Volume 01 Issue 6 September 2023

AgriTech Today

AGRICULTURE AND ALLIED SCIENCES E-MAGAZINE

https://agritechmagazine.com

AgriTech Today

Volume 1, Issue 6
September, 2023

Publisher
Valmiki Sahitya Sampada
Harthikote Post
Hiriyur, Chitradurga Dist.,
Karnataka - 577545

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From the Editor-in-chief's Desk

I am happy and proud to announce the release of the sixth issue of AgriTech Today Magazine. It gives me great pleasure to inform you that we have curated and finalized 50 articles for publication in this issue.

This issue covers a wide range of topic includes recent technologies agriculture for sustainable agriculture, LSD management, organic dairy farming, few success stories of farmers, Women Helpline Scheme, Green Farming, Anthocyanin Pigments of Banana Flower Bracts, Suitable Growing Media for Roof Top Gardening, Entrepreneurship Opportunities and many more.

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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Building Resilience in Vegetable Farming: Strategies to Thrive in a Changing Climate

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The worrying phenomena of climate change has the potential to have an impact on global agriculture production systems. Uneven weather patterns are a result of climate change, which has both natural and human-caused causes. Numerous international organizations have predicted that through 2050, threats associated to climate change will cause a 2% drop in total agricultural productivity every decade. High population density developing nations are particularly susceptible to this occurrence. In addition to ongoing crop failures brought on by climate change, immediate effects include altered soil fertility, a rise in insect pest and pathogen levels, and abnormal pollinator behaviour. These effects ultimately result in decreased productivity of crops, including vegetables. By supplementing the minerals, vitamins, crude fibers and many other essential dietary components, vegetable crops are important providers of nutrition. Several enhanced agronomic techniques for growing vegetable crops have developed over time for various locales. These techniques have the potential to lessen the effects of climate change if they are used responsibly.

Crop Diversification

Diversifying the crop portfolio is one of the guiding concepts of climate resilience in vegetable growing. Growing a variety of vegetables lowers the likelihood of problems caused by the climate. While some vegetables might do better in hotter climates, others might do better in cooler ones. Farmers can spread their risks and guarantee a more consistent harvest by diversifying.

Water Management

Climate change often has negative effects including water scarcity and unpredictable precipitation patterns. For vegetable growing to be resilient, it is essential to implement effective water management strategies. To maximize water utilization and minimize waste, this involves the use of drip irrigation, rainwater collecting, and soil moisture monitoring devices.

Soil Health and Conservation

The foundation of a successful vegetable farm is healthy soil. To enhance soil health and lessen erosion, climate-resilient farmers place a high priority on techniques including cover cropping, crop rotation, and low tillage. Extreme weather events can be better withstood by healthy soil, which also gives crops vital nutrients.

Climate-Adapted Varieties

Crop success can vary significantly depending on the selection of climate-adapted vegetable cultivars. These kinds are frequently bred to survive particular pests, illnesses, and weather patterns that are common in a given area.

Integrated Pest Management (IPM)

Pest and disease behaviour and distribution can change due to climate change. IPM measures, which incorporate biological control techniques and the prudent application of pesticides, can help manage these dangers while reducing the impact on the environment.

Season Extension Techniques

Farmers may need to modify planting and harvesting schedules due to rising temperatures and shifting weather patterns. Farmers may protect crops from harsh weather and lengthen the growing season by using techniques like high tunnels and greenhouses.

Monitoring and Data Analysis

Making informed decisions requires routine monitoring of the weather, soil moisture, and crop health. Data gathering and analysis can be aided by contemporary technology, such as weather forecasting apps and remote sensing instruments.

Farmer Education and Networking

Sharing knowledge and experiences with people in their community and beyond can be beneficial for farmers. Farmers can stay updated on climate-resilient techniques by taking part in workshops, conferences, and online forums.

Conclusion

Vegetable farmers confront significant challenges as a result of climate change, but by implementing proactive and sustainable actions, they can increase their resilience and protect their way of life. By incorporating crop diversification, sustainable water and soil management practices, season-extension technologies, pest and disease management plans, data-driven decision-making, education initiatives, and capacity building, vegetable farming can become more resilient to climate change. These programs serve to secure food security as well as environmental sustainability and the long-term profitability of rural communities.

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Mechanical Impedance of Soil: A Silent Thief

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At present in India, tractors are being used for tillage of 82.78% of total area and sowing 61.30% of total area. Major adoption of agricultural machinery in addition to irrigation equipment and tractor, is thresher. Combine harvesters are commonly used in different parts of the country for harvesting wheat, paddy, maize, soybean and gram in few states. Traditional threshing by animal treading has been almost fully replaced by power threshers operated by 5-15 hp engine or electric motor. Now a day, tractor drawn mould board plough, harrows, cultivators and rotavator are better machinery used by the farmers for cultivation of crops. But continuous use of heavy vehicle induced mechanical impedance in soil and also developed soil compaction.

Mechanical impedance (MI) is an important property of root restricting, tillage-induced pans. It increases with an increase in soil dry bulk density due to soil compaction. Compaction developed due to formation of a plough sole as in the case of rice fields on medium textured soil, use of heavy machinery on a moist soil or presence of kankar (calcium carbonate) layers. Roots growth rate is reduced as mechanical impedance is increased.

Compaction is an apprehension because it affects plant growth. There are not enough pores or spaces in compacted soil to allow unrestricted root movement, infiltration, drainage or air circulation. Restricted roots are often unable to take up sufficient water or nutrients from the soil. Result is less plant growth and lower yields, particularly during periods of drought.

Causes: Soil compaction

Many factors such as animals and machinery causes soil compaction on farms. Machinery is most important factor, mostly tractors and heavy cultivation and harvesting equipments induced soil compaction. The extent of compaction depends on the force compressing the soil, the contact area with the soil, the strength in the soil and the type of soil. Animal hooves and tyres of light vehicles compact the soil directly underneath and around the contact area. Heavy vehicles compact the soil more deeply.

If we plough regularly to the same depth the soil compacts under the plough and forms a plough pan. Ploughing wet soil causes greater compaction than ploughing dry soil. As well, it may reduce water and air movement. Some soils are more prone to compaction than others, particularly soils with a lot of fine sand and silt and little organic matter. Wet clay is much more easily compacted than dry sandy soil.

Types of soil compaction due to mechanical impedance:

Soil compaction is classified as

1. Surface
2. Subsurface

Surface compaction is usually caused by high contact pressure between the wheel and the soil surface, and is related to the tyre inflation pressure. Freeze-thaw cycles in spring and use of forage crops in a rotation naturally loosen compacted soil. Surface compaction can be reduced by reducing traffic, using lighter machines, using dual wheels and larger tire sizes and reducing tire inflation pressure.

Subsurface compaction often called a plough pan. It is usually more problematic than surface compaction. Since it is not easily detected and is not corrected by natural freeze thaw cycles. It caused both by tillage and by traffic with heavy field machinery. Repeated tillage operations over several years can contribute to both the formation and downward augmentation of a plough pan.

Effect of mechanical impedance on plants and soil

Soil compaction affects plant growth in many ways.

- ✓ Air and water movement and storage in the soil are restricted, causing shortages to the plants.

- ✓ Roots do not develop well or penetrate well in impeded soil, so shallow root systems and malformed roots are symptoms of impeded soil.
- ✓ Plants are generally stunted, and moisture and nutrient stresses may occur.
- ✓ Nitrogen and potassium deficiency symptoms in plants are common under impeded situation. Crop growth and yield probably will be reduced.
- ✓ Impeded soil is more resistant to tillage forces and after tillage tends to be cloddier.
- ✓ Shallowly compacted soil may form a crust after rainfall or irrigation due to poor soil structure and reduced infiltration.
- ✓ Soil compaction affects soil storage and supply of nutrients by increasing soil bulk density, decreasing porosity, soil water infiltration and water holding capacity.
- ✓ Besides increasing runoff and erosion, crusting may impede plant emergence and lead to uneven crop stands.

