiotic stresses by regulating molecular, physiological, and biochemical processes (Jithesh et al., 2019). In general, abiotic stress responses involve the production of Reactive Oxygen Species (ROS), ionic imbalance, altered Ca^{2+}, K^{+} signalling, stomatal behaviour and leaf temperature as well as the induction of heat stress factor genes (HSFs) and other transcription factors (TFs) which limit the growth and productivity of plants (Jithesh et al., 2019; Lin et al., 2022). Seaweed extracts are emerging as commercial formulations to boost tolerance by targeting multiple stress pathways. Seaweeds are red, green and brown macroalgae representing 10% of marine productivity (Van Oosten et al., 2017).

The red and brown algae make up the vast majority of seaweed formulations. Tropical red seaweeds are macroalgae that can accelerate plant metabolism and boost plant efficiency. The presence of phytohormones and several organic molecules acting as compatible solutes has been attributed to the beneficial effects of seaweed extracts. High concentrations of phenolic compounds with antioxidant properties that protect against stress-induced ROS can be used to improve stress tolerance.

Seaweeds are an important part of the aquatic and coastal ecosystems and have commercial importance in improving agricultural productivity (Ali et al. 2021). Some bioactive elicitors in different seaweed extracts induce pathogen-associated molecular patterns (PAMPs) because of their structural similarities to pathogen-derived molecules. This is accomplished by priming or eliciting the induced systemic resistance (ISR) and systemic acquired resistance (SAR) pathways' defence responses (Shukla et al. 2021).

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Nature's Exotic Masterpiece in the Rainforest: Heliconia

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Heliconias, which are native to South and Central America, are popular as ornamental plants and cut flowers because of their brilliant colours and exotic appearance. Their enhancing beauty has made them, a best landscape and as a potential cut flower. The heliconias exhibit a wide array of colours led by red, pink, orange, yellow and green combined with different sizes and shapes.

Due to its exotic appearance and brilliant colours, it fetches premium price in the market. Leaves of some varieties of heliconia are also sold as cut leaves for flower decoration. The genus Heliconia (Heliconiaceae) includes a number of species showing potential as commercial cut flower crops. *Heliconia psittacorum* and some of its hybrids (e.g., 'Golden Torch') are particularly promising because of their attractive flowers, long straight clean peduncles, prolific year-round flower production, excellent postharvest characteristics, and few pest problems. The inflorescences can be used in a manner similar to those of bird of paradise, but they are less massive and are therefore, easily incorporated into smaller floral arrangements.

Chromosome no: Basic X= 12, diploid 2n=2X=24

Family: Heliconiaceae

Common names: Lobster claw, False bird of paradise, Parrot flower

Origin: South and Central America

Growing environment:

Natural tropical forest- water, rich soil and sunlight is suitable. It can be found in moist or wet regions sometimes, in seasonally dry areas and needs elevation below 1500 feet. Most of the genus are near the river banks and patches of the forest.

Propagation

For propagation, rhizome divisions and seeds are employed. Since not all species produce seeds, seeds are not used. These seeds even have a lower germination percentage and take a year to germinate. At commercial level, rhizome is used as planting material for heliconia. The

Heliconia psitticorum

Heliconia bihai

Heliconia stricta

Heliconia caribaea

Heliconia chartacea

Heliconia indica

rhizomes are divided into sections that contain at least one bud and the base of the leaf stem, and they only need 4 to 8 weeks to sprout.

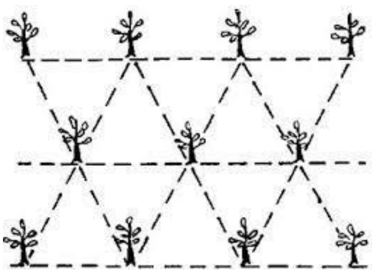
Light

Increased light intensity leads to better development and yield. Its penetration also boosts floral production four times more than that of 63% shadow. Lower light intensity grows taller, weaker plants with slightly intense bract colour and low productivity.

Temperature

Grows well under temperature range of 21°C to 35°C.

Growing media and planting



Raised beds of 1.5-2 m are used for planting. A triangular pattern planting is employed. A spacing of 0.75 to 1 m is provided for the plants initially. A good growing medium can be made using equal parts soil, wood chip mulch and peat moss for starting heliconias in a pot and also can be added to the hole when planting in the ground. Farm yard manure at 5 kg/m² is recommended.

Table 1: Airial and soilborne diseases

Disorders	Disease	Treatment
Aerial disorders		
Leaf spots	*Bipolaris spp. And alternaria spp.*	Bravo and/or tilt
Shoot rots		
Emerging shoots	*Pythium myriotylum*	Previcur and/or fongarid avoid water-logging
Basal rots		
Pseudostem at ground level	*Cylindrocladium floridanum*	No chemical control currently available. Usually attacks weakened plants, so avoid water-logging, which can cause other root rots
Soilborne plant disorders		
Wilt syndrome	A form species of fusarium oxysporum	No chemical control available. Clean knives when harvesting flowers. Clean planting material. Never re-plant on diseased ground.
Rhizome rot	*Cylindrocladium floridanum*	No chemical control currently available. Avoid waterlogging.
Root Knot nematode	*Meloidogyne spp.*	Nematicides not recommended due to cost and toxicity. Organic mulches, e.g. green manures, forage hay incorporated into beds at planting.
Root Rots caused by poor soil drainage		
Fine–feeder roots	*Phytophthora spp. and Pythium spp.*	Recommended fungicidal drench, e.g. Copper oxychloride, Fongarid. Avoid planting in wet season. Incorporate gypsum in clay soils to aid in water dispersal. Do not plant rhizomes too deep in beds.

The rhizomes should be planted fresh with the top i.e., leaf stem/new shoots/buds pointing upwards. Planting depth of 3-4 cm under the soil is recommended. New shoots or larger buds should be above the soil. If planted too deep, root rot is likely to occur. After planting water thoroughly. But do not water again until soil is getting dry.

Growing in pots: Even the lesser Psittacorum species may be cultivated in relatively big pots, as can most heliconias. To sustain the weight of the higher growing species, the pot must be sturdy and heavy. A new shoot will grow from the rhizome's base when the older stems wither and die. Store the pots in a warm, bright area. Plants can be replanted in well-drained soil after their leaves begin to unfold.

Replanting in soil: The majority of species can stretch out in all directions and need a lot of area. Larger species, like *Heliconia caribea*, can reach heights of up to 25 feet. Plant the rhizomes at least fifteen feet apart. Plant smaller species closer together, like *Heliconia psittacorum*. Remove old stems that have finished flowering and any dead leaves. In the beginning, a slow-release fertiliser is best; 20 g of N, P, and K are advised. More water and fertiliser are needed for larger, more established plants.

Growing speed and flowering: Heliconias grow really quickly. Heliconias range in height from 60 cm to 6 m, depending on the species. When cultivated from a rhizome, the majority of the larger species will take 12 to 24 months to blossom. When cultivated from rhizomes, the smaller psittacorum varieties often blossom after 6–12 months.

Shading: In order to protect the leaves from sunburn and to stop wind loads that could harm the leaves, temporary shades are placed over the leaf canopy. To safeguard the blooms during their growing season, plantations should practise basic hygiene. A 30% to 50% shade net is typically advised.

Pruning: To encourage robust new growth, tall plants can be pruned or pulled down. Trim or snip off flowering or foliage plant stems immediately above leaves or aged leaf junctions. Reduce overgrowth to encourage stronger growth in the remaining areas. "Deadhead," or withered flowers or seed heads, should be removed to encourage the growth of fresh flowers. When necessary, remove any dead, fading, or diseased leaves. When transferring, remove some leaves to lessen the strain on the newly planted roots.

Irrigation: Use of substantial amount of water. Root problems are caused by poor drainage, and longitudinal rolling of the leaf is caused by water stress. Use of overhead sprinklers relieve water stress in leaves and helps in uniform spreading through the dense foliage till the centre, if low level sprinklers are used it is inefficient due to density of the pseudo-stem.

Manures and fertilizers: Rich compost and more water is essential. Active growing season FYM-4kg/m^2, 20g of N, P_2O_5, K_2O/m^2 - at the time of planting and N-20g/m^2 top dressing after 2 months. As N:K ratio increases size of the plant and size of the inflorescence increases.

Micronutrients spray: Foliar spray 3-4 times/year improves leaf colour and micronutrients deficiency. Heliconia is a heavy feeder, good response to fertigation by increase plant size, flower size and productivity. Balanced soluble fertilizers with high nitrogen promotes rapid growth and flowering terminal inflorescence initiated with pre-determined no. of leaves 4-6 leaves in *Hipeastrum psittacorum*.

Weed control: weeds are manually removed for first few months and later there will not be any weed competition.

Plant protection: Scale, mealy bugs, wet feet causing rot in root system no such severe problem.

Nitrogen deficiency: overall yellowing of plants.

Iron deficiency: Due to high soil pH and poor drainage, causes yellowing in young leaves.

Magnesium deficiency: Yellow bands along older leaf margins.

Leaf Spot on psittacorum flower caused by *Curvularia incurvata*

Base and rhizome rot caused by *Cylindrocladium floridanum*

Internal vascular discolouration of lower pseudo stem of *Heliconia psittacorum* spp. caused by a form species of *Fusarium oxysporum*

Harvesting: Heliconias are normally harvested when fully mature as the flowers will not open once they get harvested. While flowers last longer if the bracts are less open.

Yield: 60 to 120 stems/m^2

Grading and Bunching: Excellent heliconia blooms are fully developed, devoid of flaws (such as fading or damage), and have high-quality foliage. Each smaller hanging species and the bigger upright species are grouped together by stem.

Storage conditions: Heliconia is extremely vulnerable to harm from chilling. Never hold them at a temperature lower than 10–12.5°C. Flowers can be kept in water at 12.5°C or in moist, crushed newsprint. Has a 14–15 day shelf life and is unaffected by preservative treatments.

Packing: Normally packed in horizontal fibre board box.

Intercultural operations: Suckering is the important phenomenon of heliconia. Therefore, to promote greater suckering and flowering, nutrients must be maintained. In general, heliconia plant basins treated with NPK at a 2:1:1 ratio and 3 kg/m^2 /year showed the highest response for several variables, such as flower weight, leaf area, and all vegetative characteristics. In addition to inorganic fertilizers, application of well decomposed FYM or green manure has beneficial effects on flower and sucker production in heliconia.

Grades

Heliconias are usually graded by bract size and classified as small, medium, large, and extra-large.

Grade	Stem length (cm)	Bloom	Bract
Small	80	15	-
Medium	70-90	20	3-4
Large	More than 90	25	3-4
Extra	More than 90	30	3-4
Pendant	110	More than 30	5-6

Pulsing

pulsing the stems with 10%, 30% and 50% sucrose solution for 30, 60 min, 12 and 24 hours. Stems subjected to pulsing with 10% sucrose for 60 min maintained the quality of the inflorescenses compared to the other treatments. This treatment allowed the stems to reach 20 days of longevity, being 20% longer than the control, showing color and brightness appropriate to the quality standards.

Ethylene Sensitivity: There is no evidence of any deleterious effects of ethylene exposure on the vase life of Heliconias.

Table 2: Factors affecting Flower Quality

Physical	➢ Abrasion due to wind causes brown superficial lesions on peduncles and bracts	➢ Incorporate wind breaks, e.g. native timber, palms and/or barna grass.
Chemical	➢ Spray-damage due to herbicide drift can cause discolouration of bracts. ➢ Poor spraying practices can cause scorch marks and reduce bloom quality.	➢ Do not spray on windy days; choose calm weather conditions. ➢ Spray in early morning or late evening, i.e cooler parts of day. Use correct formulation, concentrations recommended on the label.
Biological	➢ Flowers attacked by ants and rodents are not saleable. ➢ Curvularia spp. and Alternaria spp. can cause severe spotting on bracts. ➢ *Bipolaris incurvata* can cause flower bract spots.	➢ Aim to reduce pest populations through appropriate trash management. ➢ Regular spray program of Bravo. Improve aeration during wet season to avoid water buildup on leaves. ➢ Regular spray program of Mancozeb, Rovral and Tilt. Improve aeration during wet season to avoid water build-up on leaves.

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Cultivating Crop Health in the Digital Era: Harnessing AI for Plant Pathology

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The fusion of digital technologies and artificial intelligence (AI) is pushing the global agriculture sector towards a transformational era. An ever-increasing global population's need for higher food production as well as environmentally friendly and sustainable farming methods provide substantial problems for modern agriculture. In order to satisfy these needs, the agricultural industry is embracing the digital age and leveraging AI to transform every aspect of crop cultivation (Liu, 2020).

Plant pathology, a science devoted to comprehending and lessening the effects of diseases on crops, is at the centre of this transformation. To identify and treat crop diseases in the past, plant pathologists used conventional techniques like visual examinations and manual data collecting. These techniques do, however, have some drawbacks that frequently result in delayed responses and considerable yield losses. We are now living in the era of digital agriculture, where plant pathology is advancing at a rate never before seen. New options for disease identification, monitoring and management have been made possible by AI's capacity to process enormous volumes of data, spot tiny patterns and make predictions with astounding precision. By utilising AI, we are enhancing food security for a growing global population while also producing crops that are healthier and have a less environmental impact.

It examines the enormous effects of AI on plant pathology and how it has changed the face of agriculture. We explore the many uses of AI, from data-driven precision agriculture to automated disease detection utilising advanced imaging equipment. Additionally, we look at the difficulties and ethical issues that come with incorporating AI into agriculture and present studies from the real world that demonstrate the practical advantages of this digital transition (Hicham *et al.*, 2023).

Understanding the consequences, prospects and challenges associated with AI-driven plant pathology is crucial as we move through this exciting period of growing crop health in the digital age. AI can guide agriculture towards a future that is more sustainable, productive and resilient by adopting these advancements wisely.

Role of Artificial Intelligence in Plant Pathology

In the study of plant pathology, artificial intelligence (AI) has become a game-changer by providing fresh approaches to persistent issues relating to crop health. Fundamentally, AI uses sophisticated algorithms and processing power to simulate human intellect, but at a scale and rate that are beyond the capabilities of human specialists working alone. This skill has opened the door for a wide range of plant pathology applications, revolutionising how we identify, track and control diseases in crops.

Disease detection

One of the most appealing uses of artificial intelligence in plant pathology is disease identification. The use of visual inspections-which can be time-consuming and subject to human error-is a common component of traditional approaches. The analysis of large datasets from multiple sources, such as photographs, sensor data and environmental elements, is where AI, on the other hand, excels. These datasets may be analysed by machine learning algorithms, which can spot abnormalities and subtle patterns that the human eye might miss. AI may dramatically improve the speed and accuracy of disease diagnosis, whether it's finding early indicators of infection in leaves, identifying pathogens in soil samples or spotting changes in plant behaviour.

Disease Management

AI is essential for both the identification of diseases and the management of existing diseases. It offers advice and insights based on data for farmers and other agricultural professionals. For instance, AI can assist in maximising the time and dosage of treatments, which will minimise the usage of pesticides and fungicides, cut expenses and lessen the impact on the environment. Artificial intelligence driven solutions provide more precise and proactive disease management techniques by continuously monitoring environmental factors and disease dynamics (Jin *et al.,* 2023).

How AI is Transforming Current Plant Pathology Practises?

The use of AI in plant pathology is a paradigm leap from earlier approaches. Here are some significant ways that AI is revolutionising this industry:

Detection and prevention at an early stage

In traditional plant pathology, manual inspections and routine sampling are common. AI makes it possible for automated, continuous surveillance, which permits the early discovery of diseases before they spread. Large scale agricultural loss can be avoided, thanks to this early warning system, which also lessens the need for dramatic action.

Decision-Making Driven by Data

Massive volumes of data, such as weather patterns, soil characteristics and historical disease records are processed by AI systems. This data may be analysed by AI to produce exact suggestions for planting, irrigation and disease control that will maximise crop yields yet using fewer resources.

Individualised Farming Methods

Personalised field-level management is made possible by AI. Individualised care based on each crop's unique requirements can be provided, decreasing the need for general solutions and lowering resource waste.

Scaling Knowledge

Experienced plant pathologists' knowledge and skills can be captured by AI. This means that artificial intelligence (AI) can offer beneficial insights and help for disease management even in areas with a dearth of specialised specialists.

Digital Tools and Technologies in Crop Monitoring

Precision agriculture has been transformed by the Internet of Things (IoT), which has made it possible to collect and monitor data in real-time on farms. IoT devices that have sensors and actuators gather data on variables such as temperature, humidity, soil moisture and pH levels. This information gives farmers vital information about environmental factors affecting plant health and growth. Since these gadgets frequently have wireless connectivity, farmers can quickly decide whether to alter irrigation levels, apply fertiliser or take other disease prevention steps.

Unmanned aerial vehicles (UAVs), drones and other remote sensing technologies provide a distinctive viewpoint for crop health monitoring. These devices collect data across a range of wavelengths, including visible, infrared and thermal, giving crucial details about the condition of the crop. While drones and UAVs provide high-resolution imaging capabilities that enable the detection of individual plants and small changes in agricultural conditions, satellite imagery provides large-scale monitoring (Reddy and Vijayreddy, 2023).

In addition to assisting in crop health monitoring, these digital tools and technologies also provide useful data sources for AI-driven systems that improve disease identification and diagnosis.

AI-Based Disease Detection and Diagnosis

Agriculture uses machine learning algorithms, specialised imaging systems and AI-based disease detection and diagnosis. Large quantities of information about healthy and ill plants, including pictures, spectral data and other pertinent characteristics, are used to train these algorithms. They categorise plants according to their state of health, making them important instruments for spotting diseases early. Convolutional neural networks and support vector machines, two examples of supervised machine learning algorithms, excel at classifying photos of plants and their leaves to find visual signs of disease. These algorithms can quickly scan huge amounts of images and deliver precise diagnoses, enabling quick action to stop the spread of disease.

For precise disease identification in plants, AI-powered imaging systems-which frequently include cutting-edge cameras, sensors and image processing software are used. They record data in the multispectral and hyperspectral range, indicating tiny differences in plant health that may be caused by stress or disease (Moreira *et al.,* 2022). These systems can be used in the field or incorporated with automated farming machinery and they provide benefits including speed, precision and scalability. They are able to analyse numerous parameters at once, giving a thorough picture of the health of the plant that goes beyond obvious symptoms.

Challenges and Ethical Considerations in AI-Driven Plant Pathology

There are various ethical issues raised by the use of AI in agriculture. These include data ownership and privacy, access and equity, accountability and transparency, bias and fairness and employment displacement. Farmers and other stakeholders must be in charge of their data and aware of how it is used. There is a danger of a digital divide emerging when just a few farmers or geographical areas have access to cutting-edge AI-driven solutions. Given that AI models can be intricate and enigmatic, accountability and transparency in AI algorithms are essential. AI algorithms that are biased can produce unjust results, especially for marginalised people. The automation of some agricultural jobs by robotics and AI may result in job displacement.

Security and data privacy are also very important. To guarantee that farmers have ownership over their data, consent processes must be implemented. Sensitive agricultural data must be protected from assaults and breaches using strong cybersecurity measures (Liu and Wang, 2021). For thorough analysis, data interoperability is necessary and for agricultural data, regulation compliance is vital. In order to avoid hurting farmers, taking advantage of weaknesses or jeopardising privacy, ethical data use is crucial. The ethical use of AI in plant pathology requires addressing several ethical and data-related issues.

Conclusion

The use of Artificial Intelligence (AI) for plant pathology is emerging as a transformational force in fostering crop health in the digital age, where technology and agriculture converge. There is no denying that AI has the potential to revolutionise disease detection, monitoring and management. AI enables farmers to take well-informed decisions that maximise yields, conserve resources and promote sustainable agricultural practises by providing real-time insights and data-driven solutions. But as we go out on this trip towards the digital future of agriculture, we must be on the lookout for obstacles and ethical issues. Responsible adoption requires data privacy, openness and equal access to AI-driven products. Furthermore, tackling prejudices and job loss guarantees that AI's advantages are ethical and inclusive. In addition to being a technological accomplishment, the combination of AI and plant pathology is a critical step towards safeguarding our world's food supply in the face of mounting difficulties. We can promote crop health in a way that supports our planet and our expanding population by embracing AI responsibly. The future of agriculture looks greener, healthier and wealthier thanks to the application of AI to plant pathology.

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Cold Plasma: An Emerging Technology for Food Processing and Preservation

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The concern for food safety and its nutritional integrity has increased manifold among consumers in the recent years. Traditional methods of food preservation such as pasteurization and sterilization, involve extensive heating of the foods, which alters their nutritional and organoleptic qualities. Use of chemical preservatives has constantly been under scrutiny for their ill-effects on health. These factors have shifted the focus on to non-thermal technologies. Cold plasma technology has become popular in food industry recently. Cold plasma technology is an effectual substitute of other technologies used for shelf-life enhancement and food decontamination. Cold plasma therapies have demonstrated negligible effects on the physical, chemical, nutritional, and sensory characteristics of different items because of their non-thermal nature. Because of its unique characteristics, this technology has gained more attention in recent years than others. There are distinct advantages to Cold Plasma over conventional processing technologies because of its versatile design, non-thermal nature, affordability, and environmental friendliness.

What is cold plasma?

Plasma is the fourth state of matter and 99% of the perceptive universe is made up of it. Plasma is generally made up of atoms, free electrons and partially ionized gases that contain charged particles, free radicals, and various reactive species. Plasma can be classified into two main types based on temperature. Thermal plasma, referred to as equilibrium plasma, is characterized by all plasma particles having a uniform and elevated temperature. Conversely, non-thermal plasma, often referred to as non-equilibrium or cold plasma, is characterized by a state in which the temperatures of the lighter electrons are substantially greater than those of the heavier atoms and molecules, which stay at ambient temperature (25–60°C). Cold plasma has been found to deactivate microbes and enzymes by creating Nitrogen Species and Reactive Oxygen (RON, ROS) and damaging the macromolecules.

Methods of cold plasma generation:

1. **Glow Discharge Plasma**: An electric field is applied to a low-pressure gas to produce this kind of cold plasma. It produces a visible glow and is commonly used in various applications, including material surface treatments, cleaning, and thin film deposition in electronics and semiconductor industries.
2. **Dielectric Barrier Discharge (DBD):** DBD plasma is formed between two electrodes separated by an insulating dielectric material. It's used in applications like ozone production, surface modification, and sterilization due to its ability to generate reactive species without direct exposure to electrodes.
3. **Corona Discharge:** This type of cold plasma occurs at the surface of a conductor or in a gas gap when high voltage is applied, leading to the formation of ionized species. Corona discharge finds applications in air purification, ozone generation, and electrostatic precipitation.
4. **Atmospheric Pressure Plasma Jet (APPJ):** APPJ operates at atmospheric pressure and generates a plasma jet that can be directed towards specific targets. It's used for various applications, including surface treatment, sterilization, and wound healing in the medical field.
5. **Microwave Plasma:** Microwave plasma is generated by introducing microwaves into a low-pressure gas. This type is often used in material processing, surface modification, and thin film deposition due to its ability to produce uniform and controlled plasma.
6. **Capacitive Coupled Plasma (CCP):** CCP involves two electrodes separated by a dielectric, allowing the creation of plasma by applying an alternating current. It's used in semiconductor processing, surface cleaning, and modification due to its uniform and high-density plasma generation.

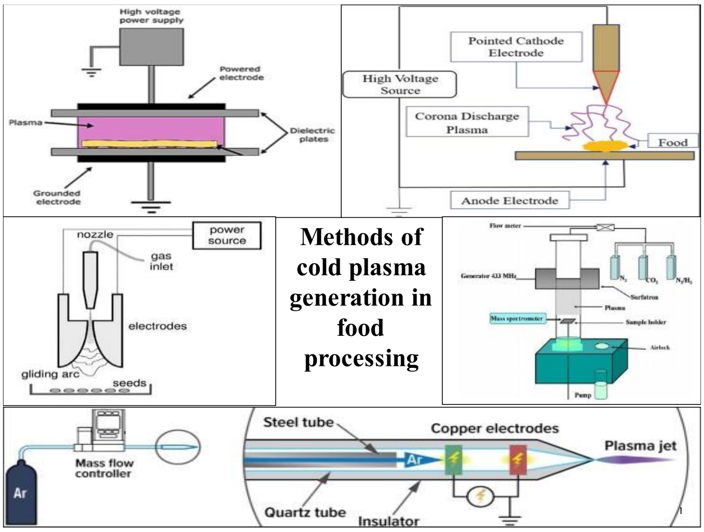
7. **Floating Electrode Dielectric Barrier Discharge (FE-DBD):** This form of DBD plasma involves an additional floating electrode which allows for specific control of the discharge. It's used in surface treatment, modification, and sterilization applications.

Cold plasma has shown significant potential for applications in food processing industries. The industries employ a variety of cold plasma generation techniques, including corona discharges, microwave plasma, gilded arc plasma, jet type plasma, radio frequency plasma, and dielectric barrier discharge plasma. Due to their straightforward, adaptable, and versatile designs and operating procedures, dielectric barrier discharge and jet plasma are the two techniques that are most frequently utilised for food research. In the former, cold plasma was often utilised in the polymer, sterilising, and electrical sectors, among other industries. However, in topical years, cold plasma's uses have rapidly extended to include the treatment of biological materials, biomedical devices and even food. Each type of cold plasma has its unique advantages and is suitable for particular applications based on factors such as the required level of energy, types of reactive species produced, scalability, and the specific properties of the targeted surface or material. The selection of the type of cold plasma is determined by the intended application and the desired outcomes.

Applications in Food Industry

The unique properties of cold plasma make it suitable for a variety of applications in food processing and preservation. The following are a few significant uses of cold plasma in the food industry:

1. **Surface decontamination:** Cold plasma is effective in decontaminating surfaces of food products, equipment, and packaging materials. It can destroy bacteria, viruses, and molds present on the surface of fruits, vegetables, and meat products without altering the food quality or characteristics.
2. **Extension of shelf life:** Treatment with cold plasma can help extend the shelf life of various food products. By targeting and eliminating spoilage microorganisms, it prevents or slows down microbial growth, thereby reducing the rate of spoilage and maintaining the quality of perishable foods.



3. **Packaging sterilization:** Cold plasma technology can be used to sterilize food packaging materials. It helps in disinfecting the packaging to ensure that the food remains uncontaminated throughout its shelf life.
4. **Improvement of food safety:** Cold plasma treatment is a non-thermal process that can enhance food safety by reducing pathogens and contaminants on the food surface without altering its nutritional content or sensory attributes.
5. **Enzyme inactivation:** Cold plasma treatments can also be used to deactivate enzymes that cause food spoilage, thereby extending the product's freshness and quality.
6. **Modification of food properties:** Cold plasma treatment can alter the surface properties of food, leading to changes in wettability, adhesion, and other characteristics. This can be useful for applications like improving the effectiveness of coatings or modifying the texture of certain food products.
7. **Reduction of chemical additives**: Using cold plasma in food processing can potentially reduce the need for chemical preservatives, as it offers a non-chemical method to maintain food safety and quality.

However, while cold plasma technology holds significant promise, there are still some challenges to be addressed, such as scalability, cost-effectiveness, and standardization for widespread industrial adoption.

To sum up, cold plasma technology has a lot of promise for the food business. It provides creative, non-thermal methods for processing and preserving food, which enhances food safety, lengthens shelf life, and lessens the need for chemical preservatives. It has been observed that the processing of cold plasma affects the quality characteristics of food products both during handling and storage. The further exploration and advancement in this domain will probably enhance and broaden the uses of cold plasma in food technology.

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Crop Residue Management: A Step to Sustainable Future

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Crop residue is the portion of the plant that is left in the field after harvest of the crop, which is not used domestically or sold for commercial purpose (i.e.- straw, stems, leaves, stalks, roots). crop residue is also the those which are generated from packing sheds and discarded during processing.

Types of crop residue

There are two different types of crop residues

Field/Harvest residue

_It is the left-out material after harvest of the crop. These can be ploughed directly into the soil. Good management of crop residues improves soil physical, chemical and biological properties

Example- straw, stubble, stovers, haulms, leaves

Process residues

Process residue is the material left after the crop is processed into a usable resource. These can be used as animal fodder and soil amendment, can be used as organic manures and be used in manufacturing sector.

Example-bagasse, molasses, cobs of maize, sorghum, bajra, groundnut shells

Multiple use of crop residues

The crop residues can be used for various purposes

- Livestock feeding
- Soil mulching
- Bio manure/compost
- Mushroom production
- Bio-fuel
- Biochar production
- Thatching in rural house holds
- Fuel purpose in domestic and industrial sector
- After incorporation to soil, improve soil physical, chemical and biological properties

Crop residue management

Crop residue management is the conservation system that promotes use of non-commercial portion of the plant for protection and improvement of soil system. It is a cultural practice that includes fewer or less intensive tillage operation, preservation of more residues in soil from the previous crop. It helps to protect soil and water resources and provides additional plant nutrient and environmental benefits

Necessity of crop residue management

Effective nutrient management involving available organic sources including plant-based waste and crop residues is very important step to provide additional nutrient deficit apart from chemical sources. It will help to the reduce demand for chemical/external fertiliser source as the demand of chemical fertiliser will increase by 10-15% in near future.

Benefits of crop residue management

- Acts as soil amendment
- Improves soil structure
- Erosion control
- Balances soil temperature
- Enhances soil microbial activity
- Nutrient recycling
- Reduces water evaporation
- Improves soil water holding capacity

The major effect of crop residue management in soil:

It develops soil physio-chemical properties of soil in various way. Some of the major points are mentioned below.

Effect of crop residue on physical properties of the soil

- Soil structure
- Soil bulk density and porosity
- Hydraulic conductivity
- Soil temperature

- Soil moisture

Effect of crop residue on chemical properties of the soil

- Organic carbon
- Soil pH
- Cation exchange capacity
- Available N, P and K
- Available micro nutrients

Effect of crop residue on biological properties of the soil

- It provides energy for growth and activities of microbes and acts as substrate for microbial growth
- Provides suitable environment for biological N fixation
- Increase soil enzymatic activities
- Increase microbial population
- Humus formation

Problems faced by farmers with crop residue left in the field

Use of combine harvester leaves around 80% residue in field making difficulty in crop management. Farmer find it laborious and are burning it on field to get rid of it and start new sowing

Impact of stubble burning

Stubble burning causes a wide range of problems on environment, soil fertility, health hazards, impacts economy and many more

a. Impact on Environment

The burning of 1t of paddy straw releases 3 kg particulate matter, 60 kg CO, 1460 kg CO_2, 199 kg ash and 2 kg SO_2, increasing the air pollution.

A large number of toxic pollutants like methane, volatile organic compound and carcinogenic polycyclic aromatic hydrocarbons are released that rise to the formation of smog.

b. Impact on Soil Fertility

Stubble burning destroys existing soil minerals, soil organic matter that makes soil less fertile.

The heat from burning paddy straw penetrates 1cm into the soil, elevating the temperature to 33.8 to 42.2 degree Celsius, that kills the bacterial and fungal populations critical for a fertile soil. Loss of eco-friendly pests. Drastic reduction in solubility capacity of the upper layers of soil.

In addition, other soil properties like soil temperature, pH, moisture, available phosphorus are greatly affected due to burning.

c. Impact on Human Health

Burning crops release particulate matter (PM) 2.5 that is easily carried away along the wind, causing numerous health issues.

These particles are tiny enough to get trapped deep inside the lungs, increasing the risk of lung cancer by 36 percent.

The smog-formation and poisonous gases arising from the stubble burning in Punjab and Haryana turns Delhi and other regions of the Gangetic plains into a gas chamber.

Children (below 5 years) and elderly (above 59 years) in urban areas are at high risk of acute respiratory infection (ARI) associated with crop burning, compared to those living in rural areas.

d. Impact on Economy

According to a report published by the International Food Policy Research Institute (IFPRI) in January, 2019, India loses $30 billion every year from crop fires.

The estimated the economic cost of exposure to air pollution from crop residue burning at USD 35 billion or nearly Rs. 2.35 lakh crore annually for the three north Indian states of Punjab, Haryana and Delhi.