Preventing measures for mechanical impedance:

- ❖ Mechanical impedance can be best prevented by staying off wet fields. Subsurface drains and contouring promote drainage helping the soil dry out.
- ❖ Tyre inflation pressure may be lowered as these spreads the axle load over a larger surface area. This is especially effective when all field implements have the same working widths (preferably large).
- ❖ Always driving over the same tracks reduces overall field compaction.
- ❖ Deep tillage is often suggested as a method of breaking up plough pans. In this context chisel ploughing is one of the best methods.
- ❖ Deep tillage is likely to be most effective if performed when the soil is very dry in late summer after harvest of a cereal or forage crop.
- ❖ Deep tillage can increase root depth, improve infiltration and water storage and ultimately increase crop yield.
- ❖ To help reduce compaction, it is desirable to conduct normal tillage operations when soil moisture is less than 50 per cent of field capacity.
- ❖ Motivate farmers to cultivate deep rooted crops in the rotation that are able to extend to and penetrate the restrictive layer. This practice should not be applied where unfavourable soil materials such as sodium, calcium, gypsum or other materials.

Soil compaction is fetching a more serious problem for farmers. Because compacted soil has smaller pores and fewer natural channels, water infiltration is drastically reduced. This causes greater surface wetness, more runoff, which in turn increases soil erosion, and longer drying time. This wet field conditions delay planting, harvesting and decrease crop yields. Plant roots do not grow well in dense soil. Restricted moisture and nutrients reach the plant, and consequently yield is reduced. Field machines are heavier so there is motivation for farmers to work the soil when it is too moist is need of the hour.

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Melatonin as Plant Immune Booster: Pros and Cons

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Melatonin (N-acetyl-5-methoxytryptamine) is ubiquitously spread across all kingdoms of life and is prominently regarded as a sleep regulator in humans. In plants, melatonin has principally been considered as an antioxidant, controlling the pool of reactive oxygen and nitrogen species. It has been extensively studied for its function in a variety of physiological processes, including growth, roots, photosynthesis, fruit maturity, and protection against abiotic and biotic stresses (Arnao and Hernández-Ruiz, 2019). Melatonin biosynthetic genes present in *Rhodospirillum rubrum*, a purple non-sulphur photosynthetic bacteria that evolved into mitochondria in eukaryotes and cyanobacteria that became chloroplasts, are thought to have been progressively transferred to other organisms over time (Kanwar *et al.,* 2018). In animals, melatonin is synthesized from serotonin, which is produced from tryptophan in two steps involving tryptophan 5-hydroxylase (Trp5H) and aromatic L-amino acid decarboxylase (AADC), where tryptophan hydroxylase acts as the rate-limiting enzyme. In contrast to animals, plants contain two organelles for the production of phytomelatonin, namely mitochondria and chloroplasts. Due to their respective roles in respiration and photosynthesis, mitochondria and chloroplasts are continually exposed to incessantly produced reactive oxygen species (ROS) under steady-state circumstances (Kanwar *et al.,* 2018). In light of this, the capacity of plants to synthesise phytomelatonin in two organelles stimulates the intense curiosity of plant scientists to comprehend how phytomelatonin and ROS interact throughout various activities in subcellular compartments. It has a significant role in regulating the gene expression of plant hormones, including those involved in the metabolism of indole-3-acetic acid, cytokinin, ethylene, gibberellin, and auxin carrier proteins. The pleiotropic role of melatonin in controlling the transcripts of many genes supports its critical role as a multi-regulatory chemical that designs many aspects of plant development. Most of the plant species in which the presence of melatonin has been reported belong to the families Rosaceae, Vitaceae, Poaceae, Apiaceae, and Brassicaceae (Murch and Erland, 2021).

Melatonin biosynthesis in plants

The integrity of melatonin biosynthesis in plants is merely influenced by the genotype, environmental factors (photoperiod, temperature), and stage of development. Evidence suggesting that melatonin in plants is produced from the aromatic amino acid tryptophan (Murch and Erland, 2021). Empirically, tryptophan is first converted to tryptamine through a decarboxylation reaction catalyzed by tryptophan decarboxylase (TDC). Tryptamine is then hydroxylated to serotonin (5HT; 5-hydroxytryptamine) by tryptamine-5-hydroxylase. While TDC is highly regulated in most plant species, the conversion of tryptamine to 5HT appears to occur rapidly and with little feedback or regulation, aside from competition for tryptamine, which also serves as a precursor for many secondary metabolic pathways. Biosynthesis of melatonin from 5HT occurs through two major intermediates, *i.e.,* (1) N-acetylserotonin (NAS), in a reaction catalyzed by serotonin N-acetyltransferase (SNAT), and/or (2) 5-methoxytryptamine (5-MT), in a reaction catalyzed by a caffeic acid-O-methyltransferase (COMT; **Figure 1**). SNAT can use tryptamine as a substrate for NAS production, skipping the need for production of 5HT, and can also catalyze the acetylation of 5- MT to form melatonin. Recently, a novel deacetylase enzyme, NAS-deacetylase (ASDAC), has been characterized that catalyzes the reverse reactions converting NAS to 5HT, or melatonin to 5-MT allowing for the possibility of interconversion between 5HT and melatonin (Lee *et al.,* 2018). The final step in this pathway includes methylation of NAS to melatonin catalyzed by the

enzyme either NAS methyl transferase (ASMT), or COMT.

Melatonin biosynthesis has been shown to occur in both the chloroplast (Zheng *et al.*, 2017) and the mitochondria (Wang *et al.*, 2017) with some possible cytosolic involvement. Melatonin is metabolized to produce a number of important bioactive molecules in plants that can generally be grouped as: (a) products of oxidation reactions, (b) products of catabolism and (c) conjugates and derivatives (**Figure 1**). Nitroso-melatonin, N-acetyl-N-formyl-5-methoxykynuramine (AFMK) and N-acetyl-5-methoxykynuramine (AMK) are products of oxidation reactions as are several of the 5- MT derivatives. AFMK and AMK were the first melatonin metabolites described in plants and function as antioxidants with the capacity to quench reactive oxygen (ROS) and reactive nitrogen species (Schaefer and Hardeland, 2009). The levels of AFMK have also been found to vary in coordination with melatonin making it unlikely that melatonin is the primary precursor. With so many potential roles and interactions, further investigation of the functions of these metabolites and isomers is warranted. These future investigations should include not just quantification of these compounds but also aim to understand the roles of these metabolites in plant metabolism.

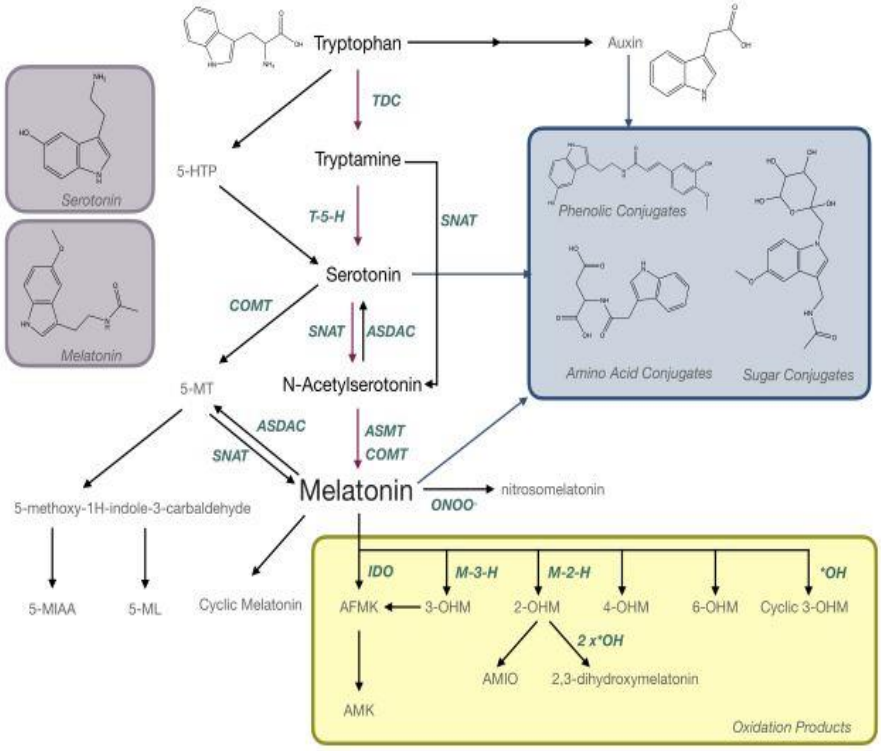

Figure 1. Biosynthesis and metabolism of melatonin in plants

Melatonin boosts plant's innate immunity

A handful studies in the late 1990s related to plant melatonin research, has blossomed into a vibrant and active area of investigation. Melatonin has been found to play critical roles in mediating plant responses and development at every stage of the plant life cycle from pollen and embryo development through seed germination, vegetative growth and stress response (Murch and Erland, 2021). In-field investigations have significantly supported the possible role of melatonin on flower development, enhancing male to female ratio in vegetables (cucurbits), improvement of fruit setting, fruit development, parthenocarpy, fruit drop (especially in citrus, mango, guava, etc.), breaking seed and tuber dormancy, fruit quality (size, colour, nutraceutical value), seed development, fruit ripening and senescence (to improve postharvest life/shelf life of fruits, vegetables, and cut flowers). Root treatment of melatonin may help to improve the success ratio and initial root development and growth of crops which require nursery transplanting (rice, tomato, chilies, cabbage, cauliflower, eggplant etc). Recently, scientists have anticipated melatonin to have auxin like properties and its involvement with auxin remarkably promotes grafting and vascular connection establishment (Melnyk *et al.*, 2015). Keeping in mind the physiological, biochemical, and genetic and

epigenetic actions of melatonin in multiple organisms, it seems melatonin may prove to be an important molecule to influence especially field crops, and may prove helpful in increasing crops yields and the nutraceutical value helping to address the food security issues around the world.

Melatonin for abiotic stress management

Several studies have revealed melatonin to regulate physiological functions of plants. Melatonin is now known to alter many plant characteristics including germination, seedling growth, alteration of flowering time, grain yields, and senescence (Byeon and Back, 2014). Melatonin as potential immune booster for plant system significantly involve in stress mitigation (Turk *et al.*, 2014). Exogenous application of melatonin (0.1μM) significantly alleviated the growth inhibition caused by elevated salinity; this enabled the plants to maintain their photosynthetic capacity (Arnao and Hernandez-Ruiz, 2019). Melatonin has also been found to be involved in the biosynthesis and catabolism of gibberellic (GA) and abscisic acids (ABA), respectively; it was shown to up-regulate ABA catabolism genes and down-regulate ABA biosynthesis genes resulting to a rapid reduction in ABA. At the same time, it positively up-regulated GA biosynthesis genes during the early stage of germination, which leads to better germination and better plant growth during the initial stages. Melatonin application enhanced tolerance to salt and drought stress in soybean, and upregulated the expression of genes that were inhibited by salt stress (Wei *et al.*, 2015). Recently, melatonin has been reported to provide protection against butafenacil (a singlet oxygen-generating herbicide), in the study in question, melatonin-rich transgenic rice plants exhibited lower levels of malondialdehyde and hydrogen peroxide. These plants also exhibited elevated superoxide dismutase and catalase activities compared to control plants (Park *et al.*, 2013).

Melatonin for diseases and pest control

In addition to many other positive functions in plants, exogenous application of melatonin (0.05–0.5 mM) improved resistance against one of the most severe diseases, Marssonina apple blotch (fungal diseases caused by *Diplocarpon mali*); this involved modulating the activities of antioxidant enzymes and plant defense related enzymes. In a recent study, the application of 10 μM melatonin on to *Arabidopsis* induced pathogenesis-related genes which further supports the idea that melatonin may be a defense signalling molecule in plants against pathogens (Lee *et al.*, 2018). Certainly, the possibility that melatonin may help in controlling plant diseases (fungal, bacterial, viral, viroides) should not be overlooked and requires further investigation. Moreover, melatonin (an indoleamine) is believed to have a role against insect attack, and could prove to be a potential means to control or reduce insect feeding on commercial crops, as insects cause huge losses (billions of dollars) and substantially reduce crops yields.

Conclusion

The abundance of information on melatonin indicates that it is a crucial signalling molecule and that it is essential for supporting the immune system of plants against both biotic and abiotic stress factors. Melatonin works as a key regulator of gene expression and interacts with other phytohormones in a variety of plant biological processes, both under favourable and unfavourable environmental conditions. The melatonin generated by the body, nevertheless, is occasionally insufficient to handle challenging situations. As a result, exogenous melatonin and other methods are used to raise endogenous melatonin levels in order to maintain plant immunity and normal development capability. Underpinning this information regarding the plant immune resiliency is believed undeniably to open new paradigms of phytomelatonin potential to architect the plant growth under capricious environments, especially for sustainable agriculture.

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Plant Based Milk - An Alternative to Nutritional Security

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Back in 1950s it was common to drink entire glass of cow's milk as a beverage. With increasing cost of milk, availability issues, short shelf life making it necessary to have an alternative to animal based milk. Now a day, plant based or non-diary milk is available as a better alternative to address the animal based milk availability issue. As an alternative beverage, plant-based milk prepared from sources like soy, oat, hemp, coconut, rice, and nuts, are available in the market. These non-dairy milk alternatives (or milk analogues) are water extracts of plants and have become increasingly popular for human nutrition. Over the years, the global market for these products has become a multi-billion dollar business and will reach a value of approximately 26 billion USD within the next 5 years. Moreover, many consumers demand plant-based milk alternatives for health-related, lifestyle, sustainability and dietary reasons resulting in an abundance of products based on nuts, seeds or beans.

Market scenario of plant based milk products

Plant based milk market size was valued at 35.0 billion USD in 2021 and is poised to grow from 40.3 billion USD in 2022 to 123.1 billion USD by 2030. The plant-based milk alternative market was valued at over 17.0 billion USD in 2018 and is projected to grow at a Compound annual growth rate (CAGR) of 11.5% for 2023 (Markets and Markets, 2019). The estimated plant based dairy market size across India in a high growth scenario was likely to be over 106.0 billion INR in 2030. In comparison, for a low growth scenario of plant based dairy, the market size was over 48.0 billion INR. Plant-based milk market exit in different countries *viz*. U.S.A., Canada, Mexico, Germany, U.K., Italy, France, Spain, Russia, Switzerland, Turkey, Belgium, rest of Europe, China, Japan, South Korea, India, Singapore, Thailand, Indonesia, Malaysia, Philippines, Australia, rest of Asia-Pacific, Brazil, Argentina, and the Rest of South America, South Africa, Saudi Arabia, United Arab Emirates, Kuwait, and rest of Middle East and Africa. However, Asia-Pacific is dominating the global plant-based milk market due to the increasing consumption of plant-based milk and the market players' promotional activities boosting the demand for plant-based milk products (Data Bridge Market Research, 2023).