Further, it warns that in next five years economic loss because of burning of crop residue would be $190 billion.

Solution for crop residue burning problem

By proper crop residue management farmers will not only help in reducing pollution but also will improve the soil productivity and will also get additional profit.

Some of the methods are-

1. Waste decomposer
2. Conversion of crop residue

3. Use of Agriculture machinery

A. Waste decomposer

Waste decomposer are effective microorganisms for in-situ decomposing of crop residues. This is sprayed on post-harvest stalk and residue and kept for about 1 month. Microbial Decomposer Technology is a microbial-based strategy, abundant in nitrogen fixing bacteria (*Azotobacter*, *Azospirillum*, *Rhizobium*, *Acetobacter*) and Pseudomonas fluorescence.

Benefits of Decomposer

- Microbial waste decomposer is simple, reliable, economical option for crop residue management.
- Used in quick composting of biowastes (Such as crop residues, wheat and paddy straw, animal manure, garden weeds and litter, grass, hedge cuttings, and garbage).
- Waste decomposer works as Biofertilizer, biocontrol agents and as well as soil health reviver.
- The decomposed materials can be used as biopesticide for the eco-friendly management of agricultural and horticultural crops (drip irrigation, foliar spray as biopesticide).

B. Conversion of crop residues

Crop residues can be converted to animal feed, Recycled products, Card board, paper etc. It can be used in setting up Bio-mass fuel plants to generate fuel using paddy husk

C. Use of Agriculture machinery

- Happy Seeder (used for sowing of crop in standing stubble)
- Rotavator (used for land preparation and incorporation of crop stubble in the soil)
- Zero till seed drill (used for land preparations directly sowing of seeds in the previous crop stubble)
- Baler (used for collection of straw and making bales of the paddy stubble)
- Paddy Straw Chopper (cutting of paddy stubble for easily mixing with the soil)
- Reaper Binder (used for harvesting paddy stubble and making into bundles

Government Initiatives towards Reducing Stubble Burning

Laws that are in operation pertaining to crop residue burning are mentioned below

- The Section 144 of the Civil Procedure Code (CPC) to ban burning of paddy
- The Air Prevention and Control of Pollution Act, 1981
- The Environment Protection Act, 1986
- The National Tribunal Act, 1995

Conclusion

Now a days stubble burning is a most negative trend or practice in agriculture that is causing lot of health issues, environmental pollution and in addition also a great loss of economic and opportunity for employment generation, value addition and development. Proper crop residue management will not only improve soil physio chemical and biological properties but also will sustain the environment with economic development.

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Conservation Agriculture - Preserving Farmland for Future Generations

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Conservation agriculture (CA), is a farming system that aims to degraded areas can be restored and arable land loss can be avoided. It encourages the diversity of plant species, little disturbance of the soil, and preservation of a permanent soil cover. It contributes to better and sustained agricultural production by enhancing biodiversity and naturally occurring biological processes both above and below the ground. It also increases the efficiency of water and fertilizer utilization.

CA enhances beneficial farming in agricultural land and livestock husbandry for rainfed and irrigated production thereby making more easily and timely operations. CA serves as a foundation for sustainable agricultural production intensification when combined with other well-known best practices, such as the use of high-quality seeds and integrated pest, nutrient, weed, and water management, among others. It creates more opportunities for the integration of production sectors, including the integration of crops and livestock as well as the landscapes of agriculture with pastures and trees (Gupta and Jat (2010).

The Food and Agriculture Organization of the United Nations (FAO) has determined that conservation agriculture (CA) has three key principles that producers (farmers) can proceed through in the process of CA. These three principles outline what conservationists and producers believe can be done to conserve what we use for a longer period. (http://www.fao.org.ag/ca)

Principles of Conservation Agriculture

Conservation agriculture practices perused in many parts of the world are built on ecological principles making land use more. Adoption of CA for enhancing Resource use efficiency (RUE) and crop productivity is the need of the hour as a powerful tool for the management of natural resources and to achieve sustainability in agriculture. Conservation agriculture basically relies on 3 principles, which are linked and must be considered together for appropriate design, planning and implementation processes. These are:

Minimal soil mechanical disturbance

Very solid soil aggregates and various sizes of pores that permit the infiltration of water and air are produced by the biological activity of the soil. This method is not associated with mechanical tillage and can be referred to as "biological tillage." The biological soil structuring activities will vanish with mechanical soil disturbance. The rooting zone's ideal ratio of respiration gases is provided or maintained by little soil disturbance, which also moderates the oxidation of organic matter, increases porosity for water transport, retention, and release, and reduces the re-exposure and germination of weed seeds.

Permanent soil organic cover

A permanent soil cover is important to protect the soil against the deleterious effects of exposure to rain and sun; to provide the micro and macro organisms in the soil with a constant supply of "food"; and to alter the microclimate in the soil for optimal growth and development of soil organisms, including plant roots. In turn, it improves soil aggregation, soil biological activity and soil biodiversity and carbon sequestration.

Diversified crop rotations

The rotation of crops is not only necessary to offer a diverse "diet" to the soil microorganisms but also for exploring different soil layers for nutrients that have been leached to deeper layers that can be "recycled" by the crops in rotation. Furthermore, a diversity of crops in rotation leads to diverse soil flora and fauna. Cropping sequence and rotations involving legumes help in minimal rates of build-up of population of pest species, through life cycle disruption, biological nitrogen fixation, control of off-site pollution and enhancing biodiversity.

Advantages of Conservation Agriculture

(i) **Cost of production** – cost of production will be decreased due to the rapid adoption of zero-till technology. Cost reduction is attributed to savings on account of diesel, labour and input costs, particularly herbicides.

(ii) **Reduced incidence of weeds** –When zero-tillage is adopted resulting in reduced in use of herbicides.

(iii) **Saving in water and nutrients** –considerable saving in water (up to 20% – 30%) and nutrients are achieved with zero-till planting and particularly in laser levelled and bed-planted crops.

(iv) **Increased yields** – CA has been reported to enhance the yield level of crops due to associated effects like prevention of soil degradation, improved soil fertility, improved soil moisture regime (due to increased rain water infiltration, water holding capacity and reduced evaporation loss) and crop rotational benefits.

(v) **Environmental benefits** – Conservation agriculture involving zero-till and surface managed crop residue systems are an excellent opportunity to eliminate burning of crop residue which contribute to large amounts of greenhouse gases like CO_2, CH_4 and N_2O. Burning of crop residues, also contribute to considerable loss of plant nutrients, which could be recycled when properly managed. Large scale burning of crop residues is also a serious health hazard.

(vi) **Crop diversification opportunities** – Adopting Conservation Agriculture systems offers opportunities for crop diversification. Cropping sequences/rotations and agroforestry systems when adopted in appropriate spatial and temporal patterns can further enhance natural ecological processes. Limited studies indicate that a variety of crops like mustard, chickpea, pigeon pea, sugarcane, etc., could be well adapted to the new systems.

(vii) **Resource improvement** – No tillage when combined with surface management of crop residues begins the processes whereby slow decomposition of residues results in soil structural improvement and increased recycling and availability of plant nutrients. Surface residues acting as mulch, moderate soil temperatures, reduce evaporation, and improve biological activity.

Constraints for adoption of conservation agriculture

- **Lack of appropriate seeders especially for small and medium scale farmers:** Although significant efforts have been made in developing and promoting machinery for seeding wheat in no till systems, successful adoption will call for accelerated effort in developing, standardizing, and promoting quality machinery aimed at a range of crop and cropping sequences.
- **The wide spread use of crop residues for livestock feed and fuel**: Specially under rainfed situations, farmers face a scarcity of crop residues due to less biomass production of different crops. There is competition between CA practice and livestock feeding for crop residue. This is a major constraint for promotion of CA under rainfed situations.
- **Burning of crop residues**: For timely sowing of the next crop and without machinery for sowing under CA systems, farmers prefer to sow the crop in time by burning the residue. This has become a common feature in the rice-wheat system in north India. This creates environmental problems for the region.
- **Lack of knowledge about the potential of CA to agriculture leaders, extension agents and farmers**: This implies that the whole range of practices in conservation agriculture, including planting and harvesting, water and nutrient management, diseases and pest control etc. need to be evolved, evaluated and matched in the context of new systems.
- **Skilled and scientific manpower:** Managing conservation agriculture systems, will call for enhanced capacity of scientists to address problems from a systems perspective and to be able to work in close partnerships with farmers and other stakeholders. Strengthened knowledge and information sharing mechanisms are needed.

Conclusion

Compared to the conventional paradigm of agricultural research and development, which was primarily focused on meeting specific food grain production targets in India, conservation agriculture offers a fresh approach. Given the pervasive issues with resource degradation that have accompanied previous production-boosting tactics that showed little regard for resource integrity, a paradigm change is now required. Sustainable productivity increase currently requires integrating considerations about the environment, soil quality, resource conservation, and productivity. In terms of knowledge base, developing and promoting CA systems will be extremely challenging. This will require scientists to have significantly greater ability to approach issues from a systems viewpoint, to collaborate closely with farmers and other stakeholders, and to increase the exchange of knowledge and information.

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http://www.fao.org.ag/ca

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Health Spine Gourd: The Impact of Vegetarian Diet

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Abstract

Spine gourd is a dioecious perennial cucurbitaceous climbing creeper. It is an Asian native with a large spread in India and Bangladesh. Over thousands of years, it has been utilized not only as a preventive and curative agent for numerous diseases, but also as a vegetable with high nutritional content. Spine gourd is regarded an underappreciated vegetable, despite the existence of some chemicals with higher nutritional value than several commonly consumed vegetables. Furthermore, as a traditional medicinal plant, there is still potential for its phytochemical components, which increases the need for further extensive research to support its other therapeutically responsibilities.

Introduction

The word "Spine Gourd" does not usually relate to a specific plant or fruit. It's possible that you're referring to "Spine Gourd" as a local or regional term for a specific type of gourd or vegetable. The thick skin and fleshy interior of gourds distinguish them. They are available in a variety of shapes, sizes, and colors. Some gourds have spines or prickles on their skin, which may explain the phrase "spine gourd" in some contexts. Spine Gourd fruits are oblong or spindle-shaped, measuring about 4-5 cm in length.

They are covered with numerous little spines or prickles, therefore the common name "spiny gourd." The fruits are green while immature and turn yellowish-orange as they grow. When the fruit is unripe, the flesh is white and crisp, but when fully mature, it becomes soft and red.

The Spine Gourd commonly known as teasel gourd, Adavihagal and Madahagal-Kayi in Kannada and Vahisi in Sanskrit, Kakor, Parora and Golbandra in Hindi, Banzakartoli in Marathi, Kartoli in Bengali, Akakara and Bodakakara in Tamil. It is a perennial climbing vine belonging to the Cucurbitaceae family. It is native to the Indian subcontinent and is widely distributed in tropical and subtropical regions of Asia, including countries like India, Bangladesh, Sri Lanka,

Myanmar etc. Spine Gourd has been cultivated in India for millennia, but it is only recently that it has gained popularity due to its numerous nutritional and health benefits. It is dioecious and perennial in nature, but commercially grown as vines and annuals with simple tendrils and fruits in axils and tuberous roots. It is becoming increasingly popular in the country as a result of its great therapeutic value.

Nutritional Value

Spine Gourd fruits are low in calories and high in fiber. They also include minerals such as calcium, potassium, and iron. Furthermore, the fruit is known for its antioxidant capabilities.

Nutrients	Quantity (per 100g)
Energy (kcal)	288.25
Fat (g)	3.1
Fiber (g)	3.0
Protein (g)	3.1
Carbohydrate (g)	7.7
Iron (mg)	14
Zinc (mg)	134
Sodium (mg)	150
Calcium (mg)	50
Potassium (mg)	830

Source: (Sattya and Mohammad, 2014)

Culinary Uses: Spine Gourd fruits are mostly used in cooking. The tender unripe fruits are used in many Asian cuisines, particularly in India and Bangladesh, in dishes like as curries, stir-fries, and pickles. The ripe fruits, with their soft and sweet flesh, are eaten fresh or used in sweets and preserves.

Medicinal Uses: Spine Gourd has a long history of traditional medicinal use in Ayurveda and other traditional healing systems. Different parts of the plant, including the fruits, leaves, and roots, are used to treat various ailments. It is believed to have anti-inflammatory, antidiabetic, and antimicrobial properties.

Antioxidant Activity: Spine gourd contains antioxidant substances that can limit the generation of oxygen-derived free radicals and protect cells (Anant *et al*., 2019). Fruit extracts are diuretic, alexiteric, stomachic, laxative, hepatoprotective, and antivenomic. It is used to treat asthma, leprosy, and excessive salivation (Bawara *et al*., 2010), as well as to avoid inflammation caused by lizard and snake bites, fever, mental and intestinal diseases, and cardiac problems. Fruits are used to treat pimples and acne on the skin because of these qualities.

Anticancer activity: According to (Anjana *et al*., 2020), root extracts have several constitutions with anti-cancer properties. Spinasterol-3-o-a-D-glucopyranoside is a significant chemical that inhibits cancer cell growth (Jha *et al*., 2017).

Allelopathic activity: Spine gourd seed oil is naturally insecticidal. Spraying the extracted oil on cereal grains gives anti-feed effect against cereal-feeding insects (Anjana *et al*., 2020).

Ayurvedic values: Other than the vegetable, ancient peoples employed spine gourd as a folk medicine. Spine gourd root fluids have anti-diabetic and anti-inflammatory properties, and applying extract of spine gourd leaves to the skull is an effective headache cure. When applied to the entire body, root extracts give a superficial effect for high fever. Oral administration of the leaf paste is used to treat a variety of skin problems such as pimples, acne, and skin softening (Talukdar *et al*., 2014). Spinach is the most beneficial nutrient vegetable for children, lactating moms, and pregnant women because it strengthens the immune system in the body (Salvi and Katewa, 2015).

Other Uses: Spine Gourd is planted as an ornamental plant due to its lovely leaves and distinct fruit appearance, in addition to its culinary and medicinal benefits. Spiny gourds can be utilized in flower centrepieces and offer aesthetic appeal to gardens.

Health Benefits of Spine Gourd

Insulin Secretion: Spine Gourd has been shown to increase insulin production by pancreatic beta cells. Insulin is a hormone that regulates blood sugar levels by allowing glucose from the bloodstream to enter cells. Spine Gourd extracts has been demonstrated in some trials to increase insulin release from beta cells, potentially contributing to better glucose control.

Digestive Health: Spine Gourd has long been utilized in Ayurveda and traditional medicine to support digestive health. It is thought to aid digestion, increase appetite, and treat constipation.

Weight Management: Spine Gourd can help with weight loss because to its low calorie and high fiber content. It promotes feelings of fullness, suppresses hunger, and promotes healthy digestion.

Immune System Support: Spine Gourd has vitamins and antioxidants that can help boost the immune system. They help the body's defence against infections and improve immunological function generally.

Anti-inflammatory Effects: Chronic inflammation is linked to insulin resistance and poor glucose metabolism, both of which play important roles in the development of type 2 diabetes. According to certain research, Spine Gourd has anti-inflammatory qualities. These qualities may assist to reduce inflammation and maybe enhance insulin sensitivity.

Slows ageing: Anti-aging components found in spiny gourd include antioxidants, beta-carotene, alpha-carotene, lutein and zeaxanthins. Their ingestion inhibits the onset of aging.

Conclusion

Plants were mostly used by ancient humans and our ancestors to recuperate from ailments. However, the recent tendency of avoiding natural sources of sickness rather than artificial sources is discouraging. Because ongoing reports of antibiotic resistance and synthetic medication adverse effects all throughout the world indicate a worldwide health emergency. Spine gourd contains a large number of secondary metabolites. Furthermore, the use of Spine gourd is beneficial to the environment and has less adverse effects than other synthetic medications. It will also be safer and less expensive than man-made medicine formulation.

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Good Agricultural Practices for Standard Quality Farm Produce

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Good Agricultural Practices are a collection of principles to apply for on-farm production and post-production processes, resulting in safe and healthy food and non-food agricultural products, while taking into account economical, social and environmental sustainability. GAPs may be applied to a wide range of farming systems and at different scales. They are applied through sustainable agricultural methods, such as integrated pest management, integrated fertilizer management and conservation agriculture. The implementation of GAP should contribute to Sustainable Agriculture and Rural Development (SARD).

Importance

Good Agricultural Practices is important because it reinforces responsible farming methods from site selection and land preparation to harvesting and handling. According to the Food and Agriculture Organization of the United Nations (FAO), GAP applies available knowledge to address environmental, economic, and social sustainability for on-farm production and post-production processes, resulting in safe and healthy agricultural products. Implementing Good Agricultural Practices can improve the livelihood of producers and the local economy as a whole, contributing to fulfill national development objectives or sustainable development goals.

GAP codes, standards and regulations

Good Agricultural Practices (GAP) codes, standards and regulations are guidelines which have been developed in recent years by the food industry, producers' organizations, governments and NGOs aiming to codify agricultural practices at farm level for a range of commodities.

Why do GAP codes, standards and regulations exist?

These GAP codes, programmes or standards exist because of growing concerns about food quality and safety worldwide; fulfillment of trade and government regulatory requirements and specific requirements especially for niche markets.

Principles of GAP

- Economically and efficiently produce sufficient (food security), safe (food safety) and nutritious food (food quality).
- Sustain and enhance natural resources (environmental sustainability).
- Maintain viable farming enterprises and contribute to sustainable livelihoods (economic viability).
- Meet cultural and social demands of society (social acceptability).

Pillars of Good Agricultural Practices

The 4 pillars of Good Agricultural Practices are the core principles used for the effective promotion and adoption of GAP. By following these pillars, farmers can build their reputations as providers of affordable yet high-quality goods and keep up with competitive export markets. As described by FAO, the 4 GAP pillars are economic viability, environmental stability, social acceptability, and food safety and quality:

- **GAP Pillar 1: Economic Viability**

This means to maintain viable farming enterprises and contribute to sustainable livelihoods. Generally, it refers to the profit earned from management of productive land.

- **GAP Pillar 2: Environmental Stability**

This means to sustain and enhance the natural resource base. The most recent Good Agricultural Practices outlines critical requirements such as assessing the risk of causing environmental harm on and off new sites, keeping records of the hazards assessed, and detailing the chemicals used to sterilize soils and substrates.

- **GAP Pillar 3: Social Acceptability**

This means to meet the cultural and social demands of society. An essential way of practicing this principle is to protect the agricultural workers' health from hazards brought on by the improper use of chemicals and pesticides.

- **GAP Pillar 4: Food Safety and Quality**

This means to economically and efficiently produce sufficient, safe and nutritious food. Control should begin in the field to reduce the hazards of contamination.

Objectives of GAP

- Ensuring safety and quality of produce in the food chain.
- Capturing new market advantages by modifying supply chain governance.
- Improving natural resources used workers' health and working conditions to creating new market opportunities for farmers and exporters in developing countries.

Benefits of GAP codes

- Standards and regulations are numerous, including food quality and safety improvement.
- Facilitation of market access.
- Reduction in non-compliance risks regarding permitted pesticides, Maximum Residue Limits (MRLs) and other contamination hazards.

GAP for Crop Protection

- Use resistant cultivars and varieties.
- Crop sequences, associations and cultural practices.
- Biological prevention of pests and diseases.
- Maintain regular and quantitative assessment of the balance status between pests and diseases and beneficial organisms of all crops.
- Adopt organic control practices where and when applicable.
- Apply pest and disease forecasting techniques where available.
- Determine interventions following consideration of all possible methods and their short and long-term effects on farm productivity and environmental implications. This will allow the minimizing of agrochemicals, in particular, to promote Integrated Pest Management (IPM).
- Store and use agrochemicals according to legal requirements of registration for individual crops, rates, timings, and pre-harvest intervals
- Ensure that agrochemicals are only applied by specially trained and knowledgeable persons.
- Ensure that equipment used for the handling and application of agrochemicals complies with established safety and maintenance standards.
- Maintain accurate records of agrochemical use.
- Identify the GAP in each protection method.

Crop Rotation Systems

- Sequence crops by selecting pest host relation.
- Selected crop for rotation in order to break the life cycle of pest (Jowar should be rotated with pulses to combat striga weed).
- The selected crop for rotation should not be the food of previous crop pest.
- To select appropriate crops for rotation: Analyze the pest habitat, Follow forecasts and Monitor pest and natural enemies

Privilege Resistant Species

- Cultivate plant varieties which are less prone to pest attack.
- The resistant varieties reduce production cost.
- Pest resistant transgenic crops developed for specific pest can be used. This is new avenue for reducing pesticide load.

Promote Useful Animals

- Keep good predator population.
- Promote growth of beneficial insects.
- Create an environment congenial for predators e.g. keeping bird perch in the field.
- Identify the useful animals and study their habitat for providing the required environment.

Observe and Control Populations

- Follow forecast-short term and long term.
- Study habitat of pest and congenial weather.
- Accordingly take necessary precautions to manage pest.

Give priority to mechanical and biological measures

- Get the full knowledge about botanical pesticides.
- Get the knowledge on available parasites and predator/friendly insects and pests.
- Accordingly develop action plan for mechanical and biological measures.
- Use of non cash inputs saves money.
- Use information on plant protection to analyze spatial and temporal distribution

Record Keeping

- Monitoring of performance through taking notes each year/season.
- Keep the pest management record along with season, weather and other agriculture activity.
- Document the pest load and control achieved
- Use this experience for future planning.

However, there are various challenges related to GAP. The most prominent is a definite increase in cost of production. There is lack of harmonization between existing GAP-related schemes and availability of affordable certification systems which often leads to increased confusion and certification costs for farmers and exporters. There is a high risk that small-scale farmers will not be able to seize export market opportunities unless they are adequately informed, technically prepared and organized to meet this new challenge. It is required that governments and public agencies play a facilitating role in this aspect. However, at times it has been experienced that compliance with GAP standards does not promote all the environmental and social benefits which are claimed.

Some key points for adopting GAP are:

- Selecting the right type of land to be cultivated for food crop production;
- Planting the best-quality seeds and of the most appropriate varieties;
- Use of authorized and acceptable chemical inputs (fertilizers, pesticides);
- Controlling the quality of irrigation water (in case of use);
- Use of appropriate harvesting and on-farm storing and handling techniques;
- Use of suitable methods for shipping of produce to markets or food processors.

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Garlic- The Health Savior

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Garlic (*Allium sativum* L.) commonly called as Lahsun is one of the most important vegetables cultivated worldwide. It is a monocotyledonous aromatic vegetable belonging to *Amaryllidaceae* family. Garlic is characterized by a strong aroma that distinguishes it from other vegetable crops. It is required in every other household today for daily use.

Garlic- The Medicinal Herb

Garlic is a widely consumed spice, known as "Rasona" in Ayurveda. In recent times, it has proven to be a health savior.

Here are some of the points which have made garlic a potential savior & remedy.

- Presence of sulphur compound called Allicin that attributes to antibacterial, antifungal, antiviral and antiseptic properties of garlic.
- When it comes to skin, there is no better remedy than Garlic. It can be used to cure skin infections particularly fungal infections.
- It can help you to get rid of acne, unclog pores and clear your skin.
- Garlic supplements can lend a helping hand in fighting one of the world's biggest killer cardiovascular diseases like heart attacks and strokes.
- Owing to its antioxidant property, garlic supplements have proven to be effective in lowering bad cholesterol, blood pressure.
- Garlic derived organosulphides have been found to inhibit tumor growth. They have been effective in treating gastric cancer.

Medicinal History of Garlic

- Since ancient times, garlic has been referred by different names like 'russian pencillin', 'natural antibiotic', 'snake grass'.
- In Vedas, garlic has been mentioned among other medicinal plants as an irreplaceable nutritional supplement.
- In ancient Egypt, labourers were fed with garlic to make them strong and capable of doing work.
- Louis Pasteur, famous microbiologist referred garlic as a strong antibiotic having antibacterial properties to kill bacteria.
- Well known remedy for typhoid, dysentery, cholera, influenza.
- It has been used as a home- made recipe to cure common weakness, cold, cough

Medicinal Properties of Garlic

- Anticoagulation: Inhibits platelet aggregation and enhances fibrinolytic activity
- Antioxidant: Garlic contains compounds that can remove reactive oxygen species (ROS) and reduce lipid peroxides and low-density lipoprotein (LDL) oxidation.
- Antimicrobial: Garlic is effective against a number of gram-negative, gram-positive, and acid-fast bacteria, including *Staphylococcus*, *Salmonella*, *Vibrio*, *M ycobacteria*, and *Proteus* species
- Cell mediated immunity: Garlic seems to increase the immune system functions. It stimulates macrophages, lymphocytes, NK cells, DC and eosinophils.
- Antihypersensitive: Garlic consumption results in significant reductions in systolic blood pressure (7.7 mm Hg greater reduction),

and reductions in diastolic blood pressure (5 mm Hg greater reduction).

- Antitumor: Patients should be advised that there may be a reduction in the risk of cancer, particularly stomach and colon cancer, with high consumption of garlic and other allium vegetables (e.g., onions, leeks, shallots, chives)

Bioactive Compounds

Garlic is a storehouse of diverse organo - sulphur compounds which gives it a unique aroma along with several other health benefits.

- Allicin
- Alliin
- Allyl disulfides
- Allyl sulfides
- Allyl trisulfides
- Cysteine
- Diallyl sulfides
- Dimethyl sulfides
- Glutathione

2.1 Allicin

Allicin is the primary organo-sulphur compound present in garlic. When fresh garlic is chopped,

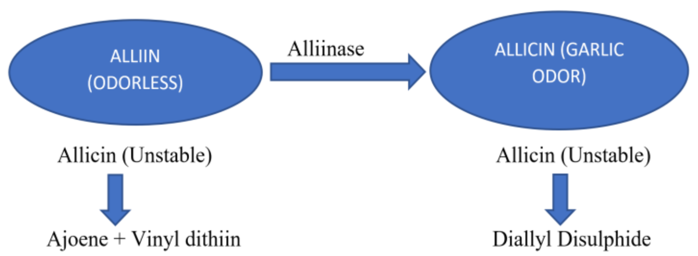

Fig. 1: Production of Allicin by the action of Alliinase on Alliin

Upon cleavage by enzyme alliinase, the odorless compound (alliin) gets converted into allicin which gives odor to garlic.

On being highly unstable, allicin gets converted into other bio sulphur compounds (diallyl disulphide).

Chemical Constituents

Garlic is a highly nutritious crop which can help us to combat various diseases and improve our longevity.

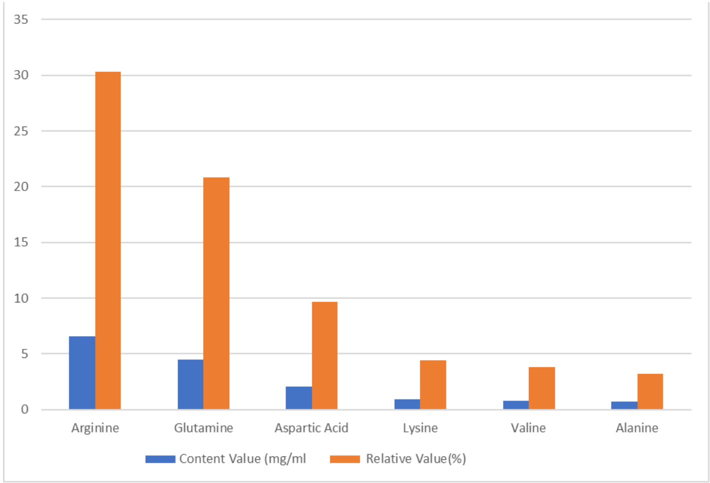

Fig. 2: Graphical representation of chemical constituents of Garlic

It is a very good source of minerals like manganese, selenium, phosphorus, calcium, potassium, iron and copper.

- Also, garlic is an excellent source of vitamin B_6 (Pyridoxine) and vitamin C (Ascorbic acid)
- Enzymes present in garlic are (alliinase, peroxidases, myrosinase)

Processed Garlic

In recent times, demand of processed garlic products has increased on a large scale. Many countries including India have started processing fresh garlic bulbs in dehydrated forms.

- Inadequate storage ability
- Inadequate off-season availability
- Fluctuations in daily environmental conditions
- Difficult to maintain quality
- Difficult to maintain quantity
- To meet demand of consumers

Due to nutritional quality, aroma and flavor, Indian garlic has always been in great demand. India has become a huge exporter of processed garlic products and has started exporting garlic by a large scale to countries like Germany, UK, USA, Russia, Belgium, Brazil, Poland, Spain, South Africa, Netherlands.

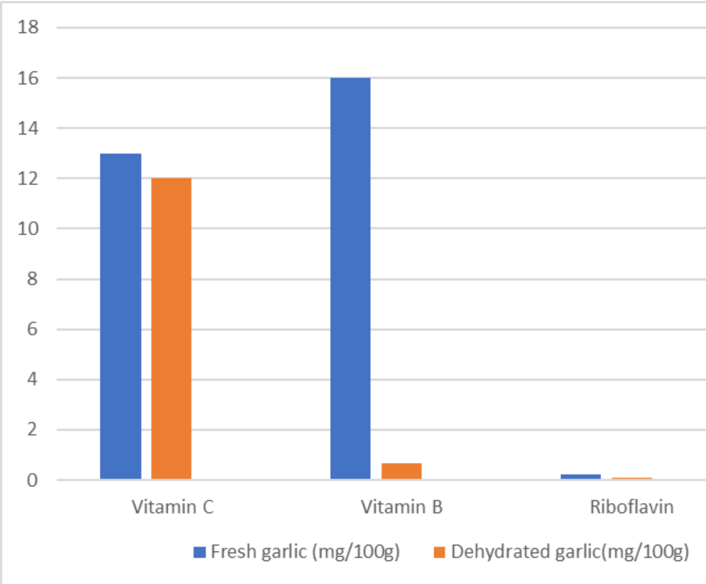

Fig. 3: Comparison between Fresh Garlic and Dehydrated Garlic

Processed Garlic Products

- Garlic Oil
- Dehydrated garlic granules
- Garlic capsules
- Odorless garlic
- Aged odorless garlic extract
- Garlic tablets
- Garlic salt
- Super odorless garlic

Conclusion: Garlic is a herbal spice used worldwide and has the potential of curing many diseases by inhibiting the growth of various strains of bacteria and fungi. The scientific literature related to garlic provides the evidence of its antibiotic and antidiabetic effects. This article may help exploring the therapeutic effects of garlic and also the use of different garlic extracts on standard drug therapy.

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Endophytes: Prospects and Applications for the Plant Disease Management

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Plant diseases, caused by agricultural pests and pathogens, commonly result in crop losses and are a significant threat to food security. Agrochemicals are efficient in plant disease management (Xia et al., 2022). However, the intensive application of chemical fertilizers and pesticides has negative effects on the ecosystem and human beings, causing environmental pollution, pathogen resistance, and ecological imbalance1. Biocontrol, unlike chemical methods, are environmentally friendly through the action of natural control agents, such as beneficial microorganisms and their products, metabolites [Vianle et al., 2008].

Endophytes and their bioactive metabolites have received considerable attention due to their potential as biological control agents (BCAs) [Dutta et al., 2014; Rabiey et al., 2019]. Endophytes, including endophytic fungi, endophytic bacteria, and endophytic actinomycetes, exist in various organs, tissues, and intercellular spaces of plants without causing immediate signs of diseases [Wison, 1995; Jia et al., 2016]. They have established a mutually beneficial relationship with host plants during long-term coevolution. Plants provide nutrients for endophytes, while endophytes contribute to maintaining the health of plants [Khare et al., 2018; Yan et al., 2019]. The mechanisms proposed for disease prevention include competition with pathogens for niche and nutrition, induction of plant resistance, secretion of bioactive metabolites, and promotion of plant growth, usually working in concert [Dubey et al., 2020; Martínez-Arias et al., 2020].

Endophytic microorganisms, such as *Bacillus*, *Burkholderia*, *Enterobacter*, *Pseudomonas*, *Streptomyces*, etc., are used as microbial formulations against various phytopathogens [Jacob et al., 2020]. Endophytes can produce metabolites with a variety of biological activities, such as alkaloids, polypeptides, polyketides, terpenoids, etc., which are of great significance and value in different fields, especially in agriculture and the pharmaceutical industry [Dubey et al., 2020]. In plant health protection, the major function of these bioactive metabolites is to directly or indirectly help the host plants resist biotic and abiotic stresses. For example, some antimicrobial compounds produced by endophytes are well known for strongly inhibiting pathogens, hydrolases secreted by endophytic bacteria can decompose the cell wall of pathogens, and phytohormones released by endophytes play a vital role in plant development and stress response [Singh et al., 2017].

The major members of endophytic fungi include Ascomycota, Zygomycota, and Basidiomycota. In general, endophytic fungi have been recognized as two broad groups according to the life history traits and evolutionary relatedness, namely, (1) the clavicipitaceous endophytes colonizing within some grasses and (2) the non-clavicipitaceous endophytes from asymptomatic tissues of nonvascular plants, conifers, ferns, and angiosperms. Whereas endophytic bacteria belong to a diverse group of species, ranging from gram-positive to gram-negative bacteria, such as Bacillus, Agrobacterium, Brevibacterium, Pseudomonas, etc. [(Xia et al., 2022).

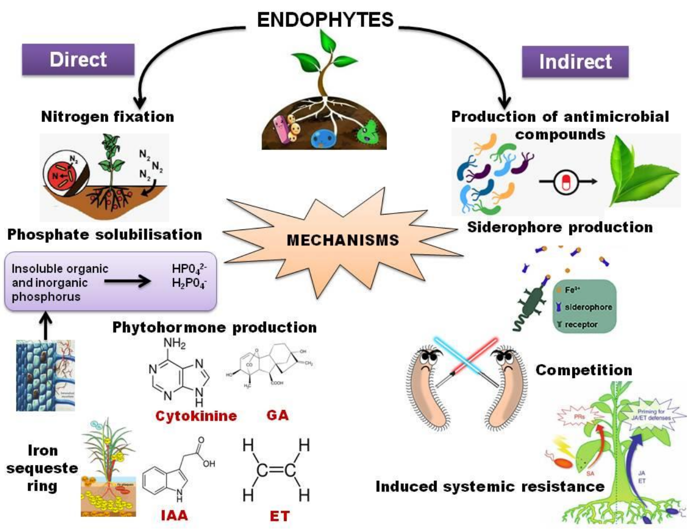

Fig. 1: Outline of various mechanisms adapted by endophytes to promote plant growth

Endophytes secrete various metabolites that directly or indirectly enhance the tolerance of the host to different stresses, thus making them beneficial to the plants, and they potentially serve as promising biological agents in controlling plant diseases. the key mechanisms of endophytes are (1) competing with pathogens for niche and nutrition, (2) producing antimicrobial compounds, (3) secreting lytic enzymes, (4) inducing systemic resistance in host plants, and (5) producing plant hormones and plant growth promoting regulators. There are still more problems to be solved. An overview of the main functions, future prospects, and challenges in using endophytes and their metabolites in plant disease management is shown in Figure 1.

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The Silent Defenders: Unravelling the Roles of Small RNAs in Plant Disease Resistance

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In agriculture and botanical science, plant immunity is a key defence mechanism against plant pathogens that causes diseases. To fend against these assaults and secure their survival, plants have developed a variety of defence mechanisms. At the core, plant immunity is a complicated dance between the plant and numerous pathogens, including bacteria, fungus, viruses and nematodes. To recognise, battle and cohabit with these invaders, plants have evolved an astounding array of defence mechanisms. There is a developing arms race between plants and diseases as a result of the ways that pathogens have developed to avoid detection and circumvent these defences. Innovative disease management techniques are urgently needed as populations rise and disease dynamics change due to climate change. Chemical pesticides and other conventional disease control techniques frequently have unanticipated negative effects on the environment and human health (Vijayreddy, 2023). As a result, it is increasingly important to create novel and sustainable strategies to manage plant diseases. These strategies should make use of novel technology, comprehend plant immune systems and look into creative ways to improve disease resistance in crops.

The complex systems that enable plants to protect themselves against a variety of diseases have long been a source of fascination in the field of plant biology. Small RNAs have emerged as quiet defenders that direct a sophisticated and tightly controlled defence system, playing a critical role in plant immunity. A fascinating tale of molecular conflict at the cellular level has been revealed as a result of the exponential growth in our understanding of the functions performed by these tiny RNA molecules in plant disease resistance in recent years.

Small RNAs, such as microRNAs (miRNAs) and small interfering RNAs (siRNAs), are short RNA molecules that regulate gene expression by directing the destruction or translational inhibition of target messenger RNAs (mRNAs), rather than by directly encoding proteins. These molecules have crucial roles in a number of biological functions, such as immunology, stress reactions and development. Researchers from all over the world have focused on their involvement in coordinating plant defence responses against pathogens, though. We set out to solve the puzzles surrounding the role of short RNAs in plant disease resistance in this examination of the complex world of small RNAs. We will explore the processes by which short RNAs are produced, prepared for use and finally used to mount a defence against invasive infections. It will also draw attention to the amazing adaptability and specificity of these molecules in locating and regulating the expression of vital immunity-related genes (Rose *et al.*, 2019).

As we explore further into this intriguing area, we will come across tales of molecular espionage, in which tiny RNAs operate as spies, communicating details about the presence of viruses and setting off a chain of processes intended to eliminate the threat. We shall see how plants can fine-tune their immune responses thanks to these unseen protectors, striking a careful balance between defence and development. We will also look at how this knowledge may be used to improve crop protection and agricultural methods, opening up fresh opportunities to improve plant disease resistance and food security.

A world where molecular whispers have the ability to guard against quiet threats will become clear as we explore the mysterious roles of small RNAs in plant disease resistance.

Discovery of Small RNAs in Plant Systems

With the discovery of small RNAs, a substantial advance was made in our understanding of the complex systems driving plant immunity and defence. The researcher's fascination in these tiny molecules, which are frequently only a few dozen nucleotides long, has revealed a new facet of genetic regulation in plant systems.

The discovery of RNA molecules that defied conventional classification by early pioneering investigations in the late 20th century served as the starting point for the exploration of tiny RNAs in plants (Agarwal and Jin, 2007). These mysterious chemicals cast doubt on the widely held belief that genetic information only moves from DNA to RNA to proteins. Instead, they suggested a more complex regulatory framework in which small RNA molecules could have an unanticipated impact on cellular processes and gene expression.

MicroRNAs (miRNAs) and small interfering RNAs (siRNAs), among other small RNAs, were among the small RNAs that the researchers discovered as they dug further. Each siRNA had a distinct role in the coordination of plant responses. These discoveries sparked a revolution in the field of plant biology, resulting in a greater comprehension of how pathogen presence affects how plants perceive and react to environmental stimuli (Kong *et al.*, 2022).

Small RNAs are inconspicuous molecules that develop during the biogenesis process, a difficult procedure involving complicated enzymes including Dicer and Argonaute proteins. By either suppressing or fine-tuning the activity of the target genes, these molecules play a critical part in controlling the expression of genes. Additionally, they play a crucial role in post-transcriptional regulation, guaranteeing a prompt, focused and well-honed response to pathogens. The complex mechanisms governing biogenesis and a long trip have propelled the short RNA revolution in plant biology. These chemicals are crucial in the intricate world of plant disease resistance because they defend plants silently in the continual conflict with pathogens. Comparable to interpreting a carefully choreographed ballet, understanding the complexities of short RNA synthesis in plants requires an understanding of how each stage affects the final result.

Types and Functions of Small RNAs in Plant Defense

Small RNAs are flexible and essential participants in the complex mechanism of plant defence. These tiny molecules, renowned for their function in gene regulation, come in a variety of shapes and sizes, each of which serves a particular purpose in defending plants against the ongoing dangers posed by pathogens.

microRNAs (miRNAs): Regulators of Gene Expression

The precise regulators of gene expression known as microRNAs (miRNAs) are at the forefront of short RNA diversity. Usually 20 to 24 nucleotides long, miRNAs target particular messenger RNAs (mRNAs) and control their stability or translation. MiRNAs coordinate a precise response in the context of plant defence, ensuring that crucial defence genes are active while guarding against collateral damage to the plant's own physiological functions (Kumar, 2023).

Small Interfering RNAs (siRNAs): RNA Silencing Mediators

Another class of tiny RNAs known as small interfering RNAs (siRNAs) is essential for plant immunity. These compounds participate in RNA silencing pathways, frequently emerging from the immune system's response to viruses or transposable elements. Plants can fend off viral infections and maintain genomic integrity in the face of mobile genetic elements by siRNA-guided degradation or translational inhibition of complementary RNAs (Bilir *et al.*, 2022).

Piwi-interacting RNAs (piRNAs): Guardians of Genome Stability

Piwi-interacting RNAs (piRNAs), which are primarily linked to animals, have also been found in plants, where they help to monitor transposable elements and maintain the integrity of the genome. PiRNAs illustrate the diverse functions that small RNAs play in preserving genomic integrity by adding yet another degree of complexity to the short RNA landscape in the context of plant defence (Chen and Rechavi, 2022).

Small RNAs in Plant Immune Signaling

Plant immunological signalling is greatly influenced by small RNAs, which are frequently produced in response to pathogen invasion. They serve as signalling molecules that warn plants about potential dangers and prepare nearby cells for an immediate defensive reaction. This communication system improves the plant's capacity to mount a planned and successful immunological response. Small RNAs interact with plant defence hormones like salicylic acid (SA) and jasmonic acid (JA) in the intricate network of plant defence signalling, fine-tuning the balance between defence against diverse pathogens (Yu *et al.,* 2022). The complexity of plant immune responses must be understood in order to fully appreciate this interaction. We will learn about the diversity of short RNAs and their varied functions in coordinating plant defence mechanisms as we investigate these issues.

Small RNAs in Disease Recognition and Response

In the conflict between plants and diseases, small RNAs are essential for spotting invaders and precisely coordinating defence responses. Plants first line of defence is pathogen recognition, and short RNAs play a crucial role in this process. Pattern recognition receptors (PRRs) help plants find pathogen-associated molecular patterns (PAMPs) (Islam *et al.,* 2018). Small RNAs can be produced as part of the plant's defence response after a pathogen is detected, acting as messengers to transmit the signal of pathogen presence and launch a series of defence processes. These reactions can involve the activation of hypersensitive reactions, the upregulation of antimicrobial resistance genes, the strengthening of cell walls and the start of systemic acquired resistance (SAR). Depending on the type of pathogen and the particular threat it offers, small RNAs serve as both scouts and generals, fine-tuning the plant's defence strategy.

Engineering Disease Resistance Through Small RNAs

Ingenious methods for engineering disease resistance in crops have been developed as a result of a better understanding of the role of short RNAs in plant defence, offering sustainable agriculture and food security. Small RNAs are used in RNA interference (RNAi) technology to silence certain genes, especially those of invasive pathogens, developing methods to reduce pathogen virulence and proliferation. With the use of this method, it has been possible to confer resistance to a number of plant diseases, including bacteria, viruses, fungi and nematodes.

In the search for disease resistance, CRISPR-Cas genome editing technology has discovered a working relationship with short RNAs. Plant genomes can be precisely edited by researchers to increase resistance to particular pathogens, making plants more resistant to disease threats while reducing unintended side effects. A potent tool for modifying plants to tolerate disease threats while minimising side effects is provided by this precise genome editing method. The development of disease resistance in crops using advanced technologies like RNA interference and CRISPR-Cas systems is paving the path for a more resilient and sustainable agricultural future (Vijayreddy, 2023).

Conclusion

Small RNAs have become prominent as potential quiet defenders in the complex realm of plant health and defence. These tiny molecules, such as piRNAs, small interfering RNAs and microRNAs, are crucial in directing how plants react to infections. The precise regulation of gene expression by small RNAs makes sure that the body's defence mechanisms are tailored to the particular threat. Additionally, they serve as messengers, warning the plant of intruder's presence and preparing nearby cells for quick defence reactions. In addition to their function in detection and reaction, short RNAs present novel ways to engineer disease resistance in crops. With the use of short RNAs, RNA interference (RNAi) and CRISPR-Cas technologies allow precise targeting of pathogen genes and genome editing for increased resistance. These minuscule molecules hushed murmurs hold the key to a more resilient and sustainable agricultural future. In our fight to preserve plant health, safeguard the world's food supply and overcome the difficulties brought on by ever-evolving plant diseases, small RNAs stand as crucial friends. Their importance highlights the ability of science and creativity to protect our plant world.

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Piggery Development under Changing Climate Scenario in Nagaland

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Pig farming is an age-old traditional practice in Nagaland. Almost every household in Nagaland raises pigs because they require minimum financial investment and manpower. Traditional pig production systems are based on low input and output (zero-grain production system) in a backyard with household kitchen waste and garbage crop residues (Kumaresan *et al.*, 2007; Kadirvel *et al.*, 2017; Singh *et al.*, 2019). The state has a significant opportunity to enhance the socioeconomic status of the Naga people through piggery. Global warming and climate change are emerging threats to global livestock production, including that of pigs (Nardone *et al.*, 2010). Pigs are highly susceptible to heat stress owing to the lack of effective sweat glands and a thick layer of subcutaneous adipose tissue (Ross *et al.*, 2015). Therefore, adaptation of climate-resilient pig farming is the most feasible practical approach to minimize the adverse effects of climate change and piggery development.

Why should pig farming be promoted?

- Naga people consider pork one of their favorite delicacies. In addition, Nagaland has the highest per capita pork consumption compared to other states in our country. Unfortunately, the state is yet to achieve domestic demand for pork self-sufficiency.
- Pigs can digest a range of dietary sources. They can convert inedible feeds, forage, and mill grain byproducts into highly biologically valuable or nutritious meat.
- Pigs grow fast and produce many piglets (8-12 numbers). Under optimal management conditions, sows produce two farrows each year. In addition, the dressing percentage ranges from 60-80 % of the live body weight.
- Pig farming provides quick returns because marketable fattener weights can be obtained in 6-8 months.
- A small initial investment in buildings and equipment is required to start pig farming.
- Pork is the most nutritious meat because of its high-fat content and higher energy value than other meats. It also contains vitamins, such as thiamin, niacin, and riboflavin.

Challenges

- Climate change is an emerging threat to pig production in Nagaland. Climate change projections for Nagaland indicate an increase of 1.60°C to 1.80°C between 2021 and 2050 (Ravindranath *et al.*, 2011).
- High temperature and humidity increase animal heat load, resulting in lower animal growth and productivity. Pigs are considered more sensitive to high environmental temperatures and thermal stress. Similarly, rising temperatures and shifting rainfall patterns can accelerate the spread of existing vector-borne diseases and parasites as well as the emergence and spread of new animal diseases.
- Pig farmers in the village cannot afford commercial feed; therefore, they rely on backyard pig farming with locally available genetic resources. They rely on small herd sizes with indigenous local animals, which have a very low productive performance.
- Lack of high-quality germplasm, superior breeding of male animals (breeding stock), insufficient Artificial Insemination (AI) infrastructure, and services. Due to the limited number of boars (breeding stock), haphazard and indiscriminate breeding with inferior germplasm leads to a high inbreeding rate, which is an overall reduction in the production and reproductive performance of animals, leading to poor litter size.
- The cost of commercial feed is very high; many farmers are unable to purchase commercial feed due to financial constraints and remote locations.

- Lack of awareness of scientific pig farming. Most farmers are compelled to rely on age-old traditional farming due to their socio-economic backgrounds, remoteness, and inaccessibility to AI and veterinary services.
- Inadequacy of disease diagnosis, vaccine, disease surveillance, and forecasting mechanisms to control disease outbreaks. Recently, African Swine Fever (ASF) has devastated piggery farmers

Opportunities for piggery development in Nagaland

Pork is a favorite meat in Nagaland, with no religious restrictions, yet more than 50% of the domestic pork demand is still imported from neighboring and other parts of the country. Simultaneously, the pig population has declined since 2012 (Livestock Census 2019). These data suggest that there is a huge scope for the livestock and poultry sector in the state to fulfill domestic requirements and help reduce poverty at the household level.

Strategies for Pig Farming Under Changing Climate Scenario

1. Selection of appropriate pig breeds

Pig farming relies heavily on the selection of breeding stock. It is essential to select pig breeds that are well-adapted to local climate conditions to ensure the long-term sustainability and profitability of pig farming, particularly in the face of changing climate scenario. Under changing climate scenario, indigenous local pig breeds like Niang Megha, Mali, and Tenyi-vo and cross variety like Rani, Lumasniang are well-suited for agro-climatic conditions of North Eastern Region of India (Kadirvel *et al.*, 2019; Rutsa and Rutsa, 2019. In addition, they possess relatively better resistance to diseases and attain sexual maturity at an earlier age than exotic and crossbred pigs. Niang Megha and Lumasniang are ability to thrive in hilly ecosystems with low-input production systems.

2. Scientific breeding of practices

In Nagaland, many farmers or tribal households still use age-old traditional breeding methods to raise pigs (Kumaresan *et al.*, 2011).This practice increases inbreeding and results in poor productivity and reproductive performance, including genetic defects (scrotal, inguinal hernia, etc.), in subsequent generations. Hence, to overcome these challenges and ensure sustainable piggery development, it is imperative to use AI in pigs. AI aids scientific breeding and improves the genetics of animal populations. The advantages of AI are as follows:

- Allows the best boars to be used to produce superior offspring.
- Lower risk of sexually transmitted and infectious diseases, such as CSF, FMD, etc.
- Aids in resolving inbreeding problems in villages.
- Overcomes size discrepancies between boars and sows during breeding.

These benefits make AI an efficient and effective tool to improve pig breeding and genetics.

3. Nutritional and feeding management

Animals reduce their feed intake during hot weather, whereas cold weather may increase the energy needed to maintain their body temperature as part of thermoregulation in animals. Therefore, scientific feeding management practices that involve the production of low-heat diets can be achieved by increasing dietary fat and reducing crude protein or crude fiber content. Additionally, nutritional and feeding strategies should include micronutrient supplementation, such as antioxidants (e.g., selenium, vitamin E, and vitamin C), specific amino acids (e.g., glutamine and betaine), and minerals (e.g., zinc) (Rauw *et al.*, 2020. Micronutrients with immunomodulatory effects, including chromium and vitamin C, may help reduce production losses during heat stress.

4. Housing and shelter management

Pigs are susceptible to temperature change, heavy rain, drought, and sunlight. Ambient temperature affects the body temperature of pigs. The ideal temperature for optimal growth and feed conversion varies according to the age and weight of pigs. For example, piglets 1 d old:35°C; piglets 1 d old:30°C; piglets 1-6 weeks old:30–24°C; pigs weighing 20–60 kg:26–20°C; pigs weighing 60–90 kg:22–18°C; and adult animals:18–22°C. Adequate ventilation, insulation, and roofing are key to a comfortable and stress-free pig environment.

5. Capacity building and vocation training

Capacity building on climate-resilient pig farming practices and awareness of global change are essential for understanding and mitigating climate change, as well as enhancing production. Training in the selection of appropriate climate-resilient pig breeds, scientific breeding methods, feeding, management, healthcare, vaccination, and value-added pork preparation is required for sustainable and profitable piggeries in the current climate change scenario.

6. Access to weather information:

Weather forecasting and early warning are very important to enable farmers to take preventive measures to protect animals from extreme weather events, such as heat waves, cold waves, and heavy precipitation events, including thunderstorms, cyclones, floods, and disease outbreaks. Therefore, improved access to accurate and timely weather forecasts can help farmers make informed decisions regarding farm management, particularly during extreme weather events. However, this component is lacking in India. To make adaptation measures effective in overcoming the effects of climate change, they should be brought to an international level.

Conclusion

Pig farming plays a vital role in the livelihood and extra income of the rural masses, especially tribal households in Nagaland, but is threatened by climate change-aggrieved heat stress. To ensure sustainability, climate-resilient practices should be adopted. Conserving indigenous pigs, using modern breeding techniques, optimizing feeding strategies, capacity building, vocational training for farmers, and ensuring access to weather information are crucial for sustainable piggery development in Nagaland.

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Exploring the Potential Health Benefits of *Cordia dichotoma*: A Comprehensive Overview

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Cordia dichotoma, commonly known as fragrant manjack or Indian cherry, is a plant that is native to Asia and Australia. Various parts of the plant, such as the leaves, fruits, and bark, have been traditionally used in traditional medicine systems for their potential health benefits. It's important to note that while there is some traditional knowledge about the potential health benefits of *Cordia dichotoma*, scientific research on its medicinal properties is limited, and more studies are needed to validate these claims.

Cordia dichotoma: Uses

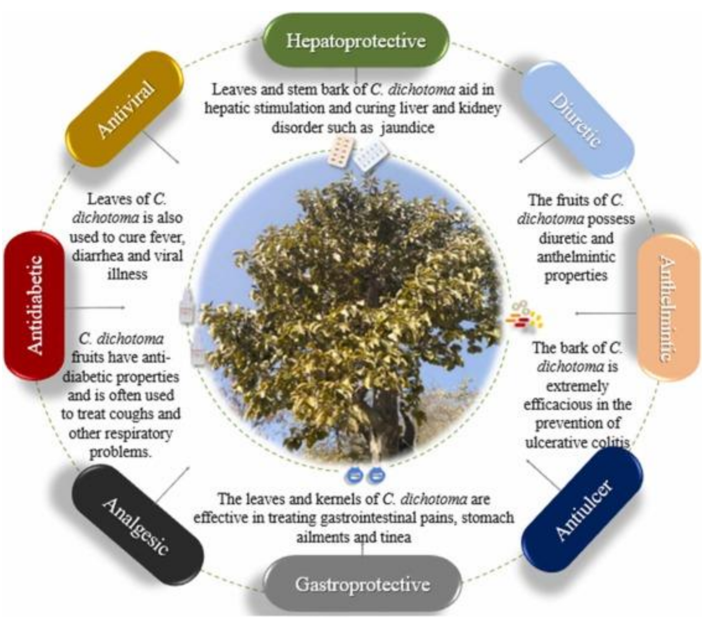
- The leaves are used as plates and cigar wraps.
- The extract of the leaves is commonly found as a component in several commercially available cosmetic products.
- The seeds may be crushed up to extract oil.
- Mucilaginous fruit may be used to make glue if the right conditions are met.
- The wood is hard, moderately robust, and ages well, but insects quickly begin feeding on it when it is cut down. It is utilised in the building of homes as well as in the production of agricultural tools.
- The wood from the tree is used for heating and cooking.

Edible Uses

- The entire *C. dichotoma* plant can be consumed as food since the entire plant is edible. Pickles are made from immature fruits, which are also consumed raw or cooked like vegetables.
- Raw fruits are a staple diet for Orissa's rural population, particularly in coastal areas. It's possible that cattle might be fed the seed kernels of the *C. dichotoma* plant since they contain a significant amount of both fatty oils and proteins.
- Polysaccharide gum is produced from the plant at a concentration of 97% and utilised for a variety of medicinal applications.
- Chromium, which is contained in the fruit, has been shown to have a therapeutic effect in the treatment of diabetes.

Medicinal Uses

- *Cordia dichotoma's* therapeutic history dates back to ancient Egypt. Bark, leaves, and fruit all contain mucilage and are diuretic and demulcent. They relieve stomach aches, coughs, and chest ailments.
- Researchers have extracted active chemicals from the plant. Alpha-amyrin and 5-dirhamnoside have anti-inflammatory properties.
- Its demulcent and mucilaginous qualities help cure coughs, sore throats, chest complaints, and urinary tract irritations. In big dosages, it's a laxative for bilious problems.



- Fresh fruit is used to treat skin outbreaks and gonorrhoea.
- A decoction of the stem bark is used to cure dyspepsia, diarrhoea, dysentery, fever, headache, and stomachache. After childbirth, it's useful.
- The bark strengthens teeth.
- The leaf juice is used to alleviate migraines, inflammation, and swelling.

Here are some potential health benefits associated with *Cordia dichotoma:*

1. **Anti-inflammatory Properties:** Some studies suggest that extracts from *Cordia dichotoma* may possess anti-inflammatory properties, which could be beneficial for conditions involving inflammation.
2. **Antioxidant Activity:** The plant contains compounds with antioxidant properties, which can help neutralize harmful free radicals in the body. Antioxidants are important for overall health and may contribute to the prevention of certain diseases.
3. **Antimicrobial Effects:** *Cordia dichotoma* extracts have demonstrated antimicrobial activity against certain bacteria and fungi in laboratory studies. This suggests a potential role in the treatment of microbial infections.
4. **Anti-diabetic Potential:** There is some evidence to suggest that *Cordia dichotoma* may have anti-diabetic properties. It may help regulate blood sugar levels, making it of interest for diabetes management.
5. **Hepatoprotective Effects:** Some studies suggest that *Cordia dichotoma* may have protective effects on the liver, potentially aiding in the prevention of liver damage.
6. **Wound Healing:** Traditionally, *Cordia dichotoma* has been used topically for wound healing. It is believed to have properties that promote the healing process.
7. **Respiratory Health:** In traditional medicine, *Cordia dichotoma* has been used for respiratory conditions. It is believed to have properties that may help with conditions such as coughs and asthma.

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Stem and Pod Rot Disease: A Threat to Groundnut Crop

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Groundnut (*Arachis hypogaea* L.) is a leguminous plant that is widely cultivated in the tropics and subtropics between 40°N and 40°S latitudes. It is valued for its high-oil content and edible seeds. It is the fourth most important source of edible oil and a third most important source of vegetable protein in the world. Groundnut is not only an important oilseed crop of India but also an important agricultural export commodity. India ranks first in Groundnut area under cultivation and is the second largest producer in the world with 102 lakh tonnes with productivity of 1831 kg per hectare in 2020-21 (agricoop.nic.in). Groundnut yield is very low in most Asian countries, owing to a number of biotic and abiotic stresses, apart from its cultivation on marginal lands. Moisture stress and frequent droughts, disease and pest attacks, low input use, etc are major production constraints. In addition, low output prices reduce incentives for farmers to invest in productivity enhancing technologies such as improved seeds, fertilizers and pesticides. Groundnut being a rainfed crop, its yield is largely determined by the quantum and temporal distribution of rainfall, in spite of which it performs well under low rainfall conditions if the rainfall is evenly distributed during the growing period.

In India, stem rot of groundnut was first recorded by Butler and Bisby (1931). The wide host range of *S. rolfsii*, its prolific growth and ability to produce persistent sclerotia all contribute to the large economic losses associated with this pathogen (Wokocha, 1990; Cilliers *et al.*, 2003 and Singh *et al.*, 2003).

Symptoms of the disease

The first symptom is yellowing and partial or complete wilting of the stem or one or more branches. In advanced stage of the disease, white mycelial growth at the junction of stem and soil, spreads over the soil and the basal canopy of the plant. The sclerotia of the size and colour of mustard seeds, appear on the infected area as the disease develops. The entire plant may be killed or only two or three branches may be affected. Infected pods were completely covered with white mycelial growth and in severe cases rotting of pod were observed.

Pathogen

Sclerotium rolfsii produces white cottony mycelial growth on potato dextrose medium and the colony morphology was compact or fluffy. Initially, white colored sclerotia were formed. Then their color changed from white to off-white, light brown and dark brown as they attained maturity and they are sub spherical, the surface finely wrinkled, sometimes flattened.


Yellowing and drooping of infected plant


Mycelial mat on stem portion


Sclerotial bodies on stem portion


Mycelium and sclerotial bodies on pods


Wilting of plants

Fig 1: Symptoms of stem and pod rot disease

Integrated Disease Management of Stem and Pod rot disease of groundnut

The treatment deep ploughing + seed treatment with *Trichoderma harzianum* @ 4 g/kg of seed + furrow application of *Trichoderma harzianum* @ 4 kg enriched with 250 kg FYM/ha + neem cake @ 250 kg/ha was significantly superior over all other treatments (Table 41). The treatment combination recorded highest pooled pod yield (13.64 q/ha) and fodder yield (49.78 q/ha). deep ploughing + seed treatment with *Trichoderma harzianum* @ 4 g/kg of seed + furrow application of *Trichoderma harzianum* @ 4 kg enriched with 250 kg FYM/ha was also effective by recording mean pod yield of 11.28 q/ha and fodder yield of 42.81 q/ha, whereas untreated control recorded very low pod yield (8.20 q/ha) and fodder yield (36.67 q/ha).

Conclusion

Stem and pod rot of groundnut caused by *S. rolfsii* is a potential threat to groundnut production and is of considerable economic significance for groundnut grown under irrigated conditions. the treatment combination deep ploughing + seed treatment with *Trichoderma harzianum* @ 4 g/kg of seed + furrow application of *Trichoderma harzianum* @ 4 kg enriched with 250 kg FYM/ha and other treatment combination that is deep ploughing + seed treatment with Tebuconazole @ 1 g/kg were also effective in controlling the disease, increased pod and fodder yield, yield parameters and benefit cost ratio.

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High Income Source in Village: Backyard Poultry

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Poultry production is an important component of livestock and agriculture sector in India and contributed about 4.99 MMT of chicken meat and 138.38 billion eggs to the food basket of the country during 2022-23. In economic terms, poultry added about Rs 2.3 lakh crores to the national coffers in 2022-23. All this highlights the significant role played by poultry sector in the development of livestock economy.

Poultry sector in India is broadly divided into two sub-sectors – a highly organized commercial sector and an unorganized backyard sector. Backyard poultry constituted about 37.22 percent of total poultry population and produced 20.2 billion eggs (14.6%) in 2022-23. Though the contribution of backyard sector to the total produce is meager, it has been growing at an unprecedented rate (45.7%) when compared to commercial poultry (4.5%). Major factors responsible for this include increased consumer awareness regarding organic or natural products, availability and easy accessibility of improved backyard varieties, rising income from backyard poultry rearing due to advances in processing technology and improvements along marketing chain. Besides, backyard poultry plays a major role in livelihood, food and nutritional security, employment generation and women empowerment.

Backyard poultry system is a low-input or no-input business characterized by scavenging or free-range rearing with little supplementary feeding and arrangement for an indigenous night shelter. The other salient features of this system are poor productivity of birds, natural hatching of chicks, local marketing and almost no health care practices. Since the birds are reared on household wastes using minimal input and comparatively lesser space, it has lower risk when compared to commercial poultry and other livestock production systems. Furthermore, rearing of birds in natural stress-free conditions without the use of chemicals or antibiotics fetches a higher demand for backyard eggs and meat in urban market. These birds sustain by consuming insects in the backyards which is a healthy protein source on one hand and helps to control insect pests at the same time. Backyard birds generally lay brown eggs which are perceived to be nutritionally better than white eggs by consumers.

There are two types of backyard birds: Native/local and Improved varieties. Improved birds being 2-3 times more productive than the native birds, due to which they are highly preferred by the farmers. Different organizations in the country like Krishi Vigyan Kendra (KVK), Veterinary College, State Animal Husbandry Department, Central Poultry Development Organization (CPDO), ICAR organizations especially, ICAR-Directorate of Poultry Research (DPR), Rajendranagar, Hyderabad and ICAR-Central Avian Research Institute (CARI), Izatnagar, Bareilly cater to the demand of improved variety birds. Depending on their requirements, farmers can procure fertile eggs or day-old chicks or even grown-up birds at competitive rates. Besides, these organizations also conduct routine training programmes and provide technical information to the stakeholders, as and when required. At the same time, institutes like ICAR-DPR and ICAR-CARI are also working to improve the native chicken breeds to increase their production performance. Once this is done, the native/local birds will fetch even a higher price than the improved backyard varieties. Also, there are several government schemes where improved birds are distributed free of cost in poor and backward areas to uplift the socio-economic condition of the rural populace.