High cost of dairy products

Dairy farming is an integral part of agriculture since ancient times. But now a day rearing livestock has become a costly affair and about 60 per cent cost is involved in animal feeding. In a country like India which is home to 536 million livestock but there is shortage of green fodder and dry fodder to the tune of 11.2 and 23.4 per cent respectively. Market price of milk is increasing continuously due to increasing cost of fodder and feed. The comparative milk price of different animals is given in Table 1.

Table 1. Milk price and fat content of different animals

S. No.	Animal	Milk cost (Rs./L)	Fat (per cent)
1	Buffalo	70 to 90	5.2 to 7.2
2	Cow	65 to 75	3.4 to 5.1
3	Goat	80 to 150	2.4 to 5.0
4	Sheep	100 to 140	6.5 to 7.5
5	Camel	120 to 150	1.2 to 6.4
6	Donkey	2000 to 5000	1.2 to 2.0
7	Yolk	1500 -1700	5.5 to 9.0

Use of plant based milk

Selection and use of plant based milk products depend upon the health-related, lifestyle and dietary reasons. Availability of nutrients and ease of digestion

are the main factors that lead to selection of a particular plant based milk. On the basis of claim, the global plant-based milk market is segmented into regular, gluten free, nut free, soy free, artificial preservatives, color free, and others. On the basis of packaging size, the plant-based milk is available in packing size of less than 100 ml, 110 ml, 250 ml, 500 ml, 1000 ml and more than 1000 ml in different packing like can, bottle and tetra pack. Based on different parameters, a comparison between plant & animal based milk and human milk is given in Table 2. Some of the prominent players operating in the plant-based milk market are Silk, Sanitarium, Alpro, Rude Health, Plenish, Provamel organic-bio, The Hain Celestial Group, Inc., Sunopta Grains and Foods Inc., Califia Farms, LLC, NotCo, Valsoia S.p.A, Yeo Hiap Seng Ltd., Simple Foods, natur-a, Nutrisslim, Australia's Own, Oatly Inc., Elmhurst Milked Direct LLC, Hershey India Private Limited, Life Health Foods, Manitoba Milling Company, and HP Hood LLC. Nutrient related proximate analysis of different of plant based milks is given in **Table 3.**

Fermentation to improve plant based milk products

Fermentation can help to improve the sensory profiles, nutritional properties, texture and microbial safety of plant-based milk alternatives with the goal of producing more tasty and valuable products. Plant-based milk fermentation mainly uses mono-cultures of microbes, such as lactic acid bacteria, bacilli and yeasts, for this purpose. Mixed-culture fermentations with two or more microbial species can be used to further improve the plant-based products. Due to the rapid progress in this field, we can expect well-balanced and naturally fermented plant-based milk alternatives in the coming years.

How to choose a healthy plant based milk?

1. **Sugar content:** Choose unflavoured and unsweetened options. Added sugars like fructose and maltodextrine are often added to enhance flavor and texture. Some brand also adds sugar into unflavored variation, so always check the ingredient list.
2. **Additives:** Plant based milk is often thinner and lighter in texture, additive such as salt, searrageenan and vegetable gums are usually added to achieve a thicker and smother texture while giving the milk a longer shelf life. These thickening agents have known to cause inflammation and gastrointestinal issues for some humans, which negates the benefit of adopting dairy free lifestyle.
3. **Water content:** Water content is important or essential factor for people on low calorie diet. For example commercial almond milk is mostly 98% water, the remaining two per cent constitute only about five almond worth of juice in every cup.
4. **Nutritional profile:** If you are looking for a milk alternative as a source of nutrition, find one that has similar protein and carbohydrates count to cow's milk *i.e.* 8 g and 12 g, respectively.

Pros and cons of dairy and plant based milk:

Dairy based milk

Pros:

1. Regular cow milk is an excellent source of good quality protein, which is essential the body for growth and repair.
2. Cow's milk also provides many vitamins and minerals such as calcium, vitamin B12 and zinc.
3. Dairy is more affordable choice per litre which is an important consideration.

Cons:

1. Dairy is not suitable for everyone like those who have an allergy to cow's milk or intolerance to lactose (sugar) in milk.
2. The full fat cow's milk is also relatively high in saturated fat.

Plant based milk

Pros:

1. Plant based milk alternative are also important for those who follow a vegan diet, so that meals containing milk can still be enjoyed.
2. Many people prefer the taste of plant based milk instead of dairy milk.

Cons:

1. Plant based milk are low in protein content. A 100 ml of cow's milk contain 4 g of protein in comparison the same amount of soy milk provides 3.2 g of protein.
2. They can also lack other essential nutrients such as calcium. Many manufacturers fortify their plant based milk with these nutrients to emulate the nutrition provided by dairy.
3. The sweetened plant-based milk such sweetened almond milk contain added sugar which should be taken in consideration.

Human based milk

Pros:

1. Breast milk provides ideal nutrition for growth and development of infant.
2. It provides specific antibodies *viz*. IgG, IgA, and IgM plays a key role in defending against pathogens.
3. Breast feeding can reduce the mother's risk of breast and ovarian cancer, type-II diabetes and high blood pressure.

Cons:

1. Sometimes it does not suit to babies because of the lactose intolerance due to lack of lactase enzyme which help in digestion of lactose.
2. Even a baby who has never been formula fed and has never had any food besides breast milk, may so signs of food allergy including diarrhea, bloody stools, vomiting, colic, eczema, constipation and poor growth.
3. The over feeding of breast milk can increase the risk of severe breast infection.

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Table 2. Comparison of plant and animal based milk based on different parameters

S. No.	Parameter	Plant based milk	Animal based milk	Human milk
1	**Nutrient value**	100 ml of almond's milk contain 1.0-1.5 g of protein. 100 ml of soy milk contain 3.0-4.0 g of protein. 100 ml of oat milk contain 1.0-1.2 g of protein. 100 ml of rice milk contain 0.2-0.4 g of protein.	100 ml of cow's milk contain 3.0 to 4.0 g of protein. One cup of low-fat milk has 100 calories and 8.0 g of protein, as well as 30% of the daily recommended value of calcium, 25% of vitamin D and 8% of potassium. While it contains 13.0 g of sugar, it's in the form of lactose, which is a natural part of cow's milk. The fat content varies depending on the type chosen (skim vs. low-fat vs. whole milk).	Mature human milk contains 0.8 to 0.9 per cent proteins, 3 to 5 per cent fat, 6.9 to 7.2 per cent carbohydrate calculated as lactose besides 0.2 per cent mineral constituents expressed as ash. Its energy content is 60-75 kcal/100 ml. Fortified Unsweetened soy milk can be used as an alternative for human milk. Colostrum contains IgG, IgA, and IgM antibodies. Special immuno-globulin (IgA) antibody is found in mature breast milk plays a key role in defending against pathogens. IgG strengthen immune system.
2	**Green house gas emission (kg/L of milk)**	Rice milk – 1.18 kg Soy – 0.98 kg Oat milk – 0.90 kg Almond – 0.70 kg	Dairy milk – 3.15 kg	Total per capita greenhouse gas (GHG) emissions vary from country to country. GHG emission in India is 2.5 metric tonne CO_2e per capita per year (2018).
3	**Eutrophication**	Rice milk – 4.69 g Soy – 1.62 g Oat milk – 1.5 g Almond – 1.06 g	Dairy milk – 10.65 kg	-
4	**Freshwater use**	Rice milk – 371.46 g Soy – 269.81 g Oat milk – 48.24 g Almond – 27.8 g	Dairy milk – 6.28 kg	Freshwater uses in India 49275 litre per capita per year.
5	**Land use**	Rice milk – 0.76 m^2 Soy – 0.66 m^2 Oat milk – 0.50 m^2 Almond – 27.8 m^2	Dairy milk – 8.95 m^2	Human being – 10 m^2

Source: Joseph Poore and Thomas Nemecek (2018)

Table 3. Comparison of plant based milk

	Soy milk	Oat milk	Rice milk	Pea milk	Almond milk	Cashew milk	Coconut milk
Calorie	80	130	120	70	30	25	45
Carbs (g)	4	24	23	0	1	1	1
Sugar	1	5	10	0	0	3	7
Protein	7	4	1	8	1	<1	0
Fat/ unsaturated fat	4/0.5	2.5/0	2.5/0	4.5/0.5	2.5	2.0	4/3.5
Vitamin D (MCG)	30	25	0	30%	25%	25%	25%
Calcium (mg)	45	35	2	45%	45%	45%	45%
Potassium (mg)	287	95	35	450	160	1	40

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Weed Management in Pearl Millet

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Millets, the earliest domesticated food crops in Asia and Africa, are grouped in two groups. The first group comprised of Pearl millet and sorghum categorized as major millets while finger millet, barnyard millet, little millet, foxtail millet, kodo millet, proso millet and brown-top millet are grouped as minor millets. They are the major crops of the semi-arid regions of the country, and have the potential to contribute substantially for food, fodder and nutritional security. Traditionally millets are cultivated on marginal lands with low or no inputs resulting in low yield. However, with the use of hybrids and with improved production technologies, the productivity of major millets has improved a lot.

Pearl millet is the fourth most important food grain crop in India after rice, wheat and sorghum. Pearl millet can tolerate drought, low fertility, and high temperature. It is a summer annual crop well suited for double cropping and crop rotation. Pearl millet contains phytochemicals that lower cholesterol. It also contains folate, magnesium, copper, zinc, and vitamins E and B-complex. It is a sensitive crop concerning biotic & abiotic stresses; weeds are a major constraint. Weeds compete with crop for nutrients, soil moisture, space and sunlight. Millets are poor weed competitors in the early stage of growth. Among the biotic factors, weeds cause maximum yield reduction in different crops. Presence of weeds in general reduces crop yields by 31.5% in winter, 22.7% in summer and 36.5% in Kharif season and some cases can cause complete devastation of the during the rainy season. Pearl millet is grown in kharif season, hence most of the rainy season weeds including grassy, broad leaved and sedges infest the crop. In Haryana, pearl millet is infested by more than 15 weeds species of different groups. *Trianthema portulacastrum, Digera arvensis, Amaranthus viridis, Phyllanthus niruri, Physalis minima* and *Mollugo pentapyhla* are dominant broad leaf weeds whereas *Dactyloctenium aegyptium, Echinochloa colona, Digitaria sanguinalis* and *Cenchrus echinatus* are most prevalent grassy weeds and *Cyperus rotundus* among sedges infesting the pearl millet crop. The infestation of dominant weeds in a field can be used in chalking out a sound management strategy for the farmers.

Weed management is an important factor for enhancing the productivity of pearl millet, as weeds compete for nutrient, water, light, and space; reduce crop yield and quality with crop plant during the early growth period. Pearl millet grows slowly at first and is a relatively poor competitor with weeds during the first few weeks of development.

There are three main methods of weed management in pearl millet:

Cultural methods

These methods involve manipulating the environment to create conditions that are unfavorable for weeds. This can be done by following techniques:

- Preparing the seedbed well to ensure good aeration and germination of crop.
- Planting the crop at the optimum time and spacing.
- Rotating crops with other crops that are not susceptible to the same weeds.
- Using cover crops to suppress weeds.
- Growing of intercrops like mungbean, cowpea etc. as intercrops in pearl millet could exert smothering effect on weeds.
- Narrow row spacing, use of higher seed rate
- Proper placement of fertilizers
- Mulching: A variety of mulch can be used such as straw.

Manual and mechanical methods

These methods involve using tools to remove weeds from the field. Manual and mechanical weeding is by far the most widely followed method of

weed control in millets. Hand weeding or inter-row cultivation provides reasonable weed control. However, during kharif season, inter-culture operations have to be delayed due to frequent rains and weeds overtake the crops and cause severe reduction in yield. Non availability of labour as and when required and higher cost is also a major constraint in adoption of manual weeding option in millet crops.

Chemical methods

These methods involve using herbicides to kill weeds. Herbicides can be applied pre-emergence (before the weeds emerge) or post-emergence (after the weeds emerge). Herbicides can be used to control a wide range of weed species in pearl millet. However, it is important to use herbicides carefully and according to the label instructions. Some herbicides can be harmful to pearl millet if they are not used properly. Atrazine along with one hoeing is used to control weeds in pearl millet crop. At CCS HAU, Hisar atrazine provided excellent control of *T. portulacastrum* and *Echinochloa* but not effective against *C. rotundus*. Atrazine 0.75 kg/ha *fb* 2,4-D 0.5 kg/ha and atrazine at 1.0 kg/ha as pre-emergence application provides effective control of weeds and comparable yield to the mechanical weeding. Atrazine application effectively controls the broad leaf weeds while poor against *Cyperus rotundus*. So, *Cyperus rotundus* has become most problematic weed in Pearl millet. At SKNAU, Jobner, Rajasthan, deep summer ploughing + tembotrione 100 g/ha (PoE) treatment effectively control the *Cyperus rotundus* and all other weeds resulting in higher pearl millet yield. At Gujarat, farmers are advised to carry out inter culture and hand weeding at 20 and 40 DAS or apply recommended atrazine 500 g/ha as pre-emergence for weed management. So for effective weed management in pearl millet atrazine 500 g/ha can be applied as pre-emergence of early post-emergence at 10-15 days after sowing.

The best method of weed management for pearl millet will vary depending on the specific weed species present, the location of the field, and the resources available. However, a combination of cultural, mechanical, and chemical methods is often the most effective way to effectively control weeds and achieve high yields of pearl millet.

Fig 1. Atrazine effect on *Amaranthus*

Figure 2. Atrazine use in pearl millets

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Microbial Inoculants and Nutrient Use Efficiency

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The use of chemical fertilizers to enhance crop productivity has affected the biogeochemical cycles negatively and the leaching and run-off of nutrients from chemical fertilizers have led to environmental degradation. One of the main reasons for these problems is the low nutrient use efficiency of chemical fertilizers (Adesemoye and Kloepper 2009). Nutrient use efficiency (NUE) can be defined in many ways like agronomic efficiency (kg grain yield increase/kg nutrient applied), physiological efficiency (kg grain yield increase/kg nutrient taken by crop) and chemical efficiency or apparent recovery (kg nutrient taken up per kg nutrient applied). Low efficiency of applied nutrients is one of the main constraints in crop production and it is a major global concern with regards to food security for an ever increasing global population (Gosh et al., 2015). In India in the past few decades use efficiencies for major nutrients like N, P and K remained constant at 30-35 %, 15-20 % and 35-40 % respectively (Tarrafdar et al., 2015). This means a large quantities of nutrients applied are lost which not only add cost by way of fertilizer application but also cause detrimental effects in the environment like eutrophication and nitrate pollution. Nutrient use efficiency can be increased through various means like manipulation of application techniques, coating fertilizers like in the case of urea; it is coated with different materials like neem, sulfur, gypsum, plastic and mud ball so as to have slow release of nitrogen. An ecologically supreme way of improving nutrient use efficiency is harnessing plant microbe interactions, as it cause zero damage to the ecosystem. It is widely believed that a vast diversity of microorganisms inhabiting rhizosphere, phylloplane and as endophytes assists plants in uptake of mineral nutrients and various other growth factors and through which they ensure better plant productivity and hence an improved nutrient use efficiency. Agriculturally important microorganisms can positively influence on the use efficiencies of different plant nutrients like N, P, K and many other secondary and micronutrients.