Selection of birds

Farmers usually select backyard poultry germplasm based on the production performance of the birds, market demand and income. When considering native/local birds, there are 19 recognized breeds of chicken in India which can be listed along with their home tract as: *Ankaleshwar* - Gujarat; *Aseel* - Chhattisgarh, Odisha, Andhra Pradesh; *Busra* - Gujarat and Maharashtra; *Chittagong* - Meghalaya and Tripura; *Danki* - Andhra Pradesh; *Daothigir* - Assam; *Ghagus* - Andhra Pradesh and Karnataka; *Harringhata Black* - West Bengal; *Kadaknath* - Madhya Pradesh;

Kalasthi - Andhra Pradesh; *Kashmir Favorolla* - Jammu and Kashmir; *Miri* - Assam; *Nicobari* - Andaman and Nicobar; *Punjab Brown* - Punjab and Haryana; *Tellichery* - Kerala; *Mewari* – Rajasthan; *Kaunayen* – Manipur; *Hansli* - Odisha and *Uttara* - Uttarakhand. These native breeds have some unique characteristics like fighting abilities of *Aseel*, higher egg production of *Nicobari* fowl and nutritional properties of *Kadaknath* meat. Due to this reason, they are in high demand throughout the country (*Kadaknath*) or at their home tracts particularly (*Aseel*). Besides the native birds, there are many improved varieties for backyard poultry available in our country. These have been developed by different organizations over a period of time with a view to improve the production performance of the birds. Most of these improved varieties have been developed by selective breeding followed by crossing to introduce desired characters into the birds. Some of the improved varieties developed by ICAR-DPR and their AICRP centres can be enlisted as - *Vanaraja*, *Gramapriya*, *Srinidhi*, *Krishibro*, *Krishilayer*, *Janapriya*, *Vanashree*, *Narmadanidhi*, *Himsamridhi*, *Kamrupa*, *Jharsim*, *Pratapdhan*, *Athulya*. Some of these varieties have a pan-India presence like *Vanaraja*, *Gramapriya* while others are state or region-specific like *Narmadanidhi* (Madhya Pradesh) and *Himsamridhi* (Himachal Pradesh). Other improved varieties include *CARI-Nirbheek*, *CARI- Hitcari*, *CARI- Upkari*, *CARI- Sonali Layer*, *CARI-Priya Layer*, *CARI- Shyama*, *CARI-Debendra*, *CARIBRO Vishal*, *CARIBRO Dhanaraj*, *CARIBRO Tropicana*, *CARIBRO Mrityunjay* etc. developed by ICAR-CARI and *Kalinga Brown*, *Kaveri*, *Aseel Cross* and *Chabro* – developed by CPDOs. Besides these, there are some other varieties developed by State Universities like *Giriraja*, *Swarnadhara*, *Nandanam* and *Rajashree* etc.

Other than chicken, Duck, Turkey, Geese, Pheasants, Quails, Guineafowl and other birds are also made available to farmers for rearing based on market demand.

Aseel	Vanashree	Kadaknath	Ghagus	Nicobari
				

Rearing of birds

Birds can be reared in different ways: (i) scavenging or free range, (ii) free range with some feed supplements and (iii) complete intensive feeding. In scavenging or free-range system, birds are allowed to feed upon naturally available feed base like household wastes, insects and green fodder while in free range rearing with supplemental feeding, feeding with cereal grains and oilseed cakes is provided in addition to scavenging on insects, worms etc. In completely intensive feeding (which is rarely seen), birds are provided with the complete nutrient feed formulations. Based on space availability, budget and market accessibility, farmers can opt for any of the rearing method. Brooding, healthcare and other management practices require extra attention and care which can be met through training.

Marketing of Backyard Poultry

The products of backyard poultry are in great demand among consumers due to increased awareness and ethical concerns. Markets are flooded with a diverse range of products like cage-free eggs, stress-free eggs, organic eggs etc., which sell like hot cakes due to high demand among urban consumers. For market accessibility of backyard produce, farmers can choose different marketing channels like local market, community-based approaches like Self Help Groups (SHG), Farmer Producer Organizations (FPO) and poultry cooperatives without the involvement of middlemen. Nowadays, many companies are following contract farming models to procure rural produce at farmers' door step. This offers exciting opportunities for rural produce and can greatly improve the economic remuneration for the rearers. However, it is important to keep in mind that birds should be sold on net-weight basis rather than flock selling to derive maximum dividends.

Government support

In order to enquire about the available government schemes related to poultry rearing in their area, farmers can visit their nearby veterinary/ animal Husbandry office. They can also contact Krishi Vigyan Kendra (KVK) and National Bank for Agriculture and Rural Development (NABARD) office for the ongoing schemes. NABARD offers several financial credit services for starting poultry ventures in rural and backward areas which can be availed of by the farmers. MUDRA loan and Kisan Credit Card schemes are other available financial options for backyard poultry farming. Also, National Livestock Mission (NLM) scheme of the central government provides financial support to poultry farmers by giving subsidy on capital.

Poultry farming is a minimum investment enterprise amongst other livestock enterprises and gives higher returns in shorter duration of time. It helps in strengthening nutritional and food security of the family besides improving employment and income generation opportunities and fostering gender equality. Backyard poultry farming has the potential to revolutionize the poultry sector of the country by alleviating rural poverty, providing protein and nutritional enrichment and promoting socio-economic upliftment.

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Innovative Strategies for Climate-Resilient Rice Farming

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The world is at a critical juncture where the impacts of climate change are becoming increasingly evident and are reshaping the dynamics of global food security and agricultural sustainability. Increases in global greenhouse gas (GHG) concentrations are believed to be a factor in both changes in atmospheric chemistry and global warming. Among the staple crops that will have to cope with these changes, rice is a vital food source for billions of people, especially in Asia where it serves as a staple food. However, the very essence of this crop is under threat as changing climatic patterns present a range of challenges, from extreme weather events to altered precipitation regimes. Globally, an average of 220,196 lives and 90 million human possessions are directly affected by drought, flood disasters, and tropical cyclones annually, with some people experiencing more than one event per year. In the current situation, the need to establish resilient rice agriculture has become a challenge for scientists, farmers, policy makers, and communities. Changing rainfall patterns, changing temperature regimes, and increases in extreme weather events are now well-known phenomena that challenge rice-growing regions worldwide. The impacts of these changes affect rice-dependent economies and can upset the fabric of food availability, social stability, and economic progress (**Figure 1**)

New innovations such as climate-smart agriculture (CSA) provide the foundation for resilience, and rice farming is no exception. Innovative practices offer promising solutions that leverage technology, knowledge, and traditional wisdom to mitigate the impacts of climate change. From the development of climate-resilient rice varieties that have improved tolerance to drought, flooding, and heat stress to the adoption of water-efficient irrigation techniques that conserve this valuable resource, the path of innovation is paving the way to a climate-resilient future. It also addresses sustainable cropping systems that combine rice cultivation with agroforestry, aquaculture, and diversified cropping patterns to improve the resilience of entire landscapes while increasing rice production. Examining the intricate relationships between scientific research, knowledge dissemination, and local community empowerment is evidence of the collaborative nature of resilient rice agriculture.

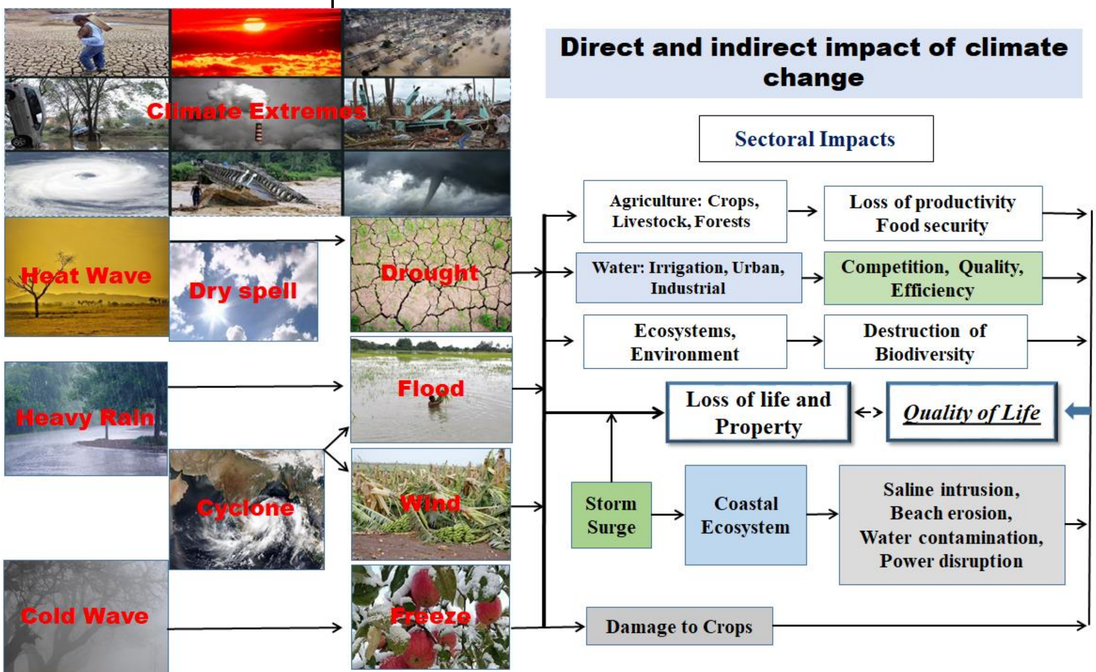

Fig. 1: Direct and indirect impact of climate change

Weather-smart technologies for rice production system

Weather-smart technologies are playing a critical role in revolutionizing rice production, providing greater resilience, efficiency, and sustainability in the face of changing climatic conditions. Rice production is closely linked to weather patterns, with temperature, rainfall and humidity having a significant impact on crop growth, development and yield. Crop insurance, weather-based crop agro-advisory, and the utilisation of information and communication technologies (ICTs) are examples of weather-smart technology that help mitigate risk by disseminating weather forecasts and climate information that enable farmers to make the best decisions at the right time.

Crop-specific insurance is needed to cover income losses due to extreme weather. Historically, there have been several crop insurances programmes, including the National Agricultural Insurance Scheme (NAIS), the Comprehensive Crop Insurance Scheme (CCIS), the Pilot Weather Based Crop Insurance Scheme (WBCIS), the Pilot Modified National Agricultural Insurance Scheme (MNAIS), and others. Currently, Pradhan Mantri Fasal Bima Yojana (PMFBY) has been approved in place of MNAIS/NAIS for implementation from Kharif season 2016.

Water-smart technologies for rice production system

One of the most important applications of water-smart technologies in rice production is irrigation alternating wetting and drying. Alternating wetting and drying periodically allows the soil to dry out between irrigation cycles, rather than constantly flooding the field. This practice not only saves water, but also promotes root development, improves nutrient uptake, and reduces methane emissions from waterlogged soils. This irrigation process saves up to 15-30% water with no/minor yield loss (Rejesus et al. 2011). SRI Practices promote growth of individual rice plants under controlled water levels, resulting in healthier plants and higher yields. When AWD is practiced in system of rice intensification (SRI) technique, it saves up to 20-25% water and increases rice productivity by 35-40%. Aerobic rice production technology involves nutrient-sensitive, high-yielding varieties in unsaturated soils that are intermittently irrigated when soil moisture content reaches a lower limit. As a water- and energy smart technology, this method could save 37 to 60% water compared to the conventional flooding.

The use of suitable irrigation methods, such as border strip irrigation, saves about 10-30% water. In addition, precision irrigation systems guided by real-time soil moisture data and weather forecasts enable farmers to deliver the right amount of water directly to the root zone of rice plants. This minimizes water runoff and infiltration at depth and ensures that water is used more efficiently and effectively. Tensiometer-based irrigation scheduling saves up to 50% irrigation water. Drip and sprinkler irrigation systems are also used to target water, reduce water waste, and optimize water distribution. Rice that was drip-irrigated produced 26% more grain yield than rainfed rice (Panigrahi et al. 2015). Due to lower evaporative losses, subsurface drip irrigation increased grain yield and biomass formation by a significant amount, reducing evapotranspiration by 26% compared to flood irrigation and by 15% compared to surface drip irrigation. Additionally, subsurface drip irrigation improves irrigation water productivity (by 20%), crop water productivity (by 25%), intrinsic water usage efficiency (by 36%), net photosynthesis (by 10%), and transpiration rate (by 22%) as compared to flood irrigation (Umair et al. 2019).

Nutrient-smart technologies for rice production system

Leaf nitrogen status of rice is closely related to photosynthetic rate and biomass production and is a sensitive indicator of changes in plant nitrogen requirements within a growing season. Leaf colour chart is an inexpensive, effective, and easily usable real-time N management tool that can help growers decide when and how much N to apply to crops. Compared to prilled urea, neem-coated urea increased yield by 6% when applied conventionally and by 21% when neem-coated urea was applied based on LCC measurement (Mohanty et al., 2017). By analyzing soil nutrient content, crop requirements, and other relevant factors, site-specific nutrient management (SSNM) helps farmers determine the exact amount and timing of fertilizer application. This approach reduces over-fertilization, minimizes nutrient runoff and ensures that nutrients are efficiently utilized by rice plants. Use controlled-release fertilizers that supply nutrients slowly over time. This not only ensures a consistent supply of nutrients to plants, but also reduces the risk of nutrients leaching into groundwater or surface waters. Green manuring and brown manuring also supply N to rice plants through biological N fixation. In in situ green manuring, plants are incorporated into the same site for 40-45 days where their seeds are broadcasted at 20-25 kg for

Sesbania aculeata and *S. rostrata* at 30-40 kg/ha. In ex situ green manuring, Sesbania is grown elsewhere and incorporated into the field with the plants. In brown manuring, Sesbania is grown in the standing rice plant and killed using herbicides. Generally, *Sesbania spp.* seeds are typically broadcasted 3 days after rice transplanting and left to grow for 30 days before being dried by spraying with 2,4-D. Azolla reduces the need for chemical N fertilizer by 25-30%, while grain yield increases by 10-30%. Microbial inoculants and biofertilizers, another facet of nutrient-smart technologies, promote the growth of beneficial microorganisms that improve nutrient availability in the soil. These microorganisms help solubilize nutrients, fix atmospheric nitrogen, and improve nutrient uptake by rice plants. By harnessing the power of natural processes, these technologies contribute to improved soil fertility and reduced reliance on synthetic fertilizers.

Carbon-smart technologies for rice production system

A method of managing agroecosystems to achieve improved and sustainable productivity, increased profits, and food security while protecting and enhancing the resource base and the environment is called conservation agriculture (CA). In the rice-maize system, zero tillage resulted in 39% lower carbon footprint, 56% lower energy consumption, and 20% lower N_2O emissions compared to conventional tillage (Lal et al. 2019). Carbon-smart technologies also include agroforestry systems that integrate trees and other plants into rice fields. Trees capture and store CO_2 from the atmosphere, mitigating the effects of climate change. Agroforestry not only sequesters carbon, but also provides shade, windbreaks, and other ecosystem services that increase the resilience of rice fields and promote biodiversity.

Energy-smart technologies for rice production system

The integration of energy-smart technologies provides innovative solutions to improve energy efficiency and minimize the environmental impact of rice production. Examples of energy efficient technologies include CA (zero and minimum tillage), various resource conservation technologies (RCT), non-puddled rice-transplanting and solar-powered machinery (solar pump, solar-powered sprayer). Minimum tillage minimally disturbs the soil compared to conventional tillage, which saves energy. In rice cultivation, non-puddled transplanting saves 31-76% fuel and 25-26% water compared to conventional tillage. Solar-powered irrigation systems, for example, use energy from the sun to drive water pumps, reducing dependence on fossil fuels and lowering operating costs. Energy-smart technologies also include the development of energy-efficient post-harvest practices. Solar dryers, for example, use solar energy to dry and preserve harvested rice grains, reducing the need for traditional drying methods that use fossil fuels. This not only saves energy, but also improves the quality of the harvested rice.

Knowledge-smart technologies for rice production system

New knowledge is helping to reduce climate-related risks and improve farmers' ability to practice CSA at scale. Intensification of cropping systems, integrated weed management, ecology-specific varieties, seed and fodder banks, and mechanical transplanting of rice are examples of knowledge smart technologies. At the heart of knowledge-smart technologies is the dissemination of knowledge and information to farmers through various digital platforms and tools. These technologies leverage advances in ICT to provide farmers with real-time weather forecasts, market trends, pest and disease warnings, and best agricultural practices. This knowledge empowers farmers to make informed decisions that optimize resource use, increase yields and reduce risks. Mobile applications and SMS-based platforms are popular tools for providing knowledge-smart solutions to rice farmers. Through these platforms, farmers can access agricultural advice, receive alerts about weather conditions, and interact with experts and other farmers to gain experience and insights. This real-time communication fosters a sense of community and the sharing of valuable local knowledge. Farmers have access to information on drought-tolerant rice varieties, pest-resistant crops, and CA techniques that improve the resilience of their cropping systems in the face of changing climatic conditions.

Conclusion

Resilient rice agriculture guided by the principles of climate-smart innovation is a promising approach to securing the future of rice production amid the complexities of climate change. Through the use of climate-resilient rice varieties, precise water and nutrient management, renewable energy integration, and informed decision-making through data-driven insights, farmers, scientists, and policymakers can embark on a path of adaptability and sustainability. The discourse embodies the collaborative spirit needed for a resilient agricultural future, combining traditional knowledge with cutting-edge solutions. Ultimately, this narrative remains a beacon of hope and a blueprint for food security, livelihoods, and ecological harmony in a rapidly changing world as we navigate the intricate interplay between climatic challenges and rice production.

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Backyard Poultry Coccidiosis and Its Management in Meghalaya's Hilly Region

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Backyard poultry farming is one of the important components of animal husbandry among the tribal farmers of Meghalaya. Backyard poultry farming is increasing rapidly due to low establishment cost, cheap source of proteins and employment (Bachaya *et al*., 2012). The total poultry population of the country is 851.81 million (backyard poultry: 317.07 million; commercial poultry: 317.07 million) (Livestock census, 2019). The poultry population of Meghalaya is 5.38 million i.e. 0.63% of the total poultry population. Coccidiosis is an intracellular intestinal parasitic disease caused by the different species of *Eimeria.* Morbidity of coccidiosis is estimated to be 50-70% and the disease is a major threat to 15-50 day old birds (Wang, 2003). It seriously impairs the growth and feed utilization of the infected birds resulting in the loss of productivity and inflicts tremendous economic losses to the poultry farmers. It causes intestinal tissue damage and interferes with the food digestion and absorption resulting in the weight loss and bloody droppings. Sometime high rate of mortality may be observed in a farm. Secondary bacterial infection with *Clostridium perfringens* may occur which may predispose them to other gut infections such as necrotic enteritis. About nine species of *Eimeria* have been recognized in poultry birds, of which *E. brunetti*, *E. maxima*, *E. necatrix* and *E. tenella* are the most pathogenic; *E. acervulina*, *E. mitis*, *E. mivati* are the less pathogenic while *E. praecox* and *E. hagani* are the lesser pathogenic (Jadhav *et al*., 2011; Nematollahi *et al*., 2008). Both clinical and sub-clinical coccidiosis retards the growth of flocks and cause huge economic loss to the farmers (Naveed and Faryal, 2019). Type of litter materials, time duration, season, humidity, temperature and disposal of dead birds are other critical factors for poultry coccidiosis.

Prevalence of coccidiosis in backyard poultry of Meghalaya

The overall prevalence of coccidiosis in backyard poultry of Meghalaya was 30.12%. Eight species of *Eimeria viz. E. tenella* (24.63%), *E. necatrix* (10.84%), *E. maxima* (0.98%), *E. mitis* (1.48%), *E. brunetti* (1.97%), *E. praecox* (1.48%), *E. mivati* (0.98%) and *E. acervulina* (2.96%) were identified by morphological characterization (Fig.1). Mixed infections were recorded in 54.68% birds. Month wise highest and lowest infection was recorded in the month of May (40.29%) and December (15.15%), respectively (Fig.2).

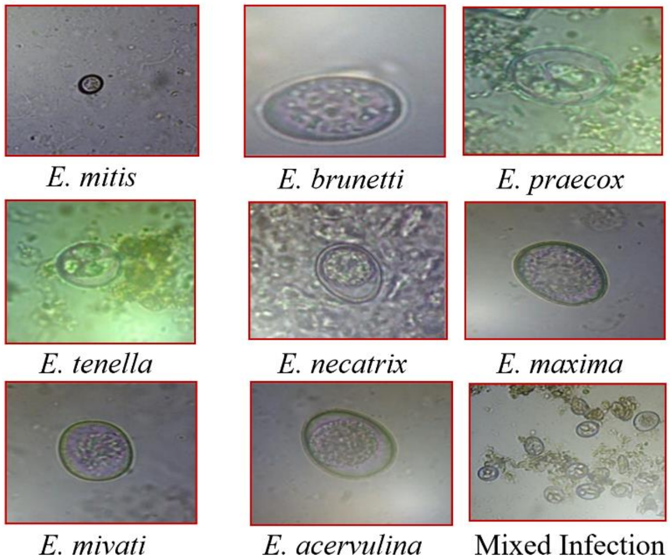

Fig.1 Different species of *Eimeria* in backyard poultry of Meghalaya

Fig.2 Mortality in poultry chicks due to coccidiosis

Month wise highest and lowest infection was recorded in the month of May (40.29%) and December (15.15%), respectively (Fig.3). Intensity of infection i.e. oocyst per gram (OPG) was recorded highest and lowest in the month of August (30000) and February (9500), respectively. Season wise highest infection recorded during monsoon (33.87%) followed by spring (32.77%), winter (27.78%) and autumn (18.37%) (Fig.4). *E. tenella*, *E. necatrix* and mixed infections were observed throughout the year. However, in monsoon season *E. praecox*, *E. maxima*, *E. mitis*, *E. brunetti* and *E. acervulina* are also observed; *E. brunetti* in spring; *E. maxima*, *E. brunetti*, *E. praecox*, *E. mivati* and *E.*

acervulina in winter; *E. mitis*, *E. praecox* and *E. acervulina* in autumn.

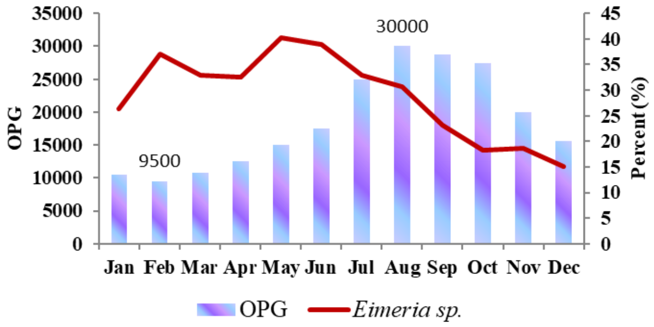

Fig.3 Month wise intensity of infection in poultry

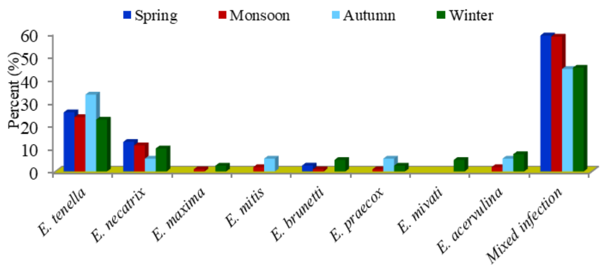

Fig.4 Season wise prevalence of Eimeria infection in poultry

High rate of infection in the monsoon season may be due to wet floor and litter of poultry farm which is very conducive for the growth and development of the *Eimeria* oocysts. *E. tenella*, *E. brunetti* and *E. necatrix* are associated with haemorrhagic coccidiosis and can be highly pathogenic, with high mortality and morbidity (Long *et al.*, 1976). However, *E. acervulina*, *E. maxima*, *E. mitis* and *E. praecox* are less pathogenic, incurring malabsorptive pathologies, although morbidity and mortality can occur depending on dose ingested, parasite strain-specific variation in virulence and host factors such as age, breed and immune status (Williams *et al.*, 2009). According to the Williams *et al.* (1996), co-infection with multiple species is common and can complicate diagnosis. *E. necatrix* has been recognized as the most pathogenic *Eimeria* sp. but *E. tenella* is more common and exerts a greater impact on poultry production (Blake *et al.*, 2015). The occurrence of coccidiosis can also vary due to climatic conditions, with evidence of elevated parasite levels and disease during wetter and warmer seasons (Luu *et al.*, 2013).

According to Omer *et al.* (2011), all ages of birds are susceptible to coccidiosis, but younger birds are more susceptible to infection than older birds which might be associated with the immature immune system in young birds leaving them susceptible to infection even with the lower or less pathogenic strain of *Eimeria* species. Das *et al.* (2020) also observed high rate of infection in young birds which may be due to decreased immunity as well as continuous exposure to infections from the contaminated litter. According to Morris and Gasser (2006), *Eimeria* sp. multiply in the intestinal tract, causing tissue damage, interruption in feeding and digestive processes as well as nutrient absorption, blood loss and increased susceptibility to other disease agents.

Treatment and prevention of coccidiosis in backyard poultry

Poultry coccidiosis can be prevented by using coccidicides, coccidiostats and vaccines as mentioned below:

1) **Coccidicides:** Coccidiosis prevention program used usually aims for eliminating *Eimeria* completely from the gut by using coccidicides that kill the parasites.
2) **Coccidiostats:** In breeders and layers, development of protective immunity is desired. It is achieved by minimal degree of exposure to *Eimeria* species. Coccidiostats are generally used to arrest the development of the parasites at different stages of development allowing for a good balance between intestinal damage and appropriate exposure for immunity development.
3) **Vaccines:** Passive or active immune responses induce immunity in animals. This immunity can reduce the pathogenic effects of coccidiosis such as less macroscopically visible lesions, decreasing of oocyst production and increasing performance of birds. Currently two types of vaccines are used with the aim of controlling coccidiosis in a chemical free way:
   - Live non-attenuated.
   - Live attenuated vaccine.

The main risk of using live non-attenuated vaccines (Coccivac, Advent, Immucox, Inovocox) is the live parasites that can develop a severe reaction in birds. Many times their use is accompanied by chemical treatments to control the inherent pathogenicity of the parasites. On the contrary, the success of live attenuated vaccines (Paracox and Hatch Pak Coccil) relies on the low risk of disease occurring because of the reduction in the proliferation of parasites and consequently a less damage in bird's tissue.

Today chemoprophylaxis in continuous medication programs appears to be the only effective tool for controlling coccidiosis in floor reared poultry although drug resistance in *Eimeria* sp. populations is a widespread problem in the broiler industry today. Strategic use of anticoccidials may thwart the development of resistance processes. The prophylactic use of anticoccidials is based on the application of additives in feed i.e. drugs are added directly to bird feed in small quantities, usually in concentrations of a few ppm (parts per million) in the morning. Additives in-feed used worldwide for the prevention of poultry coccidiosis and therapeutic anticoccidials are:

1) **Synthetic compounds:** Amprolium, clopidol, decoquinate, diclazuril, halofuginone, nicarbazin, robenidine).
2) **Polyether antibiotics or ionophores:** Lasalocid, maduramicin, monensisn, narasin, salinomycin, semduramicin).

Withdrawal times for most prophylactically used anticoccidials may last 0-5 days and longer (toltrazuril, 14 days). In case of outbreaks of coccidiosis therapeutic drugs (e.g. amprolium, sulfonamides, toltrazuril) are preferably administered via drinking water for 3- or 5-days treatment course and withdrawal periods may exceed 14 days (Heinz Mehlhorn, 2007).

Salient points for treatment of poultry coccidiosis

1) Sulfonamides are widely used.
2) Sulfadimethoxine, sulfaquinoxaline, sulfamethazine, but they shouldnot be used in layer hens.
3) Ionophones, which have an effect on membrane function of the parasite and act as both coccidiocides and coccidiostats (monensin).
4) Quinolones, which have an effect on energy metabolism of the parasite and act as both coccidiocides and coccidiostats (buquinolate).
5) Coccidiostatic thiamine analogs, which have an effect on co-factor synthesis for the parasite.
6) The supplementation of vitamins A and K promotes the fast recovery.
7) Dose of drugs administration.
    - Sodium-sulphadimidine (0.2%) in drinking water for 3 days, orally.
    - Sodium-sulphaquinoxaline (0.5%) in feed for 7 days, repeat after 5 days interval, orally.
    - Sulphaquinoxeline: Add 50 ml of solution to 10 lit. of water and give in the following schedule (3-2-3 basis). 3 days medicated water, 2 days plain water, 3 days medicated water.
    - Amprolium hydrochloride @ 30 gm in 25 litre of water for 5-7 days.
8) To avoid development of drug resistance include switching of drugs and the 'shuttle programme', which is a planned switch of drug in the middle of the growing period of birds is necessary. Most suitable drug is used for starter, while another drug is used for grower and finisher.

Prevention of coccidiosis in backyard poultry

- Maintain vigilance and treat as soon as the first symptoms are seen.
- Coccidiosis in poultry birds are prevented by maintaining hygiene and sanitation in the poultry farm. When young birds are placed on heavily contaminated litter, deaths may occur within a few days.
- For sporulation, oocysts require moisture and warmth and survive best in shade and moist conditions. So, always try to keep poultry sheds and litter dry.
- To avoid the intake of large numbers of oocysts by susceptible poultry, litters from poultry shed should be regularly removed if possible every two days.

- Periodical turning of poultry litter is also essential to keep it dry.
- Litters may be redistributed frequently to avoid concentrations of oocysts at places such as feeding or watering troughs etc.
- When poultry houses are emptied for a new batch of birds, the litter should be stacked so that the heat evolved is sufficient to kill oocysts. Heaped litter, left for 12 hours or more, will normally generate a temperature of about 51°C, which is sufficient to destroy the oocysts.
- Footbaths should be provided at the entrance of poultry farm.
- Proper steps must be taken to remove the poultry droppings at frequent intervals and to dispose them away from poultry shed.
- Poultry birds can be prevented from coccidiosis by giving prophylactic medication with anticoccidials in feed/water.
- Coccidiosis in birds may be prevented by giving anticoccidials in feeds/drinking water of birds (Amprolium @ 0.0125% in feed, Nicarbazine @ 0.0125% in feed, Nitrofurazone @ 0.005%-0.01% in feed upto 10 weeks of age).
- Treatment of infected birds immediately to prevent spread of infections.
- Droppings of birds should be regularly screened for parasitic infections.

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Marker Assisted Selection: A Potential Tool in Crop Improvement

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MAS is most widely used to select desirable lines based on genotype rather than phenotype and is an indirect form of selection. Marker assisted selection (MAS) is linked to genes that control the trait of interest and is based on the identification and use of markers. Breeders used molecular markers aided selection methods to increase the precision of selection in breeding efficiency. Marker assisted selection (MAS) offers an efficient opportunity for combining single gene traits. Variety developed by MAS are not considered genetically modified organisms (GMOs) and are easily accepted by local and international market thus allowing for time and cost saving.

Prerequisites for an efficient marker-assisted breeding program

- **High throughput DNA extraction:** An efficient DNA extraction system is needed for rapid selection of desired traits.
- **Genetic markers:** For a better marker assisted selection suitable markers are required. DNA markers are predominant types of genetic markers that are most commonly used in MAS programs however other markers (biochemical, morphological) can also be used. Some commonly used DNA markers are RFLP, SSR, RAPD, AFLP, SCAR, and SNP.
- **Genetic maps:** Linkage maps help identify marker-traits and choose markers for MAS.
- **Association between molecular markers and traits of interest:** For breeding program most crucial ingredient is knowledge of markers that are closely associated with traits.
- **Data management system:** An efficient system is required for labelling, storing, retrieving, and analysing large sets of data and producing reports useful to the breeder.

Steps for Marker Assisted Selection

Various steps involved in Marker Assisted Selection (Figure 1) are:

- **Selection of Parents:** Selection of suitable parents for MAS should be done through germplasm screening and selection of homozygous (self-pollinated) or inbred (cross-pollinated) parents.
- **Development of Breeding Populations:** In this step the selected parents are crossed to obtain the F_1 population and detection of the marker alleles so as to remove false hybrids. Planting of segregating F2 population along with screening of individuals and harvesting the ones with desired marker alleles. If F2 population is homozygous then F3 population can be used for screening of markers.
- **DNA extraction:** This involves DNA isolation from breeding population. For DNA isolation there is no need to wait for flowering or seed development stage as DNA isolation can be done through seedlings as well. The DNA is isolated with already available standard procedures. The isolated DNA is then digested and fragmented via restriction enzymes and then subjected to agarose gel electrophoresis.
- **Scoring Markers:** The marker polymorphism between the parents and their involvement in the recombinants in F_2 population is observed by using DNA probes. These DNA probes are labelled and helps in finding out the fragments having similarity. DNA probe hybridizes only with those fragments being complementary in nature.
- **Correlation with morphological traits:** Molecular markers are correlated with morphological and if the correlation is established then Marker assisted selection can be used effectively for genetic improvement of desired traits.