Microbes in P use efficiency

Phosphorus is the second most important plant nutrient after nitrogen and it's an integral component of nucleic acids, phospholipids, important in cellular membrane and provides compounds for photosynthesis in plants (Rai et al., 2013). In soil P is present in large amounts but only a fraction of it is available to plants owing to very low solubility of phosphate salts in soils. Much of fertilizer phosphate applied to crop plants is fixed in soil and the total available phosphate in soil solution is 10 mM with very low mobility (Ryan et al., 2005). Plant evolved a multitude of strategies to increase P uptake thereby increasing P use efficiency. Arbuscular mycorrhizal (AM) symbioses is the most wide spread strategy used by plants to improve P use efficiency. AM symbioses is a special kind of symbiotic relationship in which the micro partner (fungi) helps in P uptake and mobility in the macro partner (plants) and macro partner provides sugars and space for colonisation to the micro partner. AM symbioses, because of its large surface area can contribute to plant nutrition uptake especially phosphorus uptake. Since phosphorus is highly immobile element the left over phosphates which are not absorbed by plants are easily absorbed in the bulk soil and hence a phosphate free zone occurs in the rhizosphere. But, the extraradical mycelium formed by fungal partner can extend beyond this phosphate free zone and help plants in absorbing

phosphate available at a far-off distance from roots thereby making the otherwise unavailable phosphates to available phosphates (Roy-Bolduc and Hijri, 2011). *Glomus*, *Gigaspora*, *Scutellospora*, *Acaulospora* and *Entrophospora* are the most commonly occurring AM fungi (AMF) and they are obligate symbionts (Bagyaraj et al., 2015). The role of AM fungi in improving P use efficiency and general growth parameters is established in different crops by various research groups. Beneficial effects seen by AM fungi inoculation in different crops are given in Table 1. Apart from AM fungi there is one more function group of microorganisms called phosphorus solubilizers which improve phosphorus use efficiency alike AM fungi. Unlike AM fungi phosphorus solubilizers are not involved in P mobilization, but they solubilize fixed phosphates to available phosphates. A number of phosphorus solubilizing microorganisms have been utilized for tackling the phosphorus fixation problem in the soil. A few to name are *Pseudomonas striata*, *P.fluorescens*, *Bacillus megaterium* and *Aspergillus* sp. Such phosphorus solubilizing microorganisms can be used singly or in combination with other microbial inoculants like AM fungi and nitrogen fixers.

Microbes in N use efficiency

Nitrogen is the primary nutrient and it is an important constituent of proteins, enzymes, nucleic acids and plays an major role in establishment and maintenance of photosynthetic capacity, photosynthetic activity and sink capacity. Hence nitrogen is the fundamental nutrient for crop production and global food security (Herera et al., 2016). Since the availability of nitrogen in the easily absorbable form is limited in soil external application of nitrogen becomes an absolute need. But much of the N applied to soil does not find its fate in plant absorption. Only 30-35 % of the applied nitrogen is taken up by plants and the remaining is either fixed in soil or lost to the environment in the form of leaching and gaseous loss. Considering the cost of fertilizer nitrogen and the ill effects of lost nitrogen it is necessary to improve the nitrogen use efficiency. The use of microbial inoculants to improve nitrogen use efficiency is an ecofriendly option available to the farmers. Inoculation with rhizobacteria, *Bacillus simplex* and *Bacillus flexus* in wheat has shown to improve nitrogen use efficiency and grain quality (Barneix et al., 2005).In another study Adesemoye and his group of researchers have shown that reduction of chemical fertilizers by 25 % then the recommended dose and supplementing with application of a PGPR formulation (*Bacillus amyloliquefaciens* IN937a and *Bacillus pumilus* T4), has resulted in the same level of plant growth, yield, nitrogen and phosphorus uptake as that of full dose of fertilizers. When it was further supplemented with AMF *Glomus intraradices* the same effect was achieved even with 70% of recommended dose of fertilizers (Adesemoye et al., 2009). Nitrogen fixing bacteria both symbiotic (Rhizobia) and free living (*Azotobacter*, *Azospirillum* and various N fixing cyanobacteria) are also known to improve nitrogen use efficiency and also can provide atmospheric nitrogen. Hence inoculation with nitrogen fixing bacteria either at the time of sowing or at frequent intervals in the crop growth stages can reduce the application of chemical fertilizers. Arbuscular mycorrhizal fungi is known for increasing uptake of nitrogen and other plant nutrients just as they improve the uptake of phosphorus

Microbes for use efficiency of potassium

Potassium (K) is the third most important plant nutrient which plays a key role in growth, metabolism and development of plants. An adequate supply of potassium to crop plants leads to well-developed roots, fast growth and increased resistance to pests and diseases. Potassium, once thought of being

adequate in Indian soils has been reported to be low in 21 % of Indian soils and medium in 51 % of arable land (Hasan 2002). Hence there is a need of immediate K fertilization of 72 % of Indian agricultural soils. Since the cost of potash fertilizer is dependent on global market it's getting costlier every year which increases the cost of cultivation. An alternate option is use of microbe mediated technologies to improve potash use efficiency so that the input of potash fertilizer can be kept at a bare minimum. K use efficiency can be improved by inoculation of crop plants with potash solubilizing microorganisms and AM fungi. Organic acids produced by microbial inoculants are able to chelate metal and mobilize K from K containing minerals and it was reported that inoculation of PGPR *Bacillus edaphicus* NBT improved K uptake (Sheng and He 2006). Field trial were carried out with a PGPR (*Bacillus* sp.) and AMF (*Glomus intraradices*) in maize across two tillage system (no till and conventional tillage). It was shown that treatment of AMF in combination with PGPR improved the uptake of K along with N and P across the tillage systems (Adesemoye et al., 2008). Co-inoculation of K solubilizing microorganisms with K and P bearing minerals improve plant K and P uptake in sorghum across three different types of soils (Badar et al., 2006).

Microbes in use efficiency of other minerals

Microbial inoculants have been shown to improve use efficiency of many other elements in addition to N, P and K. *Mesorhizobium mediterannium* when inoculated in barley and chickpea has shown to improve uptake of Ca and Mg along with N, P and K uptake (Peix et al., 2001). *Pseudomonas mendocina* in combination with AMF (*Glomus intraradices* and *G. mosseae*) have shown to improve the uptake of Ca, Fe and Mn along with improved uptake of N and P in lettuce (Kohler et al., 2008). Application of AMF (*Glomus macrocarpum*) to *Sesbania aegyptiaca* and *Sesbania grandiflora* has shown an increased Mg uptake (Giri and Mukerji 2004). Mycorrhizal fungi are also shown to improve uptake of Zn, Fe, Cu and Mn in maize (Liu et al 2000). AM fungi have been shown to improve use efficiency of all major and micronutrients since they increase the surface are of roots.

Conclusion

Incorporation of microbial inoculants technology as a component of integrated nutrient management has dual benefit of high crop productivity in the short term and sustained production without deteriorating the soil health in the long term. Although a plenty of microbial inoculants are available to increase nutrient use efficiency, it has to be considered that no microbial inoculant is universal as their activity depends on soil type, plant grown and various other edaphic and climatic factors. Hence there is a need for widespread studies on different microbial inoculants for improving nutrient use efficiency of different crops under varied agro-climatic conditions.

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Table 1: Effect of AM fungi inoculation on P use efficiency of different crop plants.

Crop	AM fungi inoculated	Response	Research group
Wheat	*Glomus mosseae*	Increased grain yield of up to 25.8 %; Increased protein content and wet gluten content	Kumar et al., 2011
Rice and Mung bean in intercrop	*Glomus caledonium*	Intercropping and AM inoculation increased total P uptake by 57% in rice, total P and N acquisition by 65% and 64% respectively in mung bean, and nodulation by 54% in mung bean	Li et al., 2009
Maize	*Glomus intraradices*	Increased available phosphate in the rhizosphere and in the bulk soil	Cozolino et al., 2013
Green gram	*Glomus fasiculatum, Glomus mosseae*	Grain yield (by 14.8 and 13.5%) and grain P content was significantly increased (by 21.95 and 20.97%), respectively.	Bhat et al. 2011
Tomato	*Glomus intraradices*	Increased N and P uptake in both drought stress and normal conditions	Subramanian et al., 2006
Chickpea	*Glomus fasciculatum*	Increase plant yield and nutrient uptake when AM fungi was inoculated with *Rhizobium* and a Phosphorus solubilizer *Pseudomonas striata*	Zaidi et al., 2003

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Enhancing Sorghum Pest Management -Exploring Biological and Botanical Control Strategies against *Chilo partellus*

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Sorghum bicolor (L.) Moench, commonly known as jowar, is a cereal crop originating from northeast Africa. It serves as a vital source of food and fodder, particularly for disadvantaged populations in semi-arid tropics. Sorghum grain boasts a high composition of carbohydrates (72.6%), proteins (10.4%), fats (1.9%), crude fiber (1.6%), and mineral matter (1.6%). Notably, sorghum exhibits remarkable drought tolerance, enabling its cultivation in regions with higher moisture stress levels and extended durations. In India, sorghum ranks as the fourth most significant cereal crop, trailing rice, wheat, and maize. The country's sorghum production in 2019 amounted to 3.7 million tonnes from 4.09 million hectares of cultivated land, yielding an average productivity of 781.91 kg/ha. This figure falls short of the global average productivity of 1427.94 kg/ha. Additionally, sorghum plays a crucial role as a fodder source across the nation. Its cultivation is primarily concentrated in the southwestern states of Maharashtra, Andhra Pradesh, Karnataka, Gujarat, Tamil Nadu, and Rajasthan. Worldwide, the production of sorghum reached 62.20 million tons in 2022.

One of the major challenges faced in sorghum production is the presence of nearly 150 pest species. Among these, *Chilo partellus*, an infamous insect infesting the stem and causing yield and quality reduction, poses a significant threat to sorghum cultivation. The impact of *C. partellus* accounts for an estimated 18-25% loss in yield, resulting in substantial economic consequences. The annual crop losses attributed solely to *C. partellus* amount to approximately US$334 million. It is important to approach the management of *C. partellus* and other pests in sorghum cultivation through scientifically sound and integrated pest management practices to mitigate their detrimental effects on crop productivity and ensure sustainable agricultural practices.

Sorghum Stem Borer (*Chilo partellus*)

Chilo partellus, the sorghum stem borer, is a significant global pest impacting sorghum production. Understanding its biology is crucial for effective pest control. *Chilo partellus*, a member of the family Crambidae and order Lepidoptera, targets grasses and sedges, including maize and sorghum. Integrated approaches are essential for sustainable sorghum farming and food security in *C. partellus* infested regions. *C. partellus* adults have a yellow-gray coloration with scattered dark scales.

Life Cycle of *Chilo partellus*

Chilo partellus exhibits variations in its life cycle duration depending on seasonal conditions. The life cycle ranges from 44 to 64 days, with an average duration of 53.82±0.49 days. During peak summer months, it lasts around 44-48 days, while during peak winter months, it extends to approximately 60-64 days. These variations reflect the influence of seasonal factors on the development and maturation stages of *Chilo partellus*.

Fecundity

Female *C. partellus* Swinhoe has an average fecundity of approximately 150-160 eggs per female (Songa et al., 2000; Berner et al., 1993), indicating their high reproductive potential.

Oviposition Period

The oviposition period of *Chilo partellus* lasts 4-5 days, with an average of 4.2 +/- 0.13 days. This is consistent with previous studies by Chavan (2006) and others, which reported an average oviposition period of 3-5 days.

Incubation of eggs

Chilo partellus eggs are flat, oval-shaped, and milky white. They hatch within 4-7 days, mainly in the morning. Newly hatched larvae are flat, creamy white, and darken as they grow. According to Krishna et al.

(2018), stem borer eggs hatch after 5-6 days in the morning.

Larvae

Chilo partellus larvae vary in size and weight across instar stages, with lengths ranging from 2.05 +/- 0.11 to 23.38 +/- 0.55 mm, breadths from 0.34 +/- 0.03 to 3.22 +/- 0.17 mm, and weights from 1.04 +/- 0.06 to 327.5 +/- 43.3 mg. The larval phase lasts 29-36 days, with longer durations in January and February and shorter durations in May and June (Arunkumara et al., 2018).

Pupae

Chilo partellus pupae are cylindrical and light brown. Male pupae measure around 10.66 mm in length, 2.23 mm in breadth, and weigh approximately 29.15 mg. Female pupae are slightly larger, measuring about 13.13 mm in length, 2.66 mm in breadth, and weighing around 49.15 mg. Pupal durations vary, with the longest periods of 11-12 days occurring from November to February, and the shortest periods of 7-8 days observed from May to June (Arunkumara et al., 2018).

Adults

Chilo partellus, the adult sorghum stem borer, has been studied extensively. The moth has yellowish-brown forewings with black dots. Wing length ranges from 7 to 17 mm (Berger, 1992). Male adults live for 4-7 days, while females live for 5-9 days. Male adults measure approximately 13.53 mm in length, 23.55 mm in breadth, and weigh around 49.12 mg. Female adults have average measurements of 18.55 mm in length, 29.84 mm in breadth, and weigh around 57.62 mg.

Effect of botanicals

In their study, Nega and Getu (2020) investigated the efficacy of seven treatments administered to larvae in the second and/or third developmental stages. These treatments included different concentrations of *Milletia ferruginea* Hochst seed powder and aqua extract, cow urine, *Phytolacca dodecandra L.* seed powder, and their combinations. An untreated control group was also included for comparison. The results demonstrated that the highest mortality rate (100%) was achieved on the second day using 3 grams of *M. ferruginea* and 2.0 milliliters of aqua extract. Additionally, at a concentration of 3.0 milliliters, cow urine and the combination of *M. ferruginea* and cow urine showed significant efficacy, resulting in mean mortalities of 86.7% and 93.3% within a three-day period. On the other hand, the mortality rates of treatments involving *P. dodecandra L.* seed powder, aqua extract, and their combination with cow urine were comparatively lower. Overall, the study concluded that *M. ferruginea* powder and aqua extract, along with cow urine and the combination of *M. ferruginea* and cow urine, are promising alternatives to chemical pesticides for effectively combating *C. partellus.*

January et al. (2018) conducted two trials involving six treatments: two commercial biopesticides (*Beauveria bassiana* and *Metarhizium anisopliae*), two plant extracts (*Neorautanenia mitis* and *Derris elliptica*), one synthetic insecticide (Amekan 344EC) containing Cypermethrin (144 g/L) and Imidacloprid (200 g/L), and an untreated control group. Results showed that both biopesticides and botanical extracts had significant effects on reducing *Chilo partellus* damage, leading to increased mortality and improved sorghum grain yield. Yield loss was reduced from 60.01% to 19.7%, and damage incidences, such as dead heart (45% to 64.28%) and whitehead (42.01% to 76.19%), were minimized. The treated samples demonstrated a stem borer mortality rate ranging from 57.51% to 78.12%.