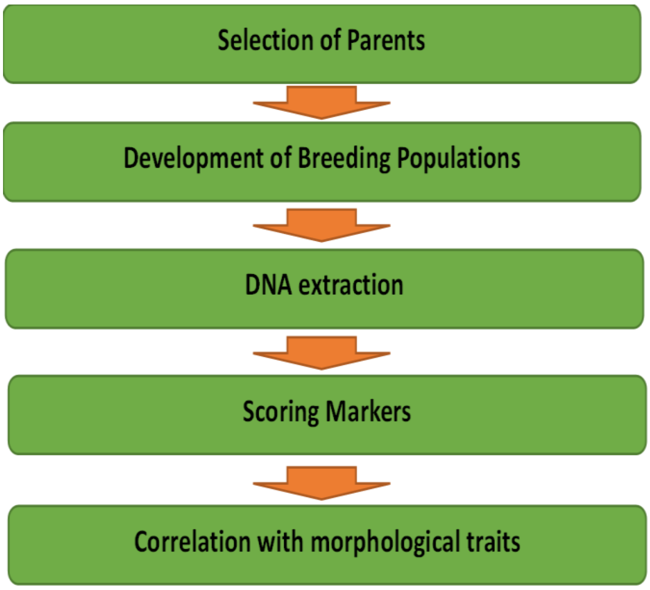

Figure 1: Steps involved in Marker Assisted Selection

Applications of MAS

- Gene transfer of desirable trait from one species to other
- Improves the quality characteristics of cultivars of different crops
- Introgression of genes with desired traits from wild to cultivating variety
- Transfers resistance to biotic and abiotic stress in various crops
- Genetic improvement of tree species having late fruiting (around 20 years, which took long time for their phenotypic selection)
- Widely applicable for oligogenic traits than polygenic traits

Recent Advances/ achievements /examples

Molecular marker technologies and the development of new plant varieties are the major areas for molecular breeding strategies. Introducing new varieties obtained via MAS is not subjected to restrictions as that of GM crop faces. Some examples of newly developed varieties using MAS are:

Rice

The majority of people on earth eat rice as their main dietary source. Using markers in conjunction with selection has grown to be a common strategy for creating improved genotypes in rice. Through marker-assisted selection, it is possible to combine the desired traits from multiple genes into a single genotype. It is typically employed for indirect selection of an important feature, such as disease resistance, productivity, or quality. Other traits of importance include biotic or abiotic stress tolerance. Microsatellites are the best molecular markers for plant breeding because they are widespread, have high rates of polymorphism, and are widely distributed throughout the genome. A variety of molecular markers have been utilised for marker-assisted breeding. The applicability of gene identification and pyramiding valuable genes has been substantially expanded by these molecular approaches. It is necessary to have thorough understanding of the genetic regulation of physiological qualities, the relationship between these physiological traits and molecular markers on chromosomes, and ultimately the genes underlying the traits. Researchers from all across the world have quickly embraced molecular markers as a useful and relevant tool for first studies addressing physiological features. Genetic linkage maps are a crucial tool for connecting marker loci to a particular plant trait.

Some examples with the gene or QTLS being introgressed or used for certain tolerance or resistance in plants are:

TRAIT	GENE/QTL	Reference
Submergence tolerance	*Sub1*	Rehman *et al.*, 2018
Drought tolerance	*QTL*	Jalil *et al.*, 2018
	qDTY1.1, qDTY2.1, qDTY3.1 (QTLs) and *Sub1*	Sandhu *et al.*, 2019
Bacterial blight resistance	*xa13* and *xa21*	Balachiranjeevi *et al.*, 2018
	xa21, xa3 and *xa5(Samba mahsuri)*	Swamy *et al.*, 2020
Blast resistance	QTLs (On chromosome 1, 2, 11 and 12)	Srichant *et al.*, 2019
Salinity stress tolerance	*Saltol*	Yadav *et al.*, 2020
Pest resistance	*Bph3*	Qing *et al.*, 2019

Although susceptibility of rice to salt stress varies over the course of its life cycle. The effects are most obvious during the seedling and reproductive stages. Therefore, use of MAS has proven to be the most effective method for creating improved salt-tolerant varieties. The bacterial blight disease Xanthomonas oryzae pv primarily affects rice. Pyramiding several resistance genes using MAS proved to be quite effective for Oryzae. A single rice variety with high yield, abiotic stress tolerance and biotic stress resistance as well as improved nutritional quality might be created using molecular markers with MAS in gene pyramiding.

Wheat

Wheat is the oldest cereal crop and Marker assisted selection provides an opportunity for selecting desirable lines based on gene type rather than phenotype. Selection for a resistance gene can be carried out without exposing the plant to the pest, pathogen or environmental stress. Resistance in wheat against various diseases like leaf rust, stripe rust, stem rust etc is generally governed by few genes and can be tagged with any PCR based DNA marker. Developing resistant varieties for single disease would not be sufficient for saving plant product and to feed growing population of developing countries. So many diseases and environmentally reduced character together cause heavy yield loss therefore urges the need to redesign the experiments to develop multiple biotic and abiotic resistant varieties in wheat.

TRAIT	GENE/QTL	Reference
Powdery mildew resistance	*PmJM23*	Jia *et al.*2020
Rust resistance	*Lr19*, *Lr24*, *LrTrK*, *Sr26*, *Yr5*, *Yr10* and *Yr15*	Mallick *et al.*2021
	Sr22, *Sr26*, and *Sr50*	Randhawa *et al.* 2019
Moisture deficit stress tolerance	*QTL*	Puttamadanayaka *et al.* 2020
Soil-borne wheat mosaic virus	*Sbwm1*	Liu *et al.* 2020

Conclusion

Plant breeding has made remarkable strides in crop improvement however the impact on variety development has been relatively small up to this point. To utilize MAS to its full potential, greater breeding programme integration, a clear understanding of the current obstacles and the appropriate solutions are necessary. The use of various applications of MAS can have a great impression in crop improvement as opposed to traditional breeding. It is necessary to customise specific MAS tactics, such as how to use new marker technology to drastically cut the cost of MAS for certain crops, traits, and financial constraints, making MAS more generally usable for agricultural breeding operations.

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Value Addition and Marketing Channel for Millets Products

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Millets are traditionally grown in resource poor agro climatic regions of the country which include sorghum, pearl millet, finger millet and small millets. These nutri-cereals are well-known for their high nutrient content, which includes minerals like calcium, iron, zinc, potassium, and magnesium as well as vital fatty acids, dietary fiber, protein, and B vitamins. Due to shifting eating patterns and the hassle of preparing food, millets are becoming less popular for immediate consuming as compared to fine cereals. Value addition in products made with millet, such as baked goods, pasta, traditional dishes, flaked and papad products are created and standardized by different organizations. To boost their use, little millets are used in place of the goods that farmers typically prepare using cereals.

Value addition of Millets

Several value-added products of millet are described below.

Puffs:

Sorghum puff: Sorghum puffs are a byproduct of explosive puffing or gun puffing, in which the grain of sorghum is puffed to its highest range in accordance with its identity (same shape).

Foxtail millet puffs: The foxtail puffs are white and crunchy in texture, equivalent to puffed rice. The shelf life is 2 months when packed in air tight MET pouches at room temperature.

Pearl millet puffs: The pearl millet puffs have a crunchy texture and a greenish-creamy color. When stored at room temperature in Sir Tight MET pouches, the shelf life is three weeks.

Sorghum Snack

This food, which is Ready to Eat, is made with a puff gun machine. Dehulled sorghum grain is placed into the puff gun machine's revolving barrel, where it is roasted and burned to produce puffed sorghum.

Malting foods

Malt made from millet is traditionally used to feed infants. Finger millet is widely used for malting in parts of Tamil Nadu and Karnataka due to its good malting qualities. Malting aids in greatly enhancing the nutritional composition, fiber content, crude fat content, availability of vitamins B and C, minerals, and improved nutrient bioavailability as well as the sensory qualities of the grains. For low dietary bulk and calorie-dense weaning foods, supplementary foods, health foods, and amylase-rich foods, millet malt is utilized as a cereal basis in fact.

Millets Pasta

In the mixing compartment of the vermicelli-making machine, sorghum, finger millet, foxtail millet, pearl millet, and refined wheat semolina are combined with water and left for half an hour before being extruded through a pasta die. Since millets have less gluten, wheat is added to meet the minimum amount needed to make pasta.

Millets Noodles

Noodles, also referred to as convenience foods, are made using a cold extrusion process and dry out to a hard, brittle texture. These noodles only take a few minutes to prepare and are incredibly convenient. There are various combinations of noodles that can be made: finger millet-only noodles, finger millet and wheat noodles in a 1:1 ratio, and finger millet blended noodles with wheat and soy flour in a 5:4:1 ratio. With a longer shelf life and significant commercial value, noodles are one of the most popular foods for people of all ages. With a slow digestibility of 25.88%, barnyard millet has relatively low carbohydrate content (58.56%).

Millets flour

Flour is a staple ingredient in many recipes. The millet grains (Foxtail, Pearl, and Finger millet) are processed by dry milling; the process begins with cleaning the grains, which are then ground in hammer mills to separate the bran, germ, and endosperm to obtain fine flour. Four types of millet flour (atta) have been developed: ragi, bajra, and finger millet.

Bakery products

Worldwide popularity and increased production of bakery goods can be attributed to their affordable prices, diverse flavor profiles, eye-catching packaging, and extended shelf life for effortless promotion. In addition to having a higher fiber and micronutrient content than other flours, using millets in baked goods will open up new opportunities for millets to be used in a variety of value-added products. The majority of them are created using wheat flour, although attempts are being made to substitute a small amount of it with millet to offer a substitute, lessen reliance on wheat, and create gluten-free bread. You can use finger millet and foxtail millet flour in baked goods such as cakes, muffins, chocolate, cheese, and nan-khatai.

Traditional foods

In millet-growing regions of South India, it has become customary to add finger millet as one of the basic ingredients, to the tune of 15-20% (w/w), along with other vital ingredients like black or green gram, rice, and spices. The addition of millet and pulse proteins resulted in an improvement in protein quality despite a minor decrease in the content of nutrients. After extended storage, finger millet papad's consumer acceptability was very good, making it a viable alternative to traditional papad.

Fermented products

In many parts of India, fermented foods like idli, upma and dosa are popular and often eaten for breakfast, as well as for dinner. Although millets are a strong source of protein, there is a rising focus on improving the quality of protein due to low levels of tryptophan and lysine. In addition to enhancing flavor, fermentation increases food value by adding protein, calcium, fiber, B vitamins, and in vitro protein digestibility while lowering anti-nutrient levels in food grains. Higher protein digestibility (>90%) results from the ground germinated pearl millet grains fermenting.

Idli: Idli is a steaming product made from rice semolina and ground pulses that is traditionally eaten with chutney or a spiced vegetable filling. It is an indigenous traditional breakfast dish found predominantly in southern Indian cuisine.

Upma: Upma is an indigenous to the country, traditional morning dish from especially southern Indian cuisine. It is made of cooked wheat or rice semolina with spices, condiments and pulses added.

Dosa: A dosa is an indigenous, traditional morning dish from predominantly southern Indian cuisine. It is a pancake cooked with ground pulses and rice semolina, usually served with chutney or a spiced vegetable filling.

Marketing Channel for Millets Products

It would be wiser to leverage the existing distribution network rather than creating a new one, as the product is in the food category and products in this category already have one in place. A new distribution network will raise the cost of the goods because both the product and the company producing it are relatively new to the market. A product's cost will also rise if it has numerous distribution channels included in its network. For the product, we recommend the following distribution channels and a maximum channel length of three levels.

1. Producer → Customer
2. Producer → Whole Sheller → Costumer
3. Producer → Whole Sheller → Retailer → Costumer

Conclusion

Additionally, traditionally, these foods have only been consumed in locations where they grow. Therefore, technology that makes millet value-added goods easy to make and affordable could generate a large demand and market, especially in metropolitan areas where people are becoming more aware of the importance of eating a healthy diet. An effective marketing plan that prioritizes brand management, price, packaging, and labeling can be crucial in boosting the sales of millet goods.

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Role of Organic Farming on Soil Health

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Abstract

Soil health is the foundation of diverse ecosystems, fostering life through a complex network of organisms, organic matter, minerals, and water. It sustains crops, forests, and habitats while also impacting air and water quality, climate regulation, and resilience against global challenges like climate change. Protecting soil health is crucial for the planet's sustainability, influencing ecosystems and securing a resilient future for generations to come. Organic farming stands as a sustainable agricultural approach that emphasizes the significance of soil health in nurturing crops and preserving ecosystems. By eschewing synthetic chemicals and employing natural techniques like crop rotation, composting, and biological pest control, organic farming prioritizes soil vitality. It encourages the nurturing of rich, biodiverse soil ecosystems teeming with beneficial microbes, earthworms, and other organisms crucial for soil structure and fertility. This practice fosters a healthier soil structure, increasing its water retention capacity and promoting better nutrient absorption by plants. Moreover, organic farming techniques minimize soil erosion, enhance carbon sequestration, and reduce pollution, contributing to the overall improvement and preservation of soil health for long-term agricultural sustainability.

Introduction

The main economic activity of agriculture is the production of various kinds of crops, fruits, flowers, vegetables, and cattle Rani *et al*. (2023). Soils are a non-renewable resource on which 95% of our food supply depends. Short-sighted chemical fertilizer applications in industrial farming are depleting soils at an alarming rate. Pesticide residues from agricultural intensification are also causing increasing soil contamination which is also an issue of increasing concern because of their toxicity to non-target species. Unsustainable agricultural practices are also a major cause of desertification, a global problem directly affecting over 250 million people and a third of the earth's land surface. It is especially concentrated in developing countries, and leads to food insecurity, climate change, poverty, and human displacement. Soil, a diverse ecosystem with billions of microorganisms, supports fertility and nutrient cycling. Despite holding twice, the carbon of the atmosphere, a third of global land faces severe degradation, losing 24bn tonnes yearly, impacting farming and leading to EU farmland crises. Shifting towards sustainable land management involves embracing holistic approaches like organic farming, agroecology, and safeguarding natural ecosystems like peatlands and forests. Preserving our soils stands as a pivotal measure in mitigating and adapting to the ongoing climate crisis (IFOAM, 2023). Healthy soil is vital for robust plant growth, thriving within a microorganism-rich ecosystem. Organic farming promotes soil health by favoring compost over synthetic fertilizers, preserving soil vitality and plant well-being. Natural fertilizers deter diseases, contrasting with pesticides/herbicides that disturb soil-crop microorganism interactions. Organic methods, including crop rotation, enrich the soil, aid water retention, and curb erosion. Soil's organic content aids air circulation and water absorption, while low levels lead to erosion and hinder nutrient release. Organic soil management, involving cover crops, mulching, and reduced tillage, helps maintain and enhance organic matter, supplying essential nitrogen, phosphorus, and sulfur for plant nourishment. Adherence to these practices boosts organic matter levels, seen in higher content in organically managed soils compared to conventional ones.

Four key practices emerged as being the most critical for impacting soil health, including:

- ✓ Cover crops
- ✓ Rotation diversity and length
- ✓ Organic amendments
- ✓ Tillage

Cover Crops

Cover crops are plants that are grown to benefit the soil rather than harvest income. They provide protection from soil erosion, nutrient losses, along with many other agroecosystem benefits. In organic systems, they can be used for weed suppression and are often a critical source of nutrients for cash crops through nitrogen fixation and green manure. Numerous studies highlight cover crops' positive impact on overall soil health, yet limited research directly compares their effects in organic systems. Despite this lack of data obscuring potential trends, it's evident that roll-killed cover crops demonstrate superior weed suppression compared to disking. Further research should delve into the influence of cover crop species, termination methods, and combinations of soil amendments on soil health outcomes. Additionally, understanding the timing of nitrogen release during cover crop decomposition is crucial to prevent either premature nutrient leaching or delayed availability causing nitrogen deficiency stress.

Organic amendments

The use of synthetic nutrients is banned on organic farms, so organic farmers must rely on naturally-occurring fertilizers such as compost and manure for enhancing nutrient content in soils. The use of organic amendments has been shown to increase soil carbon sequestration, which may help to mitigate climate change by locking away carbon that could otherwise act as a greenhouse gas in the atmosphere. However, organic soil amendments can vary dramatically in nutrient content, carbon to nitrogen ratios, and timing of nutrient release, which has led to variability in the impacts of organic soil amendments on soil health.

The variability in organic amendment type and treatment also makes it difficult to compare studies, but this project was able to uncover some general themes. Specifically, combining different organic amendments (such as vermicomposts in combination with manure) is better for soil health than using one type of organic fertilizer alone. Future research should focus on specific regional effects of fertilizer types and rates, and how timing of nutrient release can be synchronized with crop need.

Rotation diversity and length

Crop rotations, the sequence of crops grown on the same land in succession— are a critical component of maintaining healthy soils. They break pest and weed cycles, help cycle nutrients, and reduce economic risks associated with single cropping strategies. Organic farms tend to have longer crop rotations than their conventional counterparts, which leads to higher on-farm diversity. This study found that most research on crop rotations focuses on the effect of rotation length, rotation complexity and grain versus forage rotations. Diversity in rotations was key to enhancing soil health, especially when it comes to including perennials, such as alfalfa, into the systems to improve soil health indicators including soil carbon, nitrogen and aggregate stability.

Tillage

Tillage serves as a weed control method in some organic farming practices, yet excessive tillage can harm soil structure and result in soil organic carbon depletion. However, there's a growing interest in organic approaches that minimize tillage. Studies in organic systems demonstrate that reducing tillage can enhance soil carbon levels, although the varied definitions of "reduced tillage" pose challenges in identifying broader trends. While organic no-till methods may decrease yields, future research should focus on minimizing tillage without compromising yield. Additionally, shallow non-inversion tillage methods like "vertical tillage" or "strip-tillage" could potentially optimize both yields and soil carbon storage. Further research comparing various tillage methods, spanning from chisel ploughing to shallow inversion tillage, would aid in developing strategies that promote multiple aspects of soil health without hampering crop yields on organic farms.

Conclusion

Healthy soils are imperative in meeting the population's food needs, and organic farming stands as a sustainable approach that prioritizes soil and environmental health while ensuring crop yields and profitability for farmers. Studies indicate that certain farming practices, like growing cover crops, sequester greenhouse gases in the soil, preventing their release into the atmosphere and thereby mitigating contributions to climate change. This symbiotic relationship between organic methods, soil health, and environmental conservation highlights the pivotal role of sustainable agriculture in securing both food security and environmental stability.

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Rhizosphere Engineering: A Novel Strategy to Mitigate Biotic and Abiotic Stress

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Abstract

Rhizosphere engineering presents a promising solution to mitigate the adverse effects of both biotic and abiotic stress on plants. This innovative approach involves deliberate modifications to the rhizosphere, the soil zone influenced by plant roots, with the aim of enhancing plant resilience and productivity. By fostering beneficial microbial interactions, altering root exudation patterns, and optimizing nutrient availability, rhizosphere engineering can effectively suppress pathogenic attacks and improve tolerance to environmental stressors. This article explores recent breakthroughs and potential applications of rhizosphere engineering as an eco-friendly and highly effective tool to safeguard agricultural systems amidst escalating stress challenges.

Introduction

Continuous exposure of biotic and abiotic stress limits the growth and development of plants and check their productivity. Under natural conditions, plants initiate a variety of stress-specific responses to cope with them, modulating various physiological, molecular, and cellular systems in the process. However, plants' natural strategies to deal with stress are not sufficient and they require external assistance. Rhizosphere refers to the narrow region in soil near root zone where complex interactions occur between the roots, soil, and microorganisms. This intimate relationship act as a hotspot for intense microbial activity between plants and their surroundings that plays a crucial role in supporting plant growth, nutrient cycling, and disease suppression. Depending on plant physiology and composition of microbial communities, the physical and chemical environment of rhizosphere results into numerous competing and interacting processes. To harness the full potential of beneficial microorganisms in rhizosphere, it is essential to understand which microorganisms are numerous in the rhizosphere microhabitat and what function they are serving in order to ensure crop productivity and sustainability of agricultural systems. Rhizosphere engineering is the novel strategy that modify rhizosphere microbiome to understand the processes involved and to help plants to combat the impact of environmental stresses.

What is rhizosphere engineering?

Rhizosphere is the narrow zone of soil next to plant roots that serve as a breeding ground for numerous microorganisms. Apart from microbial secretions, the rhizosphere is also influenced by different rhizo-deposits such as carbohydrates, organic acids, amino acids and secondary metabolites. As a result, rhizosphere harbours wide range of microbial communities which serve a variety of purposes and exert numerous effects on plant growth promotion, nutrient cycling and defend plants from pathogens under biotic and abiotic stress conditions. Environmental stress factors impose major barrier in agricultural systems that dynamically modify the rhizosphere microbial ecology, adversely influencing plant development and growth, and ultimately impeding crop productivity. Plants frequently encounter unfavourable environmental circumstances, which results in low productivity and poor growth. The two main categories of these environmental challenges are biotic and abiotic stresses. Among abiotic stresses, salinity, drought, and extreme temperatures have a negative impact on plant growth and are known to trigger a series of molecular events that alter morphology, physiology and biochemistry of plants. Among biotic stress, phytopathogens are the primary contributors which leads to substantial decrease in crop yields.

Thus, strategic management of rhizosphere microbiome can be essential for mitigating both biotic and abiotic stress. For eco-friendly stress management, there are numerous ways to engineer the rhizosphere, including plant-based, meta organism-based and microbiome-based approaches. Few methods, mechanism and their advantages have been given in table 1, 2 and 3 providing insight to different approaches for shaping the rhizosphere microbiome. The plant-based approach to rhizosphere engineering mainly entails plant breeding techniques and the choice of suitable cultivars, which encourage the production of exudates, either stimulatory or inhibitory in nature that favour the predominance of certain microbial members in the rhizosphere community. Genetic engineering of plants for enhancing the production of exudates or signalling molecules, creating mutants or transgenics with disease resistance due to the production of antagonistic molecules, transgenics producing quorum sensing signal molecules have direct influence on rhizosphere microbial communities. For in-depth assessment of changes in soil microbial communities, high-throughput sequencing technology can be used to obtain comprehensive information about the composition, diversity and function of soil microbes. Under metaorganism-based approach, opines produced by transgenic plants helps in selecting the host specific microbial community which utilize specific metabolic resources. For many years, research has placed a lot of emphasis on understanding how plants and microbes interact. The physiology of plant-associated microbial community helps plant to combat various stress conditions throughout their life cycle. As a result, the composition and functioning of microbiomes should be prioritised in order to fully utilise their potential.

Plant-based approach to engineer rhizosphere

Plant breeding and genetic engineering are two separate methodologies used in plant-based processes to modify desired plant traits. The use of plant breeding techniques to select certain microbial populations is an exciting strategy since the key objective of this technique is to increase crop production by improving plant resilience to various stresses. Thus, the inclusion of microbiome selection in plant breeding techniques focused on highly important taxa and functions. In 1973, Neal *et al.* employed chromosomal substitution to increase the resistance of two wheat lines to the root rot disease and showed that specific alteration of host-plant genotype preserved beneficial bacterial population in the rhizosphere. The gene for mitochondrial citrate synthase (CS) when isolated from *Daucus carota* (DcCS) and introduced into *Arabidopsis thaliana* using *Agrobacterium tumefaciens*-mediated transformation, Koyama *et al.* 2000, compared to the wild type, transgenic plants have a greater capacity for root-based citrate secretions, which helps them to grow more efficiently in phosphate-deficient soil. Few methods, mechanism and their advantages have been given in table 1 providing insight to plant-based approaches to mitigate biotic and abiotic stress conditions.

Metaorganism-based approach to engineer rhizosphere

Microbial growth in the rhizosphere is generally promoted by carbon and nitrogenous compounds released by the plant, a phenomenon known as rhizodeposition. Since plants and microbes are interrelated, the microbiome, sometimes referred as the secondary genome of the plant which may function as a meta-organism or holobiont. This introduces the "opine concept," which combines orchestrating the host plants to secrete particular root exudates with the inoculation of microbes that are engineered to degrade substrate and often leads to the colonisation of the rhizosphere by a particular type of microbial community. By integrating pulse crops like chickpeas (*Cicer arietinum* L.), field peas (*Pisum sativum* L.) and lentils (*Lens culinaris* Medik.) into the conventional cereal-based cropping systems, crop output in the semiarid region of the Canadian prairies was found to be increased (Gan *et al*. 2015). Berendsen *et al*. 2018 showed that plants can modify their root microbiome in response to pathogen infection and resulted in recruitment of beneficial root-associated microbes that potentially maximizing the chance of plant's survival.

Microbiome-based approach to engineer rhizosphere

The rhizosphere microbial community attached to the root surface is distinct from the microbes in the non-rhizosphere soil, indicating microbial community establishment in the rhizosphere is not random but rather driven by host plant selection. In order to improve the cultivability of the microbes already present in the rhizosphere, several rhizosphere engineering procedures call for the culture of microbes. To understand the functionality and persistence of these microbial isolates focused research is needed to study their positive effects when utilised as an approach to modify the rhizosphere microbiome.

All the three approaches of engineering rhizosphere microbiome help in harnessing natural and beneficial plant-microbe interaction capable of conferring stress tolerance to host plants. Such rhizobacteria providing resilience against abiotic and biotic stress particularly known as PGPR (Plant growth promoting rhizobacteria). PGPRs are a group of bacteria that colonize the rhizosphere and have an ability to promote plant growth by exerting variety of direct and indirect mechanisms. The mobilisation of nutrients (P, Zn and Fe), nitrogen fixation, and phytohormone synthesis are some of the major direct mechanisms induced by the action of PGPR whereas, indirect mechanisms include the production of antibiotics, siderophores, lytic enzymes, induced systemic resistance etc. There has been a lot of discussion about the potential role of PGPR strains from the genera *Bacillus, Pseudomonas, Burkholderia, Azotobactoer, Enterobacter, Serrati*a and *Streptomyces* that play a significant role in the management of plant stresses (Bandyopadhyay *et al*. 2022).

Through the production and release of organic acids and protons, several genera of bacteria help in solubilizing non available form of nutrients to their available forms in the soil. Naqqash *et al*. 2020, demonstrated that TN37 species of bacterial genus *Brevundimonas* showed maximum phosphate solubilization potential and improved growth parameters of potato cultivar. Under salinity, rice plants inoculated with zinc solubilizing bacteria viz. *Bacillus pumilus* and *Pseudomonas pseudoalcaligenes* alleviated osmotic stress by accumulating soluble carbohydrates in leaves (Jha 2019). Under salt stress conditions, inoculation of greenhouse tomato plants with a microbial consortium comprising *Achromobacter, Bacillus, Delftia* and *Enterobacter* species improved mineral uptake (Na^+ and K^+) and alleviated salt stress in comparison to application of a single strain (Kapadia *et al*., 2021). PGPR combined with *Rhizobium* strains enhanced growth, nodulation, nitrogen fixation and macronutrient contents in white clover under low phosphorus conditions (Matse et al. 2020). PGPR also produces a number of phytohormones, including indole-3-acetic acid (IAA), cytokinins, gibberellins (GA), abscisic acid (ABA), 1-aminocyclopropane-1-carboxylate (ACC) deaminase and jasmonates. These hormones play a significant role in regulating plant growth or the response to various stress conditions (Liu et al. 2022). Antibacterial compound (C_{15}surfactin A) secreted by strain HN-2 of *Bacillus velezensis* effectively inhibited *Xanthomonas oryzae* pv. Oryzae causing bacterial leaf blight in rice (Jin *et al*. 2020).

Conclusions

Rhizosphere engineering represents a promising strategy to address the challenges of both biotic and abiotic stress in agriculture. The engineering of rhizosphere entails purposeful alteration of the soil environment surrounding plant roots to harness the potential of microbial communities to optimize nutrient availability, to not only improve stress tolerance, but also promote sustainable agriculture practices. This can be accomplished through a variety of strategies, such as plant-based, metaorganism-based, and microbiome-based strategies. While rhizosphere engineering is gaining popularity, it is crucial to highlight that it is still a developing area with continuing study to refine and improve the methodologies and strategies used.

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Table1. Methods, mechanism and advantages of plant-based approach used in shaping the rhizosphere microbiome

Plant-based approach		
Methods	**Mechanism**	**Advantages**
Plant breeding and choice of suitable cultivars	Production of root exudates	Influences the microbial diversity by enhancing the growth of some selected microbes present in the rhizosphere
	Alteration of plant resistance to disease and environmental stress	Improve tolerance to resist adverse environmental conditions (edaphic, biological and climatic)
Genetic modification: change in the amount of signalling molecules, organic exudates, and residues that enters into the soil	Plants engineered to secrete exudates that directs specific microbial diversity for providing beneficial services	Plant induces microbiome for beneficial functional traits like production of antibiotics/ siderophores that act as a biocontrol agent
	Plants engineered to produce exudates that modify properties of the soil like pH, efflux of anion from the roots	Plant growth is enhanced at acidic or low pH, resistance towards salinity, alkalinity and water stress. Enhance resistance of plant towards Al^{3+} and also solubilize phosphorus
	Plants engineered to produce an enzyme that causes degradation of the quorum sensing signals	Prevention of bacterial infection

Table 2. Methods, mechanism and advantages of metaorganism-based approach used in shaping the rhizosphere microbiome

Metaorganism-based approach		
Methods	**Mechanism**	**Advantages**
Managing and choosing plants and complementing microbiomes	Crop rotation	Managing soil diversity by introducing suppressive soils Increasing organic carbon content in soil
Plants engineered to produce compounds and inoculated bacteria are engineered to degrade these compounds	Plants synthesizing opines are co-inoculated with bacteria that are able to utilizing opine	Building a direct connection between two partners of interaction
Agricultural inputs	Utilising mineral fertilizers viz. ammonium nitrate, urea etc Using organic fertilizers viz. manures, composts etc	Enhancing soil organic matter through crop residue incorporation which indirectly improve biological activity of soil

Table 3. Methods, mechanism and advantages of microbiome-based approach used in shaping the rhizosphere microbiome

Microbiome-based approach		
Methods	**Mechanism**	**Advantages**
Use of microbial formulations viz. biofertilizers	Application of plant growth promoting rhizobacteria (PGPRs), arbuscular mycorrhizae fungi (AMF) etc	Biocontrol against diseases Increased production of phytohormones Helps in nitrogen fixation and nodulation Improve fertility of the soil and enhance performance of the plants

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Ring Worm Infection in Cattle and Its Management

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Numerous skin conditions commonly affect domestic animals; some are simple to treat, some are more challenging, and others are even extremely communicable to their human carers. The impact of skin conditions on animal productivity likewise ranges, from minor annoyances to sudden death, with a variety of intermediate stages affecting the animals' comfort and productivity.

Dermatophytosis (Ringworm)

Ringworm, also known as dermatophytosis, is exceedingly frequent in dairy calves and can also affect adult cows.

Etiology

The most frequent pathogen is *Trichophyton verrucosum*, with *Trichophyton mentagrophytes* and other dermatophytes occurring less frequently.

Mode of spread

The infection is spread by direct or indirect contact. Occurs more frequently in animals where they are housed or kept close to one another. The fungus is known to multiply best in environments with high humidity. Young calves are more sensitive since susceptibility is mostly determined by immunological state.

Pathogenesis

Only keratinized tissue can support ringworm growth, and the infection terminates once it reaches live cells or inflammatory tissue. Only the perimeter of the lesion is active because the fungus, which need oxygen, die out in the interior. This pattern of proliferation is what gives the lesions their distinctive ring shape.

Symptoms

- Ringworm symptoms appear in animals 7 to 28 days after infection.
- Animals have a 3 cm-wide circular scab on their skin.
- Scabs typically start to emerge initially in these areas: under the tail, on the ears, above and around the eyes. The skin is moist behind the dried scab. Scabs quickly congregate and thicken. After several days the scabs fall off. The skin underneath becomes dry with a heavy, gray-white crust raised above the skin.
- Stanchions, neck straps, halters, chutes, brushes, curry combs, milking straps for vintage bucket milking machines, and other implements can spread disease among a herd of cattle.
- In contrast to healthy herd mates that either remain unaffected or just have minor lesions, persistently infected BVDV and BLAD calves usually have extensive ringworm lesions.
- The scabs fall off after a few weeks and leave patches with no hair.
- Raised crusted lesion of ringworm. Multifocal ringworm lesions.

Diagnosis

To confirm the diagnosis, skin biopsies, scrapings of lesions for mineral oil or potassium hydroxide preps, or cultures of hair from the periphery of a lesion on selective media such as dermatophyte test medium may be utilised.

Treatment

Ringworm normally clears up on its own in animals, but it can take two to three months. Treatment is frequently required due to zoonotic risk or because a sick heifer or cow has been chosen to participate in a show or sale.

Topical

1. Lime sulfur 2% to 5% (Orthorix; Lym Dyp, Ortho Garden Supply)
2. 0.5% Sodium hypochlorite (Clorox)
3. 0.02% Enilconazole (Imaverol)
4. 3% to 5% thiabendazole paste applied once or twice daily.
5. Miconazole or clotrimazole cream once or twice daily.

Systemic

1. Griseofulvin 20 to 60 mg/kg orally for 7 or more days.
2. Sodium iodide 20% solution—150 cc per 450 kg intravenously (IV) repeat in 3 to 4 days
3. Vitamins A and D—only indicated if animals have been kept completely out of sunlight.

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Gender Equality and Environmental Justice: Exploring the Connection

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Abstract

Environmental justice emerges as a pivotal societal endeavor aimed at rectifying environmental inequities that disproportionately affect marginalized communities grappling with hazardous waste, exploitative resource practices, and adverse land use patterns. The article delves into empirical studies, revealing the unequal distribution of environmental harm and advocating for empowering marginalized communities to actively participate in environmental decision-making processes. Furthermore, this article rigorously examines the differential impact of environmental hazards, particularly heatwaves, on gender cohorts, uncovering gender-based disparities in mortality rates during such crises. While acknowledging strides in mitigating gender disparities—such as the surge in women's employment in the Netherlands—it critically highlights emergent gender inequalities exacerbated by climate change. It cautions against complacency in addressing evolving gender disparities, calling for sustained vigilance.

The study accentuates the urgency of integrating gender-sensitive approaches into environmental policy frameworks and decision-making paradigms. It emphasizes the imperative of dismantling gender-specific barriers that impede women's capacity to confront environmental challenges and adapt to climate change. Additionally, it underscores the pivotal role of feminist movements in advocating for inclusive and equitable environmental justice policies.

In summation, this article advances an interdisciplinary understanding of the intricate linkage between gender equality and environmental justice, advocating for comprehensive insights to drive inclusive, sustainable solutions benefitting both societal well-being and environmental resilience.

Introduction

The term "gender" refers to socially constructed roles assigned to individuals as men or women, shaped by factors such as gender markers, socio-economic, political, and cultural contexts. These roles are influenced by various factors, including race, ethnic origin, class, sexual orientation, and age, and they vary widely within and across cultures. Unlike an individual's biological gender, gender roles can be changed, encompassing cultural views on intellectual capabilities, personal traits, and behavior. Society constructs the concept of gender as a social model that determines the roles and positions of men and women across all spheres of public life.

Gender equality, synonymous with sexual equality or parity of the sexes, entails providing equal access to resources and opportunities irrespective of gender. It encompasses fair treatment and valuing different behaviors, aspirations, and needs regardless of gender. UNICEF defines gender equality as ensuring that women and men, girls and boys, have equal rights, resources, opportunities, and protections, without requiring absolute sameness in treatment. For a sustainable future, gender equality is essential. The UNDP's environmental justice strategy forms a foundation for an integrated approach to achieve climate justice, prioritizing gender equality and women's environmental rights in advocacy and programming. This approach focuses on environmental rights realization, the promotion of environmental rule of law, and aims to address the 'triple planetary crisis' of climate change, pollution, and nature loss, which directly impacts various human rights, including food, health, development, and life itself.

The severity of the triple planetary crisis's impact is shaped by an individual's gender, residence, income source, and socioeconomic status. Vulnerability and resilience levels vary among men, women, households, and communities. Women and girls, especially those in crisis-affected or rural areas, or belonging to minority or Indigenous groups, are particularly vulnerable. Gender inequality, unequal access to land, resources, and assets further hinder women's ability to cope with environmental crises and enjoy their environmental rights (Fabiano De andrade Correa, 2022).

Environmental justice

Environmental justice, also known as eco-justice, constitutes a social movement aimed at rectifying environmental inequities, wherein disadvantaged or marginalized communities bear the brunt of hazardous waste, resource exploitation, and land uses that offer them no benefits. Numerous studies initiated by this movement have highlighted the unequal distribution of exposure to environmental harm. The primary goal of the environmental justice movement is to empower marginalized communities, enabling them to actively participate in environmental decisions that significantly impact their lives. Environmental racism and environmental inequality are concepts closely associated with environmental justice.

Research has shown that land surface temperature affects gender groups disparately, particularly during heatwaves. Chen et al. (2015) observed varying mortality rates based on gender, age, and education level during heatwaves in Nanjing. Their findings indicated that during severe heatwaves, where the daily average temperature surpasses the 98th percentile for more than four consecutive days, women experience a significantly higher mortality rate compared to men, recording 30.3% versus 18.4%. Similarly, Ma et al. (2015) discovered a 5.8% higher risk of heatwaves in females than in males after examining 66 Chinese communities.

Despite some improvements in gender disparities, such as the notable rise in women's employment in the Netherlands from 62% in 2000 to 74% in 2019 (OECD, 2019), it remains crucial to recognize that progress in one area of gender inequality should not overshadow or justify the emergence of new gender disparities, particularly those exacerbated by climate change. While advancements in certain aspects are commendable, they should not detract from the rise of other forms of gender inequality.

Climate change and associated policies are expected to profoundly impact gender relations, particularly in developing nations. Numerous gender-specific barriers hinder the ability of impoverished women to cope with and adapt to climate change. It is imperative to eliminate these barriers in the pursuit of both gender equality and effective adaptation strategies. Additionally, integrating gender analysis into the assessment of public policies aimed at reducing carbon emissions is essential. Despite receiving limited attention in international policy discourse, including the UN Framework Convention on Climate Change and the Kyoto Protocol, feminist advocacy and increased involvement of gender experts in this realm might be altering this landscape. The forthcoming international post-2012 Kyoto Protocol agreement holds significant implications for gender equality, making the stakes high.

The dynamics of global warming are crucial concerning social and environmental justice because those contributing the least to climate change are disproportionately affected by its adverse impacts (Parks and Roberts, 2006; Roberts & Parks, 2007)

The relationship between Gender equality and environmental justice

The connection between gender equality and environmental justice is intricate and multifaceted, demonstrating various interconnections:

- **Vulnerability and Impact**: Gender inequalities often exacerbate the vulnerability of women, especially in marginalized communities, to environmental hazards and climate change impacts. Social norms and disparities limit women's access to resources, decision-making processes, and opportunities, leaving them disproportionately affected by environmental degradation, disasters, and resource scarcity.
- **Access to Resources**: Environmental justice issues intersect with gender equality through unequal access to resources like clean water, land, and energy. Women, particularly in rural settings, often bear the responsibility of collecting water and fuel, facing increased

challenges when these resources become scarce or contaminated due to environmental degradation.

- **Health Disparities**: Environmental degradation and pollution can disproportionately impact women's health due to their roles within communities and households. Exposure to pollutants, inadequate sanitation, and limited access to healthcare services often affect women more profoundly, particularly pregnant women and children.
- **Climate Change Adaptation:** Women often play critical roles in community resilience and adaptation to climate change. Empowering women and ensuring their active involvement in decision-making processes regarding climate adaptation strategies can contribute significantly to more effective and sustainable solutions.
- **Environmental Decision-making:** Gender-inclusive decision-making processes are crucial for effective environmental policies and climate action. Greater representation of women in environmental governance and policy formulation leads to more comprehensive and equitable strategies that consider diverse perspectives and needs.
- **Global Advocacy:** Intersectional feminist movements advocate for environmental justice, emphasizing the interconnectedness of gender equality and environmental issues. These movements highlight the importance of addressing social inequalities in combating environmental degradation and climate change.

Understanding and addressing the connections between gender equality and environmental justice are vital for creating inclusive and sustainable solutions that benefit both the environment and society as a whole.

Conclusion

The intricate interrelation between gender equality and environmental justice constitutes a pivotal nexus within societal sustainability. Gender disparities, particularly prevalent in marginalized communities, amplify the vulnerability of women to environmental risks. Unequal access to critical resources stemming from environmental degradation, notably evident in rural settings, disproportionately affects women. This inequity further extends to health disparities, significantly impacting the well-being of women, especially among vulnerable groups such as pregnant women and children.

Enhancing the involvement of women in decision-making processes is fundamental in facilitating effective adaptation to climate change, given their pivotal roles in fostering community resilience. Integrating gender perspectives into governance frameworks leads to the formulation of more holistic environmental policies, fostering equitable strategies. Globally, feminist movements vigorously advocate for addressing inherent social inequalities within environmental agendas, accentuating the intricate interlinkage between gender equality and environmental concerns. Comprehensively understanding and proactively addressing these multifaceted connections stand as imperative endeavors to forge inclusive and sustainable solutions that redound to the benefit of both the environment and society at large within the scholarly discourse.

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Nanotechnology: A Boon for Agriculture

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Nanotechnology refers to the branch of science and engineering devoted to designing, producing, and using structures, devices, and systems by manipulating atoms and molecules at nanoscale, i.e. having one or more dimensions of the order of 100 nanometres (100 millionth of a millimetre) or less. The nanoparticles with small size to large surface area (1–100 nm) have potential medical, industrial and agricultural applications. Scientists have carried out significant efforts toward the synthesis of nanoparticles by different means, including physical, chemical and biological methods. These methods have many disadvantages due to the difficulty of scale-up of the process, separation and purification of nanoparticles from the micro-emulsion (oil, surfactant, co-surfactant and aqueous phase) and consuming large amount of surfactants. Green methods for synthesizing nanoparticles with plant extracts are advantageous as it is simple, convenient, eco-friendly and require less reaction time. Nanomaterials prepared by eco-friendly and green methods could increase agriculture potential for improving the fertilization process, plant growth regulators and pesticides. In addition, they minimize the amount of harmful chemicals that pollutes the environment. Hence, this technology helps in reducing the environmental pollutants and nanotechnology has recently gained attention due to its wide applications in different fields such as in medicine, environment and agriculture. Particularly, the large surface area offered by the tiny nanoparticles, which have high surface area, makes them attractive to address challenges not met by physical, chemical pesticides and biological control methods.

The word "nano agriculture" refers to the infusion of nanotechnology concepts and principles in agricultural sciences so as to develop processes and products that precisely deliver inputs and promote productivity without associated environmental harm. Indeed, the unique properties of materials at nanoscale make them suitable candidates for the design and development of novel tools in support of a sustainable agriculture (figure 1).

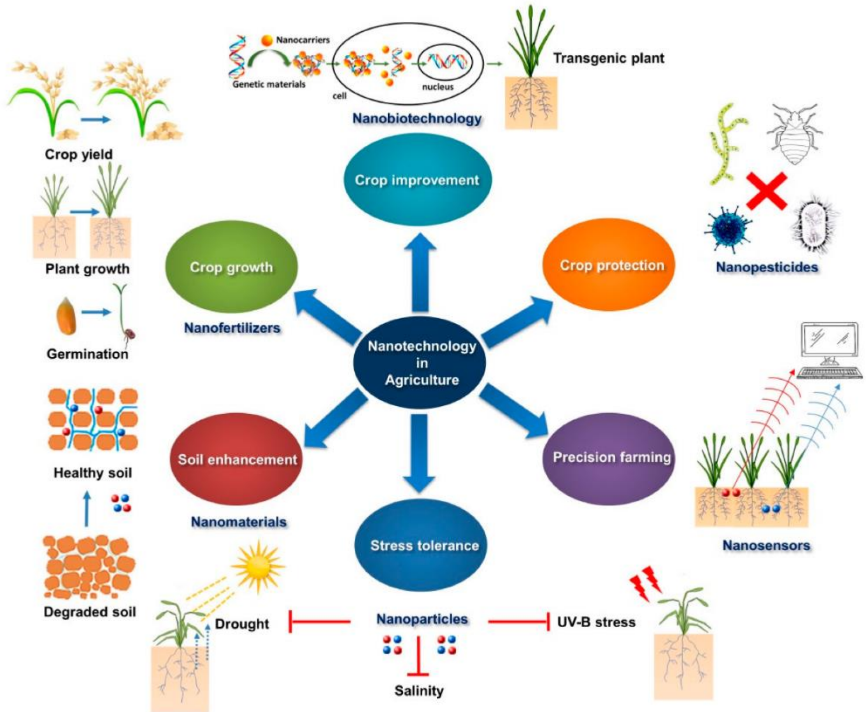

Fig. 1: Applications of nanotechnology in agriculture

The application, as an example, for the development of intelligent nanosystems for the immobilization of nutrients and their release in soil. Such systems have the advantage to minimize leaching, while improving the uptake of nutrients by plants, and to mitigate eutrophication by reducing the transfer of nitrogen to groundwater. Furthermore, it is noteworthy to mention that nanomaterials could also be exploited to improve structure and function of pesticides by increasing solubility, enhancing resistance against hydrolysis and photodecomposition, and/or by providing a more specific and controlled-release toward target organisms. Nanotechnology can increase agricultural production, and its applications include: (1) nano formulations of agrochemicals for applying pesticides and fertilizers for crop improvement; (2) the application of nano sensors in crop protection for the identification of diseases and residues of agrochemicals; (3) nanodevices for the genetic engineering of plants; (4) plant disease diagnostics; (5) animal health, animal breeding, poultry production; and (6) postharvest management. Precision farming techniques might be used to further improve the crop yields but not damage soil and water. In addition, it can reduce nitrogen loss due to leaching and emissions, and soil microorganisms. Nanotechnology applications include nanoparticle-mediated gene or DNA transfer in plants for the development of insect-resistant varieties, food processing and storage and increased product shelf life. Nanotechnology may increase the development of biomass-to-fuel production. Experts feel that the potential benefits of nanotechnology for agriculture, food, fisheries and aquaculture need to be balanced against concerns for the soil, water and environment and the occupational health of workers. Nanotechnology uses are currently being researched, tested and in some cases already applied in food technology. Nanomaterials are considered with specific chemical, physical and mechanical properties. In recent years, agricultural waste products have attracted attention as source of renewable raw materials to be processed in substitution of several different applications as well as a raw material for nonmaterial production. Insecticide resistance is one of the best examples of evolution occurring on an ecological time scale. The study of insecticide resistance is needed, both because it leads to understanding mechanisms operating in real time and because of its economic importance. It has become in insects an increasing problem for agriculture and public health. Agricultural practices could include wide range of selective regimes. Nanotechnology applications are being tested in food technology and agriculture. The applications of nanomaterials in agriculture aim to reduce spraying of plant protection products and to increase plant yields. Nanotechnology means like nanocapsules, and nanoparticles are examples of uses for the detection and treatment of diseases. Nanotechnology derived devices are also explored in the field of plant breeding and genetic transformation. The potential of nanotechnology in agriculture is large, but a few issues are still to be addressed as the risk assessment. In this respect, some nanoparticle attractants are derived from biopolymers such as proteins and carbohydrates with low effect on human health and the environment. Nanotechnology has many uses in all stages of production, processing, storing, packaging and transport of agricultural products. Nanotechnology will revolutionize agriculture and food industry such as in case of farming techniques, enhancing the ability of plants to absorb nutrients, disease detection and control pests.

Nanomaterials as Agents to Stimulate Plant Growth

Nanotechnology helps to improve agricultural production by increasing the efficiency of inputs and minimizing relevant losses. Nanomaterials are used to control the effective release of the right doses of plant nutrients which makes the fertilizer nutrients more available to the nanoscale plant pores. The application of TiO2 was reported to increase the yield by promoting growth, photosynthetic rate, and by reducing disease severity.

Nanotechnology in crop protection

Some nanomaterials can kill plant pathogenic microorganisms and resist plant viruses. Some nanomaterials can stimulate the immune system of plants. Sensors developed using nanomaterials can be used to monitor plant disease processes. Many nanomaterials, such as ZnO nanoparticles and silver nanoparticles, are available for plant disease control. We provide services for designing, synthesizing, and optimizing nanomaterials for plant disease control, and we offer services to study their disease control mechanisms.

Nanotechnology in plant genetic engineering

Nanomaterials can be made as delivery tools of nucleic acids for plant gene editing. This helps plant protection-related gene editing. We provide services to help develop passive delivery nanomaterials and precisely release controlled nanomaterials to fuel the nanotechnology application in plant editing. And we provide safety assessment services for nano-delivery materials to confirm the safety of using such nanomaterials.

Nanotechnology in stress tolerance

The application of nanoparticles helps the plant survive under stress conditions by aiding in the anatomical adaptations of the plant. The

TiO_2 nanoparticles have been successful in regulating the stomatal opening in maize plants under heat stress, thus reducing its impact.

Nanotechnology in soil improvement

Nanoparticles absorb/adsorb a large variety of contaminants and also catalyze reactions by lowering the energy required to break them down, owing to their unique surface properties. As a result, this remediation process reduces the accumulation of pollutants while limiting their spread from one medium to another.

What is the role of nano biosensors in agriculture?

Nano biosensors can be effectively used for sensing a wide variety of fertilizers, herbicide, pesticide, insecticide, pathogens, moisture, and soil pH. Taken together, proper and controlled use of nano biosensor can support sustainable agriculture for enhancing crop productivity.

Overall, nanotechnology provides creative solutions for the problems encountered by agriculture by increasing precision in monitoring soil conditions and insect infestations, optimising resource utilisation, and minimising environmental effects. Furthermore, nanotechnology can help in the development of crop types that are resilient to stress, allowing farmers to adjust to climate change and guarantee long-term sustainability in food production. The goal of the investigation of nanotechnology in agriculture is to develop farming methods that are more robust, ecologically friendly, and effective.

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Improvement of Black Pepper Production Through Biological Means Against Foot Rot (Quick Wilt) Disease

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Black pepper (*Piper nigrum* L.) is a major export-oriented spice crop of India. In Namakkal district it is cultivated in an area of 2340 ha with a productivity of 0.2 tonnes / ha (Source: Department of Horticulture, Namakkal, 2022). In Elangiyampatti village of Kollihills, the pepper plantation is mainly affected by foot rot disease caused by *Phytophthora capsici*, but growers do not take any control measures, either prophylactic or curative. Some growers spray one per cent Bordeaux Mixture or 0.2 per cent Copper Oxy Chloride before the onset of North East Monsoon. This disease became very severe during May – June and October to January, which resulted 50 – 90 % of drying of pepper vines and 90 % reduction in pepper yield. It is the most destructive of all diseases and all parts of the vine are vulnerable to the disease and the expression of symptoms depend upon the site or plant part infected and the extent of damage. Being a soil borne pathogen, the fungus infected all parts of the plant. Infection at the collar region resulted in sudden wilting, defoliation and death of vines.

Phytophthora capsici of class Oomycetes can survive in a wide range of environmental conditions. The pathogen survives in the soil on infected plant debris throughout the year, which serves as the primary inoculum source in pepper plantations of Kollihills. Disease spread is through soil, water, rain splash, root contact, contaminated materials, termites and slugs. Low temperature (22.7-29.6^{0}C), shorter duration of sunshine hours (2.8-2.5 h/day) high rainfall (>16 mm/day) and high relative humidity (>71%) contributed towards increase of disease incidence and severity. The infections are initially noticed with the onset of monsoon during May-June period on tender runner shoots which lay spread on the ground. Abundant spores, produced on rotting shoots get splashed around during rain, infecting nearby leaves and stem. With continuous rain splashing the pathogen spread from lower leaves to upper portion of the vine in a step wise fashion. However, root and collar infections continue so long as soil moisture level is conducive even after monsoon in pepper plantations of Kollihills.

Fig 1: Appication of IISR Microbial consortium to the foot rot affected plants

Fungicidal spray of black pepper against foot rot disease has been adopted by some farmers as an Integral part of maintenance of pepper plantations in Kollihills. The practice of spraying fungicides has been routinely carried out in the pepper plantations. However, satisfactory control of the disease was not observed resulting in steep fall in pepper yield year after year.

Activities implemented by KVK to tackle the problem

In order to address these issues in Pepper plantations in Kollihills, KVK, Namakkal has conducted various programmes including FLD on Biological control of foot rot in pepper plantation, off campus trainings, field visit, regular advisory services, demonstration, creating awareness through publications by newspaper and radio talk at Tribal Sub Plan village Elangiyampatti.

The FLD programme was conducted at 25 tribal farmer's field in an area of 5 ha on the black pepper variety Panniyur 1 of 5 -15 years old vine. For each demo 200 vines were used. Bio agents such as

IISR Tricho & PGPR capsule (each 3 capsules /farmer – 1 capsule dissolved in dissolved in 200 litre of water

Fig 2: Application of IISR and PGPR capsule solution to the foot rot affected pepper vines

and it was applied @ 1 litre / vine during the month of July, August and September) and each 5 kg of IISR microbial consortium and pepper booster were supplied to per farmer. Since black pepper is cultivated under the mixed farming system in Elangiyampatti, the age of the pepper vine is very old and fertility of the soil is reduced. Soil nutrient depleted by continuous cropping. Hence IISR Micorbial Consortium comprising the combination of three microorganisms namely *Micrococcus luteus, Enterobacter aerogenes* and *Micrococcus sp,* which effectively reduced the foot rot incidence and it was applied @ 50 gm / vine along with 3 kg of FYM for faster multiplication of beneficial microbes during the month of July. In addition to that Soil application IISR Pepper booster @ 5g/litre of water was done once during spike initiation stage and another after 2 months.

Output of the intervention

Fig 3: Dried pepper yield obtained from foot rot recovered pepper plantation

Better management of foot rot through timely application of *IISR Tricho* capsules and *PGPR* capsules was observed in demo fields of Elangiyampatti village and farmers felt that capsule form of *T.harzianum* application is very easy when compared to talc formation. The observations on the management of phytophthora foot rot disease in black pepper revealed that reduction of foot rot incidence (82%), less foliar yellowing (14%), less defoliation (17 %), less death of vines (5 %), highest dry berry yield of 1.32 kg per vines and highest net return (Rs.101060/ 0.4 ha) when vines were applied with IISR Tricho, PGPR capsule, IISR microbial consortium and pepper booster in the root zone area during the month of July, August and September. This might be due to suppression of phytopthora population in the soil by timely application of bio inputs, also increase the beneficial microorganism in the root zone area of pepper to combat the foot rot incidence. Enhanced soil nutrient status by application of microbial consortium and pepper booster improved the vegetative and yield performance of pepper vines. Black pepper vines were severely affected by disease with foliar yellowing (45 %), defoliation (57 %) and death of vines (15%) in farmer's practice, application of butter milk (10 lt + 10 lt water = 500 ml / vine at 2 months interval) as soil drenching once after the disease appearance and only to affected vines.

Table 1. Yield performance of Demo vs Farmers practice field

Parameter	Demo	Farmers practice
Yield / vine (kg)	1.32	0.87
Yield (kg / 0.4 ha)	476	315
Reduction of foot rot (%)	82	55
Foliar yellowing (%)	14	45
Defoliation (%)	17	57
Death of vines (%)	5	15
Gross cost (Rs/0.4 ha)	89340	87250
Gross income (Rs/0.4 ha)	190400	126000
Net returns (Rs/ha)	101060	38750
B:C ratio	2.13	1.44

Outcome and impact

Farmers from Elangiyampatti, Vasalurpatti and Veeraganurpatti villages of Kollihills used *Trichoderma harzianum* for the management of foot rot in black pepper in an area of 52 ha. In addition to that, Department of Horticulture, Kollihills also provided bio inputs for the management of foot rot under Hill area development programme. Foot rot incidence was (82 %) effectively controlled by the application of bio inputs and also improved the livelihood security of the pepper growers.

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Lifestyle Predictors of Women Undergoing In Vitro Fertilization

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Abstract

Lifestyle factors play a significant role in individuals' fertility related problems. The lifestyle choices including delayed child birth, delayed start in family making and habits like smoking, consuming high fat diet, drinking caffeinated beverages, less physical activity, greater amount of alcohol consumption, drug abuse and experience of anxiety and depression will make individuals fertility life worse. The article explores how lifestyle factors contribute to fertility life of a women undergoing in vitro fertilization.

Introduction

In every living being, reproduction is a vital biologic event. Since the reproductive health of the parent species is essential to the continued existence of any species, any potential threat to reproductive health will elicit an intense reaction from the scientific community. According to WHO (2022) estimates suggest that between 48 million couples and 186 million individuals live with infertility globally. Given that the most of the infertility cases are preventable and the magnitude of the issue requires immediate action. Global data from the last five to six decades indicate that modifiable lifestyle factors have contributed to declining reproductive health indices, particularly in industrialized and developed nations (Kumar *et al.* 2018).

Lifestyle factors refers to modifiable behaviours and lifestyle choices that may have an impact on an individual's overall health and well-being, including fertility (Acharya & Gowda 2017). Role of lifestyle factors in the history and causes of infertility has developed a growing interest in researchers. Numerous authors have reported the evidence of an association of certain lifestyle choices to infertility in both males and females. These lifestyle choices include delaying having children in order to pursue a career or further education, delaying starting a family until later in life, smoking, consuming diets high in fat, drinking coffee and alcohol, exercising, abusing drugs, experiencing anxiety or depression, using cell phones, and exposure to radiation.

Fortunately, the majority of infertility problems can be addressed with significant treatments like assisted reproductive technologies (ART). On the other hand, normalizing a few modifiable lifestyle factors may allow women to resume normal oocyte maturation and males to produce better-quality semen (Ilacqua *et al.* 2018).

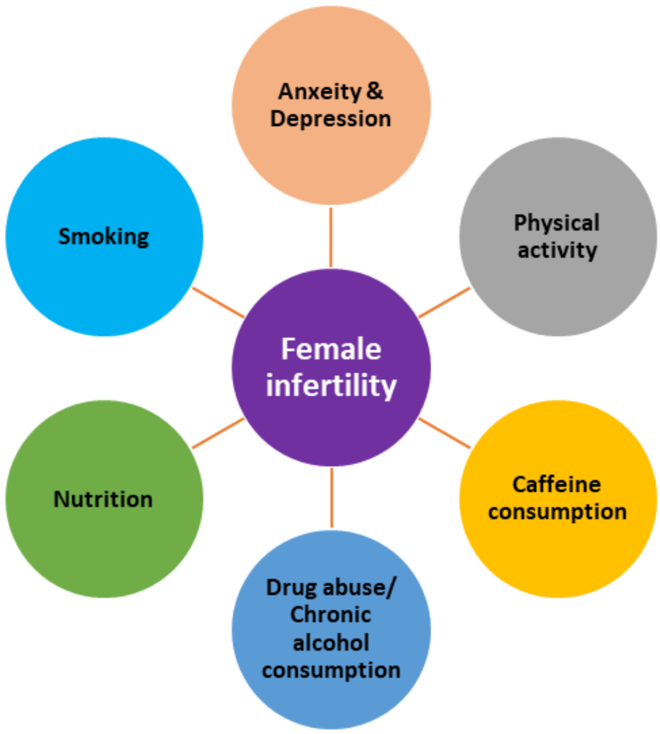

Fig.1 Diagrammatic representation of lifestyle behaviours in females

Lifestyle predictors of women undergoing IVF

Nutrition

Nutritional problems in developed countries are often associated with eating disorders and obesity, where as in developing nations, the primary nutritional challenges are deprivation, undernutrition, and malnutrition. In females, reproduction involves much greater energy expenditures than in males. However, as a protective mechanism against under-nutrition, ovarian activity is suppressed in women with eating disorders and exercise-induced amenorrhea through pathways in the hindbrain.

Evidence, indicates that among women undergoing IVF treatment, healthy eating habits, such as eating fruits and vegetables, are linked to a better chance of pregnancy and live birth (Neamtiu *et al.*, 2022).

Smoking

Cigarette smoking has been significantly associated with adverse effects on fertility even though not widely recognized, as it is significantly lessening the chances of conceiving from in vitro fertilization. The reproductive toxicants present in tobacco smoke may affect the endometrial vascularization & myometrial relaxation, results in pregnancy loss and IVF implantation failure.

Anxiety & Depression

Some authors witnessed that anxiety and depression could adversely impact the fertility Because, anxiety and depression could activate an inhibitory effect on the female reproductive system. The hormones like Corticotrophin releasing hormone (CRH) inhibits the hypothalamic gonadotropin-releasing hormone (GnRH) secretion and glucocorticoids inhibit the pituitary luteinizing hormone and ovarian estrogen & progesterone secretions which are responsible for the 'hypothalamic' amenorrhea.

Physical Activity

Regular exercise increases the insulin sensitivity and also improves ovarian functioning which further may improve the chances of achieving conception.

Caffeine Consumption

Caffeine is a stimulant that is used as a beverage like tea, soft drink, chocolate, etc. It contains more than a thousand active ingredients, or stimulants. The high consumption of caffeinated drinks has a significant impact on the reproductive system as well as the brain system and other organs. Consumption of more than five cups or 500 mg of caffeine a day can cause a pregnancy delay. Further, it interrupts the process of fertilizing and implanting eggs (Olsen, 2018).

Drug Abuse or Alcohol Consumption

Women are more likely than men to take pharmaceuticals drugs over the long term because of differences in physiology, weight, hormone levels, and other factors that can impact how these substances are metabolized in the body (Center for Behavioral Health Statistics and Quality, 2017). Women are more vulnerable to Human Papilloma Virus (HPV) and other sexually transmitted infections (STIs). This condition is intensely associated with a higher incidence of cervical cancer in females.

Alcohol enables the body to deplete a many essential vital nutrients, like calcium, salt, potassium, iron, magnesium, zinc, vitamin B, and so on. Most bodily processes depend on these vitamins and minerals, including reproduction. Women's reproductive potential and ovarian reserve may deteriorate as a result of long-term excessive alcohol use. It has been found that alcohol users have lower levels of ovarian reserve and reproductive potential markers (FSH, anti-mullerian hormone (AMH), and antral follicle count) than non-users (Emokpae *et al*, 2021).

Conclusion

Most of the lifestyle factors were modifiable. Women adopting healthy lifestyle which includes nutritious food with high protein dietary intake, regular exercise, avoiding consumption of caffeinated beverages, alcohol, smoking and less exposure to stressful situations helps in promoting the healthy reproductive age years. Since most people are unaware of the significant impact of lifestyle choices on infertility, health care professionals' public education efforts will substantially improve public knowledge and awareness regarding adopting better lifestyle choices.

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Adopt Subsidiary Occupations for Employment and Income

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Nearly 85 per cent of farmers are small-holding farmers having less than 5 acres of land under cultivation in the country. Due to lack of knowledge and experience for any occupation other than agriculture, these people are also deprived of other employment opportunities. The development of the country is possible only with the economic development of this section. The concerted efforts needs be made to encourage the farmers to take up subsidiary occupations so that they can utilize their free time by doing some economic activity to increase their income. It is high time for farmers to realise that they have to break the vicious cycle of wheat-paddy cultivation and have to opt for subsidiary occupations like pig farming, fishery, poultry and dairy farming.

With the increasing mechanization, the work for agricultural workers is decreasing. On the one hand, farming costs are increasing, while on the other hand, unemployment is increasing among the agricultural workers. Subsidiary occupation can prove to be very effective in employing such replaced manpower from the agriculture sector. Dairy farming, goat rearing, mushroom cultivation, bee keeping, pig rearing, etc. can be adopted as subsidiary occupation along with farming. Information and trainings related to these occupations can be taken either from the agricultural universities or *Krishi Vigyan Kendras*. The financial assistance for starting a new business is also provided by commercial as well as cooperative banks. Apart from this, farmers may contact the Department of Animal Husbandry and Department of Horticulture of the state regarding the provision of subsidy for these enterprises.

Self-marketing in dairy business staring from small scale with good breed cows/buffalos provides both work and profit. Fishing in empty village ponds may be encouraged. Landless workers can also start their work after taking expertise for honey bees. Rearing of broiler (meat chicken) is also very profitable. Mushroom cultivation can be done easily. Processing of fruits and vegetables can increase the work and profits manifold. The products produced from subsidiary occupations may be better marketed in own locality/village. In this regard, the government should support the farmers by creating necessary infrastructural facilities. Financial and technical assistance should also be provided by the government to establish small scale industries in villages. The cooperative societies can play major role bolstering small farmers if they are run by honest, competent and consensually elected representatives. Rural women can increase their household income through these occupations. Farm women should be provided with first hand training in preparing pickles, jams, *chutneys*, *murabba*, etc, to enable them to earn more with little efforts. Besides, at the time of glut in the market, the produce can be stored at home, cleaned and sealed in packets/boxes, etc. and sold at a higher price later on. Farmers can set up small sales centres in town or village at their own level to sell their produce directly to the consumers. Under the ATMA Scheme under the Department of Agriculture and Farmers' Welfare, the sale points (ATMA Hut) are provided to farmers where they can sell their products. Consumers also get clean and pure products in this type of market.

Educated youth of villages can earn good income by opening custom hiring centres to provide farm machinery and implements on rent. To purchase farm machinery, the state government provides subsidy to the extent of 50 per cent for individual farmers and 80 per cent to the cooperative societies and the group of farmers (8 to 10 farmers). The agro processing complexes needs to be installed in rural areas to provide employment to the unemployed rural youth. To increase their efficiency to earn more and enhancing their standard of living, various skill development trainings should be imparted to them. This may also help to decrease the trend of migration to the foreign countries in order to find their livelihood and will clear up the negativity/depression from the minds. A skilled person has no shortage of work but the skills need to be gotten polished to fetch more work, money and recognition.

Table 1: Returns from some important subsidiary occupations (Rs/annum)

S. No.	Subsidiary occupation	Scale of business	Gross returns	Total costs	Net returns (Approximate)
1.	Mushroom cultivation (Button mushroom)	30 sq m area (8 quintals wheat straw)	40,000	17,050	22,950
2.	Bee keeping	50 colonies (Stationary)	1,69,000	94,590	74,410
		100 colonies (Migratory)	7,75,000	3,02,713	4,72,287
3.	Dairy farming	10 buffaloes	11,43,525	9,94,583	1,48,942
		10 hybrid cows	12,47,375	10,14,173	2,33,202
4.	Poultry farming (Cage system)	1000 layers (300 eggs/layer/annum)	17,43,000	14,65,790	2,77,210
5.	Goat rearing	100 does + 5 bucks	14,16,610	10,31,203	3,85,407
6.	Piggery	10 sows + 1 boar	13,90,800	11,11,248	2,79,522
7.	Fish farming (Carp fish)	One acre	2,00,000	1,12,500	87,500

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Role of Women in Sericulture in India

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Abstract

Sericulture is an important means for generating employment, income enhancement crop enterprises, and is a most appropriate household activity. In all these activities, women have shown their mettle and performed their tasks most skillfully. The active involvement of women is very essential for the success of the any community development initiative. Their qualities like maternal instincts and loving care of those under their charge prove to be very helpful in the successful breeding of silk worms. It is conducted by the lightest labour. In fact, almost 90 percent of the Sericulture activities, except strenuous and hard jobs like land digging, ploughing and carrying heavy loads, women can carry on almost all works in mulberry cultivation, silkworm rearing, silk reeling, weaving, printing, etc. They also share the tasks of weeding, levelling, inter-cultivation, pruning and irrigation, raising of mulberry nursery, planting and establishment of mulberry also involve more women.

Introduction

Sericulture is one of the most labour-intensive sectors, combining activities of both agriculture (sericulture) and industry. It suits both marginal and small-scale land holders because of its low investments, high assured returns, short gestation period, rich opportunities for enhancement of income and creation of family employment round the year. It being an agro-based enterprise, plays a predominant role in shaping the economic destiny of the rural people. In India, women are mostly found as the major activist in sericulture, Presently, about 60% of total working force contributing in sericulture as worker in raising food plants, leaf collection, silkworm rearing, reeling/spinning and weaving is women. It is an occupation by women and for women because women form more than 60% of the workforce and 80% of silk is consumed by them.

Sericulture is one of such activities which open up the scope of inclusive development through promoting the marginal sections, known as 'women'. Here, most of the works are carried out by women alone, both in terms of operations performed and time invested. Thus, in a way, women contribute a significant role in different spectrum of work activities as well as in decision-making. While in general perception, women's role is mostly confined in silkworm rearing, in reality it goes beyond. (Rubia *et al.* 2019).

Sericulture is unique in its vast employment and income generating potentialities. From a mere traditional practice, it has now shaped into a viable agroindustry. India contributes about 20% to the raw silk produced in the world, ranking next only to China. It occupies only 2.4% of the world's land area but it supports over 15% of the World's population. In India, women constitute almost half of the population (men and women ratio = 1.0: 0.933). About 380 million labour forces (15 – 59 years old) are available in India, of which 51% is in agriculture and agro based industry. Majority of labour force is village-based accounting for a total of about 264 million and rural women labour account for about 83 million, representing 31.5% of the rural labour force (Source: Census report, Govt. of India, 1991).

Role of women in Sericulture

As women has a crucial role in the activities of sericulture, it equally creates opportunities and make them independent socially, economically, politically. Women are mostly favoured because of their industrious nature. They are employed in a mulberry garden or silkworm rearing or in a grainage or in weaving or in a garment-making factory, and so on. As mentioned earlier, sericulture offers a vast scope to augment the family income.

Women are actively engaged in the mulberry fields for the removal of weeds and in leaf plucking. The leaf plucking is a skilled and delicate operation. The workers must have full knowledge about which leaves to be plucked to suit different ages of silkworms. Women go to the fields in the morning for plucking the mulberry leaves and return to the rearing house before noon. In the rearing house, it is not uncommon to find women folk assisting men in feeding the silkworms. Feeding is an art very aptly done by the fair sex, though men do chopping of leaves. Women assist in bed changing and they do this with utmost tenderness, so as not to hurt the delicate worms.

Women have become experts in Chawki rearing, which is a highly delicate operation that needs to be performed with a great deal of care and patience. Good harvests depend on good Chawki rearing. When the silkworm matures and time is ripe for spinning the cocoons, it is again women who are employed for picking the ripe worms and putting them on the chandrikas (bamboo mountages on which silkworms are placed when they are just about to spin their cocoons).

Any overcrowding will lead to an increase in the spinning of double cocoons, which would be unsuitable for the production of high-grade raw silk. When the cocoons are ready for harvesting, it is mostly women who sort out the flimsy, stained, double, and deformed cocoons from the Chandrikas (Eswarappa, 2013).

Conclusion:

Sericulture also creates gainful employment for women and aged persons at homes at minimum risk. Women has patience, perseverance, caring attitude and adaptability to new technologies have made her activities more dominant in sericulture and silk production. It has opened up phenomenal employment avenues and helped women to become important players in the decision-making process—whether in the household or in the community at large. The active involvement of women is very essential for the success of the any community development initiative. It is providing stable income to many rural agricultural families and a livelihood to scores of landless farm and non-farm women labourers giving much economic strength. Unless these benefits also bring in social development and improvement in the lifestyle of these families, they cannot serve the very purpose of development.

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Remote Sensing: An Application in Agriculture

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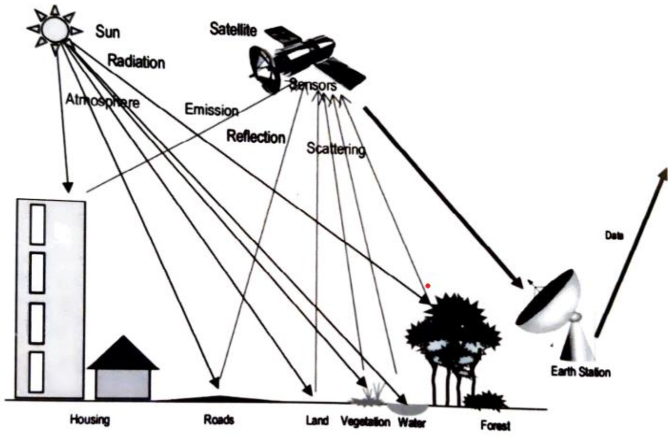
Remote sensing is the art and science of obtaining information about an object without coming in physical contact with it. According to Nicholas Short, remote sensing is a technology that uses electromagnetic radiation sampling to collect and read non-immediate geographical data that can be used to gather information about features, objects and the earth's surface, oceans, and atmosphere. The information can be gathered in a variety of ways, including differences in electromagnetic energy, variations in wave dispersion, and variations in acoustic force distribution. EMR remote sensing is primarily utilized in agriculture that is based on electromagnetic radiation.

Remote sensing works on the principle that electromagnetic radiation emitted from an item is measured in remote sensing and converted into data about the object or processes connected to the object. Different objects reflect or emit different amounts of energy in different bands of the electromagnetic spectrum. The amount of energy reflected or emitted depends on the properties of both the material and the incident energy (angle of incidence, intensity and wavelength). Detection and discrimination of objects or surface features is done through the uniqueness of the reflected or emitted electromagnetic radiation from the object.

Along with field observations, it can also be used for crop growth monitoring, land use pattern and land cover changes, water resource mapping and water status in the field, disease and pest monitoring, yield estimation, harvest date forecasting, precision farming, and weather forecasting. In essence, the detecting of earth's resources is done through remote sensing techniques. By providing fast, synoptic, cost-effective, and repeatable information on the earth's surface, remote sensing data can significantly contribute to the monitoring of earth's surface features (Justice *et al.*, 2002). Remote sensing inputs combined with crop simulation models are very useful in crop yield forecasting.

Agricultural application of remote sensing

In recent years, the research of agricultural remote sensing has focused increasingly on describing the biophysical traits of plants. Agriculture-related activity analysis and monitoring have long been done using remote sensing. Agronomic characteristics can be better understood thanks to remote sensing of crop



canopies. Remote sensing's advantage is its capacity to deliver consistent data without harmful crop sampling, which can be used to deliver important data for precision agricultural applications. Remote sensing provides a cheap alternative for data acquisition over large geographical areas (De-beurs and Townsend, 2008).

The main applications of satellite remote sensing in India are for estimating crop production and crop acreage. Based on the biophysical characteristics of crops and/or soils, remote sensing technology has the potential to revolutionize the detection and characterization of agricultural productivity (Liaghat & Balasundram, 2010).Remote sensing along with GIS is highly beneficial for creating spatio-temporal basic informative layers which can be successfully applied to diverse fields including flood plain mapping, hydrological modelling, surface energy flux, urban development, land use changes, crop growth monitoring and stress detection (Kingra *et al.*, 2016). The advances in the use of remote sensing methods are due to the introduction of narrow band or hyperspectral sensors and increased spatial resolution of aircraft or satellite mounted sensors. Hyperspectral remote sensing has also helped to enhance more detailed analysis of crop classification.

Crop condition assessment

Remote sensing can play an important role in agriculture by providing timely spectral information which can be used for assessing the Bio-physical indicators of plant health. The physiological changes that occur in a plant due to stress may change the spectral reflectance/ emission characteristics resulting in the detection of stress amenable to remote sensing techniques (Menon, 2012).

Crop monitoring is required at regular intervals throughout crop growth in order to take the proper action and to determine the likelihood of output loss due to any stressor. A number of variables, including the amount of soil moisture present, the date of planting, the air temperature, the length of the day, and the soil condition, affect the crop's development and growth phases. These elements are in charge of the health and productivity of the plants. For example, corn crop yields can be negatively impacted if temperatures are too high at the time of pollination. For this reason, knowing the temperature at the time of corn pollination could help forecasters better predict corn yields (Nellis *et al.*, 2009).

Nutrient and water status

Nutrient and water stress management are the most significant domains where we can choose to apply remote sensing and GIS through the implementation of precision farming. The use of precision agricultural technologies can enable the wise use of water in semi-arid and arid locations. For example, drip irrigation coupled with information from remotely sensed data such as canopy air temperature difference can be used to increase the water use efficiency by reducing the runoff and percolation losses (Das and Singh, 1989).

Crop evapotranspiration

Crop production is declining as a result of rainfall inconsistencies, temperature increases, and other factors that lead to a reduction in soil moisture. A long-term average condition of the balance between precipitation and evapo-transpiration in a specific location is known as a "drought," which also depends on the monsoon's timely arrival and strength Glantz and Wilhite, (1985). Sruthi *et al*., (2015) analyzed the vegetation stress in the Raichur district of Karnataka by using the MODIS data for calculating NDVI values of the particular study area and its correlation with the land surface temperatures (LST). Estimation of evapotranspiration is essential for assessing the irrigation scheduling, water and energy balance computations, determining crop water stress index (CWSI), climatological and meteorological purposes. The energy emitted from cropped area has been useful in assessing the crop water stress as the temperature of the plants are mediated by the soil water availability and crop evapotranspiration.

Weed identification and management

Precision weed management technique helps in carrying out the better weed management practices. Remote sensing coupled with precision agriculture is a promising technology in nowadays. Though, ground surveying methods for mapping site–specific information about weeds are very time– consuming and labor–intensive. However, image–based remote sensing has potential applications in weed detection for site– specific weed management (Johnson *et al.*, 1997; Moran *et al.*, 1997; Lamb *et al.*, 1999). Remote sensing technology offers a way to identify weeds in crop stands and further aids in the creation of weed maps in the field so that site-specific and need-based herbicides can be applied for the management of weeds. This is based on the difference in the spectral reflectance properties between weeds and crop. In solid stands or pure wheat plots, Kaur et al. (2013) reported higher radiance ratio and NDVI values, and lowest values under solid weed plots. Beyond 30 DAS, it was found that pure populations of *Rumexspinosus* and pure populations of wheat could be discriminated using radiance ratio and NDVI.

Pest and disease infestation

For measuring agricultural stress brought on by biotic and abiotic variables, remote sensing has become a crucial technique. For establishing plans to prevent their expansion and implementing efficient control measures, it is necessary to perfect remote sensing approaches for identifying insect breeding areas. With the assumption that these differences can be correlated, categorized, and interpreted, the remote sensing approach to assessing and monitoring insect defoliation has been used to relate differences in spectral responses to chlorosis, yellowing of leaves, and foliage reduction over a given time period (Franklin, 2001).

Detecting and mapping defoliation, characterizing pattern disruptions, and supplying data to pest management decision support systems are just a few of the uses for remote sensing that have been used (Lee *et al.*, 2010). In order to distinguish between good and unhealthy vegetation cover, William et al. (1979) analyzed various types of vegetation indices on Landsat imagery obtained before and after defoliation.

Crop yield and production forecasting

Based mostly on statistical-empirical correlations between agricultural production and vegetation indices, remote sensing has been utilized to anticipate crop yields (Thenkabail *et al.*, 2002; Casa and Jones, 2005). Planning national food policy requires knowledge on crop productivity prior to harvest. An essential element of agricultural output forecasting is a reliable crop yield.

Precision agriculture

Remote sensing technology is a key component of precision farming and is being used by an increasing number of scientists, engineers and large-scale crop growers (Liaghat and Balasundram, 2010). The main aim of precision farming is reduced cost of cultivation, improved control and improved resource use efficiency with the help of information received by the sensors fitted in the farm machineries. Variable rate technology (VRT) is the most advanced component of precision farming. Sensors are mounted on the moving farm machineries containing a computer which provides input recommendation maps and thereby controls the application of inputs based on the information received from GPS receiver (NRC, 1997). The advantage of precision farming is the acquisition of information on crops at temporal frequency and spatial resolution required for making management decisions. Remote sensing is a no doubt valuable tool for providing such information. Bagheri*et al*., (2013) used multispectral remote sensing for site- specific nitrogen fertilizer management.

Future prospects

Even at small farm holdings, remote sensing is quite helpful in identifying and managing a variety of crop difficulties. It is also very helpful in analyzing various abiotic and biotic stresses in different crops. It is necessary to establish a state- or district-level information system based on the information that is now available on different crops gathered through remote sensing and GIS techniques in order to properly use the information on crops for improving the economy. The governments can use remote sensing data in order to make important decisions about the policies they will adopt or how to tackle national issues regarding agriculture. A new and nontraditional remote sensing application involves the implanting of nanochips in plant and seed tissue that can be used in near-real time to monitor crop. Clearly, these and other new approaches will reinforce the importance of remote sensing in future analysis of agricultural sciences.

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Success Story of an Agriculture Graduate in Production of Millet and Fruit Cakes

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Abstract

Salem Krishi Vigyan Kendra has been working through various programs to improve the economy of farmers and farm women in Salem District. Need based trainings are being conducted continuously related to processing and value addition of horticultural crops and minor millets to develop entrepreneurs among farmers, farm women, unemployed rural youths etc.,. Mrs. Sujatha, an agriculture graduate from Salem district, who attended this training, was motivated and inspired after gaining awareness about value addition techniques in horticultural crops and minor millets. With motivation and enthusiasm from KVK Scientists, she started a cake making business under the name of Tamizh Cakes. She was introduced to other farmers, farm women and entrepreneurs by KVK, Salem as a budding entrepreneur.

Introduction

Salem Krishi Vigyan Kendra has been working through various programs to improve the economy of farmers, women and unemployed graduates through dissemination of modern agricultural techniques through on farm trials, front line demonstrations and various trainings. It has been conducting continuous trainings on processing and value addition of horticultural crops and minor millets for the benefit of farmers, women agriculturists, rural youths, students, Anganwadi workers and other extension officers and entrepreneurs.

An agriculture graduate developing into an entrepreneur

Mrs. Sujatha, an agriculture graduate from Salem district, who attended this training, was motivated and inspired after gaining awareness about value addition techniques in horticultural crops and minor millets. Sujatha, who was unable to pursue higher studies in agriculture, stayed at home during the Corona period and gained awareness about value addition by participating in various online training courses conducted by the Tamil Nadu Agricultural University and Salem Krishi Vigyan Kendra.

In the above training courses, she learned through agricultural scientists that the good food products provided with better nutrition and creativity will be very well received in the market and will become a profitable venture in the industry. She was encouraged to know details of various post-harvest technologies, value addition techniques, marketing techniques, business start-up grants, incentives and grants. She decided to start a business through an innovative technology in millets value addition.

Presently there are many problems in transporting our ancient minor millets to the consumers. To correct it, she succeeded in preparing different types of cakes innovatively with millets and fruit crops like banana through awareness got from advisories of KVK scientists.

Cake making, which entered our India through the British, has now become a very modernized industry and is very popular with the consumers nowadays especially during important events such as birthdays and important celebrations. However, additives like maida, sugar and the mixture of chemicals cause allergies to our body and harm our health. That's why Sujatha believed that it would be a very good business to make the cakes in a healthy and hygienic manner without the addition of maida, sugar and chemicals. So by using minor millets, pulses like horse gram and horticultural crops like banana, she started to produce different varieties of cakes using jaggery.

Route map to Tamizh Cakes

Sujatha tried to make various types of cakes in a healthy way with more taste by using millets like ragi, cumbu, thenai, pulses like green gram, horse gram and fruits like mango, banana and native sugar. Although many attempts failed in the beginning, her continued perseverance gradually brought her success. She made millet fruit cakes and set a good example for entrepreneurs in the training classes of KVK, Sandhiyur, Salem.

Her products were well received by the consumers and she shared her new range of cakes among her relatives and friends. Many suggested corrections and ideas. Accepting them, Sujatha succeeded in innovating her cake making business.

With motivation and enthusiasm, she started a cake making business under the name of Tamizh Cakes. She was introduced to other farmers, farm women and entrepreneurs by KVK, Salem as a budding entrepreneur.

Tamil Cakes were featured in the programs of Salem District Collector's Office, Exhibition organised by KVK, Salem in association with Periyar University on Minor Millet Foods and Annual Millet Festival organized by Tamil Nadu Agricultural University in Coimbatore. She succeeded in millet banana cake preparation through these different initiatives and her continuous hard work, she was introduced to many entrepreneurs.

Also, many things were shared about not only production but also marketing in the industry. With that motivation, she made efforts in many ways to produce and market millet banana cakes. She made efforts to expand her business through modern technologies like Whats App, Instagram, Facebook, etc. Gradually many opportunities came up.

She ensured the quality of food products by using cleanliness, hygiene, healthy ingredients and natural colors to provide healthy food that does not compromise on taste. Also got food quality certificate as per the guidelines of KVK scientists. She specializes in taking cake orders for home, office functions, etc.,

Apart from that, she shares his business strategies with the farmers and women who participate in training at Salem KVK and encourages them to start such businesses. At present, she is participating as an instructor in the Panamaratpatti district office's self-help groups and is giving training to many women to become entrepreneurs.

To expand her business in the future, she is taking initiatives to collaborate with food selling platforms like Amazon, Flipkart, Zomato, Swiggy. There is no doubt that her efforts will win surely in the near future.

"Minor millets are our past, Let's innovate them, Let's achieve so many benefits"

Conclusion

KVK, Salem succeeded in developing an entrepreneur in millet and fruit cake making business through trainings and demonstrations apart from farm advisories. Tamizh Cakes of Mrs. Sujatha is such a model and lead entrepreneur in Salem District.

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Cultivating Sustainability: Harnessing Paddy Straw Management to Mitigate Carbon Footprint

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Rice is the staple food for much of the world's population, particularly in Asia (Singh *et al.*, 2016), but its production generates massive amounts of straw, with the straw-to-paddy ratio ranging from 0.7 to 1.4 depending on variety and growth. Paddy straw production on a global scale ranges from 800 to 1,000 million tonnes per year, with Asia producing 600 to 800 million tonnes per year (IRRI). Each kg of milled rice produced yields approximately 0.7-1.4 kg of paddy straw (Bakker *et al.*, 2013), implying that for every tonne of rice grain produced, 700 to 1500 kg of paddy straw is produced, depending on variety, stubble-cutting height, and moisture content during harvest. Only 20% of paddy straw is currently used for practical purposes, such as the production of biofuels, paper, biofertilizers, and animal feed; the rest is either burned in place, incorporated into the soil, or used as mulch for the crop that follows. However, incorporated paddy straw degrades slowly and may harbor diseases, whereas burning is becoming socially unacceptable due to extensive atmospheric pollution, including greenhouse gas (GHG) emissions and smoke. In terms of GHG emissions, burning one kilogram of dry paddy straw produces nearly 700-4100 mg of methane (CH_4) and 19-57 mg of nitrous oxide (N_2O) (Bhattacharyya *et al.*, 2021). These contribute directly to environmental pollution and are also to blame for the haze in the National Capital Region (NCR) and the melting of Himalayan glaciers. Nonetheless, the practices and their negative consequences have spread across India's states.

Burning paddy straw raises soil temperatures to 33.8 to 42.2 ^{o}C (Singh and Verma, 2021) and harms beneficial soil organisms, leading to increased pest susceptibility and reduced solubility capacity. Sustainable solutions are needed to improve rice production while using paddy straw for soil conditioning via composting and carbonization, as well as for bio-energy production and material recovery such as silica and bio-fiber (for industrial use). Even if all of the possible options are not economically viable.

Pusa Decomposer

The Pusa bio-decomposer, developed by IARI, is a cost-effective microbial agent that accelerates the decomposition of crop residues, particularly paddy stubble. It's created from seven fungi strains that produce enzymes like pectin, cellulose, and lignin, enhancing straw decomposition. Farmers make a liquid solution using these capsules, which ferments for 8 to 10 days. This mixture is then sprayed on fields with crop stubble to expedite decomposition. Using 4 capsules, jaggery, and chickpea flour, farmers can prepare 25 liters of the solution, which, when diluted with 500 liters of water, covers one hectare and decomposes the stubble in about 20 days (Tiwari *et al.*, 2022).

Fig. 1. Pusa Bio Decomposer

Biochar

Biochar is a carbon-rich, consistent, and long-lasting product that farmers use to improve soil health and quality. Biochar is produced by thermally treating paddy straw. Carbonization, combustion, torrefaction, gasification, and pyrolysis are among the thermal treatments used in biochar production. Because of its simplicity and effectiveness, pyrolysis is the most popular technique for producing biochar. Pyrolysis can be accomplished in a furnace under oxygen-deficient conditions. Biochar has shown promise in improving soil carbon sequestration, increasing crop productivity, remediating contaminated soil and water, reducing greenhouse gas emissions, and reducing nutrient leaching (Tokas *et al.*, 2021).

Burning Issues and Alternative Management Options

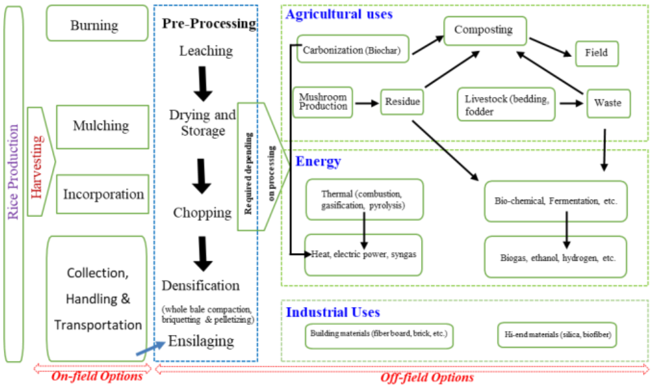

Fig. 2: Paddy-straw management options (Gummert et al., 2020)

In multi-cropping systems, intensification of rice-cropping systems has been linked to the use of high-yielding, short-duration varieties with shorter turnaround time between crops. Furthermore, the rapid introduction of combine harvesters is a game changer due to the increased amounts of straw left on the field. Because of the high labour cost, manual straw collection in the field is unprofitable. In intensive systems with two to three cropping per year, incorporation poses challenges. This is due to a lack of time for decomposition, which results in straw with poor fertilization properties for the soil and hinders crop establishment. As a result, despite being prohibited in most rice-growing countries due to pollution and health risks, open-field burning of straw has increased dramatically over the last decade. As a result, it is critical to seek out sustainable solutions and technologies that can both reduce environmental impact and add value by increasing the revenues of rice production systems. Fig. 1 depicts management options for paddy straw. Paddy straw has the inherent ability to be used for soil conditioning via composting and carbon sequestration, as well as for bio-energy production and material recovery (such as silica and bio-fiber) (for industrial use). It should be noted that not all possible options are economically viable. This is because the processing material and transportation costs in value-added solutions are still higher than in other more traditional options.

Biogas Production

Anaerobic Digestion (AD) is a biological process that degrades paddy straw in the absence of oxygen through the coordinated actions of a wide range of microbial communities. It is divided into four stages: Hydrolysis is the breakdown of insoluble organic compounds such as cellulose, protein, fat, and some insoluble organic compounds by enzymes (produced by bacteria) and anaerobic bacteria (Deublein and Steinhauser, 2011).

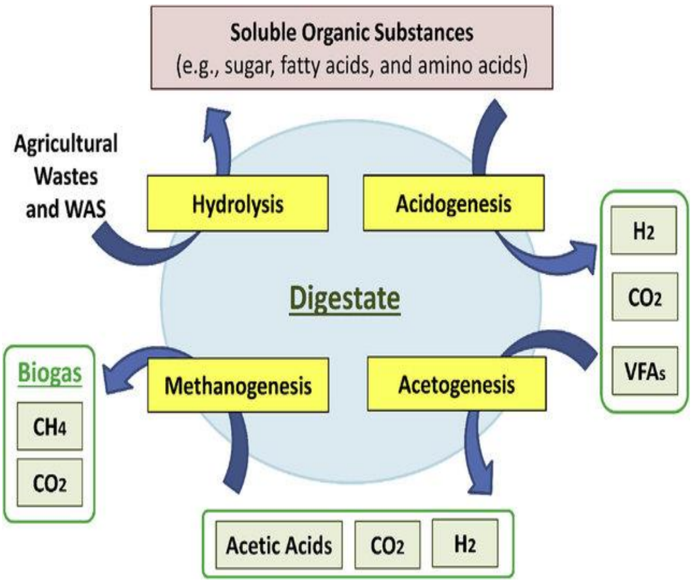

Fig. 3: Biogas Production (Pan et al., 2021)

Simple sugars, fatty acids, and amino acids are fermented to form organic acids and alcohol during acidogenesis (acid production) (Gerardi, 2003). Acetogenic bacteria grow alongside methanogen bacteria during Acetogenesis (acetic acid production), and methane is released under completely anaerobic conditions during Methanogenesis (methane production) (Ziemiski and Frc, 2012).

Medium for Mushroom Production

Paddy straw can be used as the primary substrate for mushroom cultivation. Mushrooms can decompose organic material that other microorganisms cannot. Different types of mushrooms (including *Agaricus spp*.) (Kamthan and Tiwari, 2017) thrive in paddy straw compost. Mushrooms are regarded as an important food in terms of nutrition security and human health. *Volvariella volvacea*, also known as the straw mushroom or rice-straw mushroom (RSM), is an edible mushroom that is widely cultivated in East and Southeast Asia. RSM production adds value to rice production and increases the income of developing-country poor farmers.

Conclusion

Burning paddy straw has a wide range of consequences both on and off the farm, including losses in soil organic matter, soil nutrients, production and productivity, air quality, biodiversity, water and energy efficiency, and human and animal health. Incorporating paddy straw into the soil is an option, but it must be carefully considered to ensure timely decomposition, minimize GHG emissions and helps in carbon sequestration. Management of environmentally friendly paddy straw options such as cattle bedding, mushroom cultivation, soil nutrition, power generation, combustion material, pellet making, bio-gas, bio-ethanol, biochar, acoustic material, 3D objects, cardboard and composite board, packaging materials, production of bio-composite, cement bricks, and handmade paper, used as an energy source, mulching, industrial raw material, biofuel, and animal feed.

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Therapeutic Uses of Goat Milk

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If we are searching for an alternative source for cow milk, one of the best alternatives is goat milk. Goat milk contains higher amount of calcium, magnesium and phosphors than cow and human milk. It is widely used to produce different types of cheese and yoghurt. In several countries, goat farming is essential for their livelihood, mostly in the Middle East and the Mediterranean regions. Goats are considered as "Cow of Poor Man". Around 49% of total world goat milk is produced by Bangladesh, India, Pakistan, and Sudan. Goat's milk has a soft, creamy texture and rich in vitamin and mineral content. Therefore, it may be better than cow milk as it is easier to digest.

Properties of goat milk

Goat milk contain the following properties:

- Act as antioxidant
- Act as an anti-inflammatory
- Act as anti-mucosal
- It may boost the immunity
- Act as anticancer
- Act as prebiotics
- Act as anti-microbial

Table 1. Composition of cow, goat and human milk (Alichanidis and Polychroniadou 1996)

Components	Cow (/100g)	Goat (/100g)	Human (/100g)
Total solid	12.3	13.2	12.4
Fat	3.4	4.0	3.8
Total protein	3.2	3.6	1.2
Casein	2.5	2.9	0.4
Whey protein	0.65	0.61	0.70
Lactose	4.6	4.5	7.0
Minerals	0.7	0.8	0.2
Energy (kcal/100g)	66	70	63

Benefits of goat milk

Increased digestibility

There are number of reasons why consumers experience more optimal digestion when drinking goat's milk.

- In comparison to cow's milk, raw goat's milk contains less alpha-s1-casein, a protein found in milk that has been identified as an allergen. In turn, goat's milk offers a softer curd, leading to greater digestive health support.
- Although the fat content is similar between cow and goat milk but fat globules from goat's milk are much smaller, making it easier for our body to digest.
- It also contains less lactose, which may be ideal if we suffer from a sensitivity.

Table 2. Mineral composition of goat milk

Nutrient	Amount
Iron	0.05 mg
Calcium	134 mg
Potassium	204 mg
Magnesium	14 mg
Phosphorus	111 mg
Sodium	50 mg
Copper	0.046 mg

Beneficial vitamins, minerals and enzymes

- It is evident that raw milk maintains its nutritional value, offering key enzymes, vitamins, and minerals. In fact, when consuming raw goat's milk, we benefit from 50 nutrients, including vitamins A, C, B-complex vitamins, amino acids, fatty acids, zinc, calcium and much more.
- Natural enzymes such as lipase, lactase and phosphatase help our body metabolize essential nutrients. For example, phosphatase allows your body to better absorb the calcium content of milk and since these enzymes are so delicate, they only remain intact within raw milk.
- It also offers more oligosaccharides than cow's milk, providing an amount that's similar to human milk. These beneficial probiotics support the growth of beneficial bacteria, promoting positive gut health. After all, raw milk is essentially a "living" food, offering health-promoting components that would otherwise be destroyed by heat during pasteurization.

Alkaline-forming to help P^H balance of the body

Unlike cow's milk, as well as the majority of animal and dairy products which are acid-forming, goat's milk is alkaline. When your body is acidic, this is when disease and other damaging conditions are able to thrive, due to increased inflammation. You can directly influence your body's pH by changing your eating habits.

Contains more beneficial medium-chain fatty acids

When consuming goat's milk, you benefit from more essential fatty acids, offering around 30 to 35 percent medium-chain fatty acids in comparison to 15 to 20 percent in cow's milk. Medium-chain fatty acids have been shown to increase energy without being deposited as fatty tissue. Meaning, goat's milk is naturally superior in terms of medium-chain fatty acids, which can be enhanced even further when goats are pasture-raised.

Less allergenic

- Although goat's and cow's milk share similar proteins, goat's milk has been widely studied based on its level of tolerance among children. As stated in a study, published in Bioinformation, approximately 26 percent of children suffer from a cow milk protein allergy. Within clinical studies, when treated with goat's milk, 93 percent of children with a cow's milk allergy displayed positive results.
- While studied in 38 children over a five-month period, it was found that those who drank goat's milk surpassed those drinking cow's milk in terms of weight gain, skeletal mineralization, height and blood serum levels of niacin, riboflavin, calcium, vitamin A, hemoglobin and thiamin.

Potential uses of goat milk for overall health

Potential uses of goat milk for heart

- Goat milk might contain antioxidants that may inhibit low-density lipoprotein (LDL) which is also called bad cholesterol.
- Goat milk contains medium chain triglyceride (MCT), monosaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA), which might be beneficial for heart-related diseases (Yadav et al., 2016).
- It may have low levels of cholesterol when compared to cow milk and a balanced fatty acid profile.
- The presence of all these compounds may prevent heart diseases like heart attack, atherosclerosis and stroke.

Potential uses of goat milk for boosting immunity

- Selenium is one of the key nutrients that is involved in the proper functioning of the immune system.
- This nutrient is present in cow milk in small amounts and more amount of selenium is present in goat milk.
- Therefore, goat milk may act as an immunity booster and might help in protecting a person from diseases.
- Recent studies have shown that goat milk may have immunomodulatory effects in both animal and human studies.

Potential uses of goat milk as a prebiotic

- Goat milk contains a high level of oligosaccharides (carbohydrates) derived from lactose which act as a prebiotic.
- We all know that prebiotics in the stomach may improve the health of the digestive system.
- They promote bifidobacterial (good bacteria) in the intestine, which may benefit other activities such as stimulating immunity, preventing infection, fighting against cancer, lowering cholesterol and improving lactose maldigestion.

Potential uses of goat milk for cancer

- Goat milk contains high levels of conjugated linoleic acid (CLA) which has been reported that it may have anticancer properties in animal models and human cancer cells.
- The CLA mechanism to inhibit cancer growth is not yet understood fully and more research is required.
- However, the antioxidant effect and another related mechanism of fermented goat milk might benefit cancer.

Potential uses of goat milk for bone

- In naturopathic medicine, cows are called calcium animals and goats are referred to as bio-organic sodium animals.

- This bio-organic sodium is a crucial element that may maintain joint movement.
- Goat milk may provide 35% of the daily calcium needed in a cup.
- At the same time, a cup of goat milk may provide 20% of the daily needs of vitamin B2.
- It also contains phosphorus and high level of vitamin B12 and potassium.

Potential uses of goat milk for diabetes

- In a study, kefir made from goat and soya milk may improve pancreatic β cells, reduce glucose levels in the blood and exhibit an anti-diabetic effect.
- Therefore, it might be helpful for diabetes. However, human studies are needed to confirm its effectiveness. Do not self-medicate.

Prevents Anaemia

Goat milk is rich in calcium, iron, magnesium and phosphorus. Our bodies easily digest and absorb these minerals. As a result, goat milk helps to treat nutritional deficiencies such as bone demineralisation. It also fixes iron and magnesium deficiency. It further enhances the ability of the body to use iron. Goat milk boosts the formation of RBCs too. Therefore, patients suffering from anaemia, mal-absorption issues, or osteoporosis should consume goat milk.

Increases Platelet Count

Dengue fever's significant complications are selenium deficiency and a drop in blood platelet count. Goat milk may help to treat dengue patients by increasing blood platelets, because selenium is its main component. In addition to this, it also helps in digestive and metabolic utilisation of various minerals present in the body.

Promotes a Healthy Weight Gain

A healthy weight, lowers the risk of heart disease, stroke, diabetes and high blood pressure. Furthermore, it also prevents the chance of contracting cancer. Compared to other milk types, goat milk has more calories per serving. However, it has a similar nutritional profile to cow's milk. Therefore, the extra calories lead to a healthy weight gain.

Good for Skin

Milk is an active ingredient for improving skin conditions. For example, it helps to reduce acne and blackheads. In addition to this, it help to moisturise, smoothen and whiten your skin.

- Goat milk and human skin have the same skin pH. It means that when you use goat milk to cleanse your skin, it does not disturb the skin's natural microbiome or acid mantle. So, if you have sensitive skin issues like psoriasis or eczema, goat milk will help immensely.
- Goat milk has lactic acid and fatty acids, which repair the skin barrier. The low alpha hydroxy acids (AHA) concentration in goat milk helps hydrate, gently exfoliate and treat sun-damaged skin. In addition, it contributes to noticeably softer skin. They also have probiotics to encourage the growth of normal skin flora.

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Honey For Health

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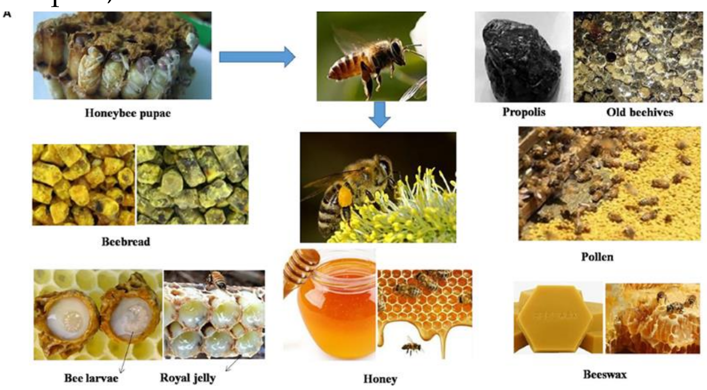
Beekeeping in India dates back to ancient times and people used to hunt/ rob honey from feral colonies of *Apis dorsata* Fab., *Apis florea* Fab. and *Apis cerana indica* Fab. Indian hive bee (*Apis cerana indica*), being domesticated species, was also kept into various indigenous feral hives such as log or wall hives till 19th Century. Bee-keeping is an absorbing hobby to some, and to others it is an industry for producing honey and wax, since ancient times, honeybees have been kept in a crude manner in India, Bee-keeping, today is based upon improved methods using the principles of movable frame-hive, honey extractor and the smoker. Rearing of honey bees is called, apiculture. Honeybee-derived products are used as traditional complementary medicines worldwide, especially in oriental countries. Bee products can be divided into three categories: (1) bee collection and brewing products, such as propolis, honey and BCP, BB; (2) Bee secretions, such as RJ, beeswax, and BV; and (3) bee ecological bodies and hives, such as bee larvae, bee corpses, and old beehives.



Source: Luo *et al.* (2021)

Honey is defined as "the sweets substance produced by honeybees from the nectar of blossoms or from secretions on living plants, which the bees' collect transforms and store in honey combs". Honey bee produces dense and stable energy food called as nectar which ripened into honey. Honey is prepared by bees from plant nectars, from plant secretions and from excretions of plant sucking insects ("honeydew"). The Food Standards Code defines it as "the nectar and saccharine exudations of plants gathered, modified and stored by the honey bee". The British Pharmacopeia (1993) defines purified honey as being "obtained by purification of the honey from the comb of the bee, *Apis mellifera* L, and other species of *Apis*. Colours of honey form a continuous range from very pale yellow through ambers to a darkish red amber to nearly black. The variations are almost entirely due to the plant source of the honey, although climate may modify the colour somewhat through the darkening action of heat.

Chemical composition

Honey is a complex natural product, containing more than 400 different substances, e.g. various carbohydrates, organic acids, proteins, amino acids, enzymes, aroma substances, mineral substances, pigments, waxes, etc. The composition and quantity of these components vary widely according to the floral and geographic origin of the honey. The average composition of honey is presented here under:

Sugars account for 95 to 99% of honey dry matter. The majority of these are the simple sugars fructose and glucose which represent 85-95% of total sugars. Generally, fructose is more abundant than glucose. This predominance of simple sugars and particularly the high percentage of fructose are responsible for most of the physical and nutritional characteristics of honey. The physical properties of honey such as sweetness, hygroscopicity, density and viscosity and food value are mainly dependent on honey sugars. Water is quantitatively the second most important component of ho=ney. Its content is critical, since it affects the storage of honey. Keeping quality, viscosity and granulation of honey depends on the proportion of water in it. An ideal honey on an average should contain 17.2 per cent of water (moisture). Only honeys with less than 18% water can be stored with little to no risk of fermentation. Acids (organic acids) are the most important. 16 different types of acids have been identified in the honey. Important among these are acetic acid, butyric acid, malic acid, succinic acid, gluconic acid, formic acid, phosphoric acid, hydrochloric acid, lactic acid and polyglutamic acid. Of these gluconic acid, which is a by-product of enzymatic digestion of glucose, predominates. Honey contains traces of amino acids also. Because of its sweetness, the acidity of honey is largely masked. Although honey has an acidic reaction of pH 3.29 to 4.80, it is potentially alkaline food, because the acidity or alkalinity of foods depends on the predominant type of minerals they contain. The organic acids are responsible for the acidity of honey and contribute largely to its characteristic taste. Minerals are present in very small quantities, potassium being the most abundant. The minerals have most important biological role, since their interaction with number of enzymes, vitamins and hormones affect the irritability of the nervous system, tissue respiration, blood circulation and so on. Honey is also an important source of minerals. On an average, ash content of honey is 0.17 per cent. The salts of potassium, chlorine, sulphur, calcium, sodium, phosphorous, magnesium, silica, iron, manganese and copper are present in the honey. Dark honeys, particularly honeydew honeys are the richest in minerals. Honey may contain as many as 60 types of amino acids which are the building blocks of different types of proteins useful for us. The protein contents of an ideal honey is, however, only 0.26 per cent.

The main enzymes in honey are invertase (saccharase) diastase (amylase) and glucose oxidase. Traces of other proteins, enzymes or amino acids as well as water soluble vitamins are thought to result from pollen contamination in honey. Virtually absent in newly produced honey, hydroxy-methylfurfural (HMF) is a byproduct of fructose decay, formed during storage or during heating. Thus, its presence is considered the main indicator of honey deterioration. Enzymes are complex molecules formed in living cells that aid in carrying out the metabolic processes of life. They act as catalytic agents in bringing about chemical reactions involving chiefly starch and proteins. The most important enzyme in honey is *invertase* which converts the sucrose of nectar into glucose and fructose. The other important enzyme found in honey is *diastase*. Its importance lies in its instability to heat. People who prefer unheated honey use the diastase level as an index of the heating history of honey. Diastase also deteriorates during long storage. The other important enzymes found in the honey are amylase, catalase, oxidase, phosphatase etc. These enzymes are mainly contributed from the plants and some of them are added through glandular secretions by the bees. Most of the enzymes in honey are destroyed by exposure to too much heat for a long period of time which may occur in processing or in long storage. Thus, long storage and high heating to honey should always be avoided. Another enzyme glucose-oxidase is also reported in honey which oxidises glucose to gluconic acid and hydrogen peroxide, the inhibin which imparts antibiotic properties to honey. Vitamins are not only essential food elements in the diet but many of these are used for curing the diseases. Aroma and flavour substances in honey are terpenes, aldehydes, alcohols, esters etc. The aroma and flavour are the most important characteristics of honey from consumer's point of view. The delightful aroma and flavour of fresh honey are remembered with pleasure as there are as many different honey flavours as there are nectar sources. In addition to loss of volatile aroma, excessive heat can alter honey flavour and introduce off type flavour from the effect of heat on sugars, acids and protein material in it. Flavour loss also occurs in long storage of honey. The important pigments occurring in honey are carotenes, chlorophyll, chlorophyll derivatives and xanthophyll. Other minor components occurring in honey are sugar alcohols, tennins, acetylcholine, honey colloids, an antibiotic material and some other biological active material.

Use of Honey

Honey is one of the foods which have religious significance. Buddhists in India and Bangladesh celebrate a festival called '*Madhu Purnima*' by giving bee's honey to monks. This is to commemorate the offering of honey by a monkey to Lord Buddha when he retreated to wilderness due to a dispute among his disciples. Hindus consider bee's honey as one of the five elixirs of immortality (*Panchamruta*). Honey is poured over the statues of deities in a ritual called '*Madhu Abhisheka*'. In Jewish tradition, honey is the symbol of new year, 'Rosh Hashana'. Traditionally slices of apples dipped in honey are eaten to bring a sweet new year. In Islam, Prophet Mohammad strongly recommended honey for healing purposes and Quran promotes it as a nutritious and healthy food. As bee's honey has wide and vivid values, the present survey is conducted in order to view some benefits of honey as a medicine, cosmetic, nutrient and a preservative.

Medicinal uses of honey

Antimicrobial properties of honey

In addition to important role of natural honey in the traditional medicine, during the past few decades, it was subjected to laboratory and clinical investigations. Antibacterial activity of honey is one of the most important findings that was first recognized in 1892; by van Ketel.

Unifloral honeys are used in folk medicine for different purposes. The applications given in the table below remain to be confirmed by experimental science. Indeed, in most scientifically conducted clinical studies the botanical origin of the honey was not determined. On the other hand, the antibacterial and the antioxidant activity of honey depends strongly on the botanical origin.

Table 3: Explanation for the use of honey in medicine

Therapeutic and health enhancing use	Antibacterial, anti-inflammatory, antioxidant, osmotic and analgesic effects
Therapy of digestive diseases like peptic ulcers and gastritis	Antibacterial and anti-inflammatory effects
Against children diarrhoea	Antibacterial and anti-inflammatory effects
Improvement of gut microbial health and of digestion	Prebiotic effect
Improvement of immune reaction of the body	Immuno activating effect
Regular intake improves cardiovascular health	Lowering of blood risk factors and specific heart conditions as extracystoles, arrhythmia and tachicardia
Long term ingestion of honey can reduce the risk of human cancer	Anticancerogenic effects
Positive glycemic nutritional effect. Can be used as a sweetener of people with diabetes type II and also probably type I	Some honeys have a low glycemic index: e.g. acacia honey. Other fructose rich honeys such as thyme, chest nut, heather and tupelo are good alternatives.
Use for the treatment of radiation-induced mucositis	Antibacterial and anti-inflammatory effects
Positive effect of honey ingestion on hepatitis A patients	Anti-inflammatory effect
Improvement of cough in children	Contact soothing effect, sweet substances, as a sweetener honey causes reflex salivation and increases airway secretions which may lubricate the airway and remove the trigger that causes a dry, nonproductive cough.

Table 4: Honey therapeutic properties

Bioactivity of honey	**Suggested Rationale**
Prevention of cross-contamination	Viscosity of honey provides a protective barrier
Provides a moist wound healing environment	Osmolarity draws fluid from underlying tissues
Dressings do not adhere to wound surface. Tissue does not grow into dressings	The viscous nature of honey provides an interface between wound bed and dressing
Promotes drainage from wound	Osmotic outflow sluices the wound bed
Removes malodor	Bacterial preference for sugar instead of protein (amino acids) means lactic acid is produced in place of malodorous compounds
Promotes autolytic debridement	Bacterial preference for sugar instead of protein (amino acids) means lactic acid is produced in place of malodorous compounds
Stimulates healing	Bio-active effect of honey
Anti-inflammatory	Number of inflammatory cells reduced in honey-treated wounds
Managing infection	Antiseptic properties found to be effective against a range of microbes including multi-resistant strains

Source: Bodganov, 2011

Quality Control in Honey

Some scientists even advocate the addition of water into honey to avoid granulation problem. But it has been laid out that nothing is to be added or subtracted from honey and it has to be sold in natural form. Such recommendations may make the consumers more cautions and suspicious about adulteration. Moreover, the addition of water not only affect the AGMARK grade status of honey but also make honey more vulnerable to fermentations. Even addition of sorbic acid or isobutyric acid or treatment with HC1 and then with NaOH for preventing granulation should not be allowed and the honey showing the residues of such substances be branded adulterated and accordingly legal action be taken against packers.

All big traders and honey exporters are having their own full-fledged honey testing laboratories. Besides various tests prescribed by AGMARK, they have even provision for HMF testing of honey as per International Standards. For some specific sophisticated testing's, exports approach NRL of IARI, New Delhi or S G S, Nagpur. Since quality of the honey, it being a food item, is of prime importance, various organization such as (PFA, 1974), BIS (IS 4941 :1974; IS 8964: 1977; IS 4941, 1994), AGMARK (1984) and European code (1969) have set various standards for honey based on specific gravity, moisture, quantity or reducing sugars, sucrose, L/ D ratio, ash content, acidity. Fiehe's test, aniline chloride test, HMF and enzymatic (Diastase) activity. On the basis of the above parameters, both BIS and AGMARK have devised three grades of honey *vis.* Special grade, A grade and standard grade. In India, it is the AGMARK standards which are most commonly being followed. The AGMARK authorities have spread a network of testing laboratories with trained manpower at least at district level, through it has not been able to reach smaller towns. The beekeeping institutions can have their own AGMARK lab to test and AGMARK, their honeys. The laboratory which can be set up to a cost of about Rs 1 lac needs a trained Agmark analyst. The Agmark authorities provide such one-month's training to science graduates.

Table 1: Average composition of honey

Component (% except pH and diastase valute)	Average	Standard deviation	Range
Water	< >17.2	1.5	13.4 - 22.9
Fructose	38.2	2.1	27.2 - 44.3
Glucose	31.3	3.0	22.0 - 40.7
Sucrose	1.3	0.9	0.2 - 7.6
Maltose (reducing disaccharides calculated as maltose)	7.3	2.1	2.7 - 16.0
Higher sugars	1.5	1.0	0.1 - 8.5
Free acids (as gluconic acid)	0.43	0.16	0.13 - 092
Lactone (as glucolactone)	0.14	0.07	0.0 - 0.37
Total acid (as gluconic acid)	0.57	0.20	0.17 - 1.17
Ash	0.169	0.15	0.020 - 1.028
Nitrogen	0.041	0.026	0.000 - 0.133
pH	3.91	-	3.42 - 6.10
Diastase value	20.8	9.8	2.1 - 61.2

Table 2: Unifloral honey in practical apitherapy.

Acacia, liquid and mild	Sweetener for people with Diabetis Type II. Improved digestions. Applied at diseases of stomach, intestines, liver and kidney
Buckwheat, dark and strong	High antioxidant activity, improves digestions, to be taken by pregnant women and when nursing
Eucalyptus, dark and strong	Against infections and diseases of respiratory organs and urinary passages. Increases immunity
Calluna, dark and strong	High antioxidant activity. Invigorating at fatigue and convalescence; against problems with kidney urinary bladder
Chestnut, dark and strong	Improves blood circulation; against anemia and infections of kidney urinary bladder
Clover, light und mild	sedative
Lavendel, aromatic	Treatment of wounds, burns, insect stings, infections or respiratory organs and depressions
Linden, strong, aromatic	Diaphoretic, diuretic, palliative, appetizing; against cold, flu, cough, sinusitis, headache, sleeplessness and anxiety
Manuka, Dark and strong	High antibacterial activity, against infections and for wound healing
Dandelion, aromatic	Hemo-protective, against gastric, intestine, liver, kidney and gall bladder diseases
Citrus, light and mild	Against indigestion and sleeplessness
Rape, mild	Sedative, relaxing
Rosmarine, mild	Hemo-protective; against gastric, intestine, liver diseases
Sunflower, mild	spasmolytic in asthma cases, gastric, intestine colic
Fir, honeydew, dark and strong	High antioxidant activity. Against infections of respiratory organs
Thyme. dark and strong	Against infections of respiratory organs; wound treatment

Source: Bodganov *et al.*, 2006

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Humus-Pesticide Interaction in Soil

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The soil environment serves as the primary recipient of diverse pollutants, especially pesticides used in agriculture. It comprises abiotic (non-living) and biotic (living) components, hosting a myriad of organisms like nematodes, fungi, bacteria, algae, and earthworms. These organisms interact in a complex web, influencing the fate of applied chemicals. Pesticides tend to persist in the soil for extended periods, necessitating evaluation of their toxicity and stability within this environment. Xenobiotics (foreign substances) in soil undergo transformation through biological and non-biological processes. Ideally, they mineralize into harmless elements, yet often form toxic intermediates. These chemicals and their by-products can move through soil via leaching, bioconcentration, and volatilization. Understanding these processes is crucial for assessing their impact on soil health and ecosystems.

Pesticide interactions with soil greatly influence their environmental fate, impacting degradation, volatilization, and leaching. Xenobiotics engage with soil through adsorption and covalent bonding processes. (Bollag et al. 1992)

The most enduring pesticide complexes form via direct covalent bonds with soil humic matter or clay, especially when pesticides share chemical characteristics with humus components. Adsorption occurs through various mechanisms such as:

1. **Van der Waals forces**
2. **ion exchange**
3. **hydrogen bonding**
4. **transfer complexation,**
5. **hydrophobic interactions**.

The strength and nature of adsorption depend on the xenobiotic's structure and chemistry, making it sensitive to environmental changes. Pesticides resembling phenolic compounds can bind covalently to humus, creating stable complexes resistant to degradation.

Over time, adsorbed residues become more stable and resistant to extraction or microbial breakdown. Soil-pesticide interactions are influenced by factors like soil properties, pesticide characteristics, climate, and agricultural practices.

Soil properties like texture, clay type, organic matter, and pH affect pesticide retention, with organic matter, particularly humic substances (HS), playing a significant role. Studies show HS's reproducible behavior in pesticide interactions, where pesticides favor humic acid (HA) over fulvic acid (FA) and exhibit greater affinity for HS rich in aromatic carbon.

Various characterization techniques like spectroscopy aid in understanding pesticide sorption to HS. These parameters significantly impact pesticide fate models used in regulatory assessments, where spatial variability of these parameters in landscapes holds more importance than the choice of the fate model itself.

Advancing knowledge of HS distribution in soil landscapes can refine exposure assessments reliant on pesticide fate models, potentially improving regulatory assessments and risk evaluations.

Categorization of Pesticides

Pesticides can be categorized as **cationic**, **ionizable** (i.e., weakly acidic, weakly basic, or zwitter ionic), or **non-ionic** (nonpolar) molecules.

- ✓ **Charge transfer and ionic bonding** are mechanisms that specifically apply to the sorption of cationic pesticides by HS.
- ✓ For **non-ionic pesticides, hydrophobic bonding** (partitioning) is most common, but other possible mechanisms for sorption by HS include charge-transfer complexes, covalent bonding, hydrogen bonding, and Van der Waals attractions.
- ✓ **Bonding mechanisms** commonly observed for ionizable pesticides and HS include charge-transfer (electron donor–acceptor) complexes, hydrogen bonding, ligand exchange, and Van der Waals attractions.

Bonding mechanisms of herbicides with humus

Bonding mechanisms for the adsorption of herbicides by humus include ion exchange, H-bonding, van der Waals forces, and coordination through an attached metal ion.

1. **Ion exchange** is of special significance because herbicides adsorbed in this manner are particularly ineffective in controlling weeds; furthermore, the adsorbed molecule may not be easily attacked by soil micro-organisms.
2. **Cationic herbicides** are also tightly bound to clay - some can be held within the expandable lattice layers of montmorillonite.
3. **Adsorption through ion exchange** is restricted to those herbicides which either exist as cations (diquat and paraquat) or which become positively charged through protonation (e.g., the s-triazines). Diquat and paraquat, being divalent cations, can react with more than one negatively charged site on soil humic colloids, such as through two COO- ions (illustrated for diquat).

Adsorption of diquat through Ion exchange

$T + H_20 \rightleftharpoons HT^+ + OH^-$ [1]

$Humus\text{-}COOH + H_20 \rightleftharpoons Humus\text{-}COO^- + H_30^+$ [2]

$Humus\text{-}COO^- + HT^+ \rightleftharpoons Humus\text{-}COO\text{-}HT$ [3]

$Humus\text{-}COOH + T \rightleftharpoons Humus\text{-}COO\text{-}HT$ [4]

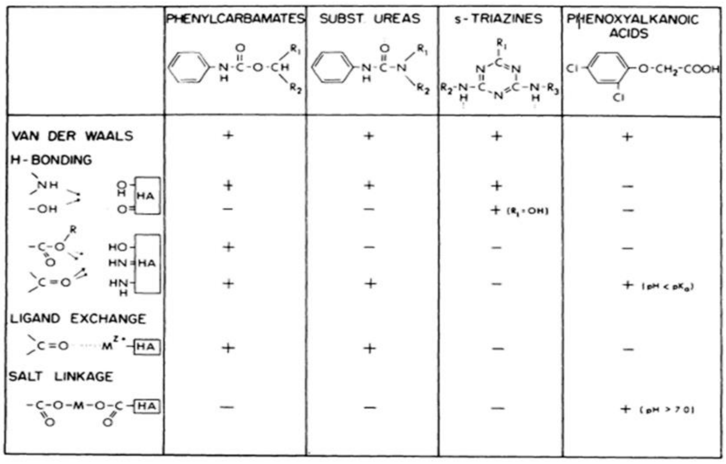
T is the s-triazine molecule, HT+ the protonated molecule, and H30+ the hydronium ion.

- Reaction [1] represents the pH-dependent protonation of s-triazines in the soil solution, while
- reaction [2] represents ionization of the humus colloid COOH group.
- Ionic adsorption of the cationic s-triazine molecule, formed by reaction [1], is shown by reaction [3];
- adsorption through protonation on the surface of the organic colloid is shown by reaction [4].

Adsorption of Pesticides on Soils

- Adsorption is an attraction/repulsion phenomenon as a resultant of the interaction between the fields of force emanating from the surface of the adsorbent and the molecules or ions of the adsorbate.

Table 1: Typical bonding mechanism for the adsorption of herbicides by soil humus



	PHENYLCARBAMATES	SUBST UREAS	s-TRIAZINES	PHENOXYALKANOIC ACIDS
VAN DER WAALS	+	+	+	+
H-BONDING				
NH	+	+	+	−
-OH	−	−	+ (R₁ = OH)	−
-C-O (R)	+	−	−	−
C=O	+	+	−	+ (pH < pKa)
LIGAND EXCHANGE				
C=O ···· M^{z+} -HA	+	+	−	−
SALT LINKAGE				
-C-O-M-O-C- HA	−	−	−	+ (pH > 7.0)

- The adsorption of pesticides by soils is a complex process but one of great importance for an understanding of the behaviour, efficacy and fate of pesticides in the soil environment.
- Adsorption processes play a vital role in determining the environmental fate of pesticides and in determining their efficacy for crop protection.
- United States Environmental Protection Agency (USEPA) has proposed guidelines for registration of pesticides requiring adsorption and movement studies in soils because adsorption helps to better understand the judicious use of pesticides.
- It controls the quantity of a pesticide in soil solution which impacts almost all the specific fate processes, including volatilization, bioavailability to flora and fauna, biodegradability, photolysis, hydrolysis, its persistence, mobility, toxicity, transformation and bioaccumulation.

Adsorption of pesticides on soil surfaces is mainly governed by

- **Soil properties**

a. amount and nature of organic matter

b. the type and amount of clay minerals

c. CEC and the hydroxide content

d. particle size distribution

e. moisture, pH and ionic strength

- **Physical and chemical parameters of the pesticides**

a. shape, configuration, molecular structure,
b. chemical functions, water solubility, polarity, polarizability, charge distribution and
c. acid and base nature of the pesticide molecule

- Temperature and
- other environment conditions (presence of organic solvents and other chemicals like surfactants).

Degradation of pesticides in soil

Degradation of pesticides is an important process in determining the fate of pesticides in soil and water environments. Extraction and chemical analysis, bioassays, oxygen uptake and evolution of carbon dioxide are several methods which have been used in study of degradation of pesticides in soil. In general, conditions that promote microbial activity enhance the rate of loss and those that inhibit the growth of microorganisms reduce the rate.

Biodegradation of pesticides in soils

- Microbial degradation plays an important role in the fate and behaviour of the pesticides in soils.
- Factors affecting the microbial degradation of pesticides in soil include pH, temperature, sorption, soil water content and soil type.
- The effect of temperature on the degradation process was more pronounced than the effect of soil type. Soil microorganisms are able to interact physically and chemically with pesticides and inducing the physical change or the complete change of pesticides.
- Soil microorganisms metabolize pesticides either aerobically or anaerobically and usually microorganisms degrade the pesticides and utilize them as a source of energy and nutrients or use them through co-metabolism.

Leaching of pesticides in soils

- Knowledge of pesticides leaching is important to understand the problems of contamination of natural water and soil environments.
- Pesticides mobility is governed by the interactions of specific physical and chemical properties of soils which determine the potential bonding mechanism and magnitude of retention to soil.
- Leaching of pesticide in unsaturated soil is largely determined by the physical and chemical properties of both the pesticide and soil.

Effect of organic matter on leaching of pesticides in soils

a. Dissolved organic matter is able to complex with the pesticides and increases the mobility of pesticides in the soil profile.
b. It is able to affect the dissolution and facilitated the transport of pesticides.
c. Therefore, application of certain types of organic fertilizer to some agricultural soils may not be advantageous as far as pesticide leaching is concerned because it may enhance or facilitate pesticide leaching through the soil profile.

Concluding Remarks and Recommendations

- Humic substances may interact with pesticides in different modes, of which adsorption is probably the most important one.
- A major question is the reversibility or irreversibility of the adsorption process, that is, whether the bound residues can be considered definitely inactivated and have become common components incorporated in the humic polymer, or they are only momentarily inactivated in reversibly-bound forms, thus representing a possible source of contamination by a time-delayed release of toxic units.
- Although experimental evidence of at least partial re-mobilization of pesticide residues has been obtained as, for example, for dichloroaniline derivatives of propanil, intact methoxychlor, methyl parathion, dinitroanilines and methabenzthiazuron, the question is still unresolved and needs further research.
- Other modes of interaction between HS and pesticides include catalytic effects of HS in hydrolysis and dealkylation reactions, photosensitization effects in various photo-

degradation reactions and solubilization effects.

- The knowledge of the chemical nature, reactivity and properties of HS, the major materials interacting with pesticides in the soil, is extremely important in determining the mode and extent of the interaction.
- Our understanding of HS and of their multiple modes of interaction with pesticides needs further research by a more extended application of advanced techniques such as NMR, ESR, FT-IR and fluorescence spectroscopies.
- Adsorption of pesticides onto soil HS gives rise to a problem in the analytical, qualitative and quantitative, determination of pesticide residues in soil and water. Thus, it appears necessary to develop new procedures and methods which take into consideration these aspects and may bring a solution.
- Joint interdisciplinary research efforts thus appear necessary for the establishment of predictive measures to face and minimize pesticide pollution problems for soil, water,
- organisms and the global environment. (Senesi 1992)

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