Saranya and Samiayyan (2017) evaluated botanicals as ovicides against *Chilo partellus* eggs. Neem oil 5% showed the highest efficiency, preventing egg hatching with a success rate of 95%. Chlorpyriphos 0.2% (86%), neem oil 1.0% (79%), NSKE 5%, and Jatropha leaf extract 5% followed with decreasing efficacy. Neem leaf extract 5% effectively discouraged oviposition by C. partellus, recording only 16.6% of oviposition. Jatropha leaf extract 5% (19.2%), neem oil 5% (22.6%), neem oil 1.0% (28.3%),

and NSKE 5% (28.7%) also exhibited some deterrent effects. Notchi leaf extract 5% was ineffective as an ovicide and oviposition deterrent.

Effect of biological control agents

Jalali and Singh (2006) found that releasing *Trichogramma chilonis* parasitoids at three to five-day intervals resulted in parasitism rates of 75.2% and 62.6% in the first generation, and 90.4% and 78.4% in the second generation on *Chilo partellus* eggs in fodder sorghum. Larvae in plots where parasitoids were released every three and five days had stem burrowing measurements of 1.8 cm and 2.4 cm, respectively, compared to 7 cm in untreated control plots. Combining *T. chilonis* with *Bacillus thuringiensis* significantly reduced insect infestation and stem tunnelling compared to individual treatments. For cost-effective control, it is recommended to release *T. chilonis* at five-day intervals, three times during the first generation and two times during the second generation.

Koji et al. (2007) studied the role of Guinea grass, Panicum maximum Jacq. field boundaries in managing the spotted stem borer, *Chilo partellus* Swinhoe. The research revealed that Guinea grass acted as a reservoir for arthropod predators and a trap plant for the pest. Abundant populations of earwigs and spiders, known predators of stem borer eggs and larvae, were observed in the Guinea grass strips. However, only young larvae were found, indicating that the low density of *C. partellus* larvae in the grass strips throughout the season suggested an unsuitable environment for stem borer larvae. These findings highlight the effectiveness of Guinea grass as a habitat management tool to enhance specific stem borer predators and serve as a sink for the pest.

Jiang et al. (2004) studied the effectiveness of *C. flavipes*, a parasitoid, in controlling *C. partellus*, a cereal crop pest. They investigated their survival and development at different temperatures (22, 26, and 30 °C) using third and fourth instars of *C. partellus*. Results showed that larval mortality was highest at the lowest temperature for non-parasitized hosts and at the highest temperature for parasitized hosts in the third instar. Development time of *C. flavipes* decreased with host instar and temperature. Sex ratio shifted towards females as temperature increased. Parasitized *C. partellus* larvae gained more weight, and food consumption was reduced at 26 °C for both parasitized and non-parasitized larvae. These findings contribute to understanding the performance of *C. flavipes* under different climatic conditions.

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Success Story - Production Technology of *Kharif* Pulse Blackgram Var. PU-31 in Bishnupur District

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Pulses are an important commodity group of crops that provide high quality protein. The cultivation of pulses builds up a mechanism to fix atmospheric nitrogen in their root nodules and thus meet their nitrogen requirements to a great extent. Pulses can be produced with a minimum use of resources and hence it becomes less costly. Pulses are highly water efficient, can grow in drought prone areas and help improve soil fertility by fixing soil nitrogen.

Inspite of so many merits in pulse production, promotion of pulse in the district is not an easy job because most of the farmers are small and marginal farmers having land holding area less than 1 ha and as such sowing of kharif pulse coincides with the main crop rice. Also rabi pulse could not be sown in time as most of the field was occupied with paddy field upto the month of November and as such there is no time of land preparation and sowing time is always delayed which resulted into poor yield due to incidence of pests and diseases and sometimes the crop was damaged with occurrence of hailstorm mostly during March-April i.e. when the crop attains maturity stage.

The concerned efforts made in the technology front during the last three years under National Food Security Mission on Cluster Front Line Demonstration of Pulses paved way for significant increase in the productivity levels.

KVK Intervention

Although there were lot of constraints in pulse production, KVK, Bishnupur gave best effort to boost the pulse production through Cluster Front Line Demonstration on kharif pulse under National Food Security Mission. In the year 2016, Blackgram was cultivated in an area of 20 ha in 4 villages viz. Irengbam, Kumbi, Saiton and Upokpi of Bishnupur district. Areas suitable for Blackgram cultivation were identified, followed by selection of farmers willing to grow Blackgram.As a precursor to organizing the CFLDs, a training programmes related to the technology with major focus on pulse production during kharif was organized in the selected villages. Such willing farmers were trained on package of practices of Blackgram cultivation, the cost benefit advantage was explained to them. This was followed by hands – on training on growing of Blackgram var. PU-31 in 8 clusters of 4 villages benefitting 28 farmers. The activities that were carried out under the programmme were distribution of inputs like pulse seed (Blackgram), biofertilizers, fungicide and insecticide, organization of training and field days, distribution of literatures.

Blackgram with seed rate 25 kg/ha were treated with Carbendazim @ 2g/kg and Rhizobium @ 10g+ 10g sugar per kg of seed before broadcasting. Also, NPKS@ 20:40:20:20kg/ha were applied to the field at the time of sowing. The variety used is PU-31, a pedigree of UPU 97-10 x DPU88-31, released in the year 2005, 70-75 days to maturity, resistant or tolerant to Yellow Mosaic Virus (YMV) and is suitable of kharif season. The CFLDs programme were carried out under the watchful eye of SMS (Agronomy) and co-workers SMS (Plant Protection) and SMS (Agril.

Extension) of the KVK guided by Senior Scientist and Head of KVK, Bishnupur. Field visit in different crop stages were also carried out. Also, field days were organized at village level to show the response of the Blackgram cultivation to neighboring farmers.

Output and Outcome

The programme has promoted efficient use of cultivated land in Blackgram areas, optimized use of available resources i.e., water, labour and other inputs. It has not only provided additional yield of pulse averaging 5 q/ha but also improved soil health due to

fixation of atmospheric nitrogen by root nodules of Blackgram. Farmers could earn a net income of Rs. 15,000 inspite of prolonged rainfall during the cropping season and they could get a return of Rs.1.6 when Rs. 1 was invested.

Impact

Having convinced with the production potential of Blackgram cultivation, the area were expanded to 40 ha in the next kharif season 2017 in 8 clusters benefitting 80 farmers. But the most interesting part is that farmers practiced line sowing rather than broadcasting method which shows a promising result and the yield was increased by 41.65%.

5. Photographs of Line Sowing

Buoyed by this success, a concentrated plan has been mooted to propagate seed production technology in Blackgram on a wider scale in the district.

Table 1: Economics

Crop	Technology	No. of clusters	No. of farmers	Total area (ha)	Average yield			Gross Cost (Rs/ha)	Gross return (Rs/ha)	Net Return (Rs/ha)	B:C ratio
					Max.	Min.	Avg.				
Blackgram var. PU-31	Seed rate- 25 kg/ha, Seed treatment with Mancozeb and carbendazim @ 2g/kg, Rhizobium @ 20g/kg, N:P: K @ 20:40:20 kg/ha)	8	28	20	8	3	5	25000	40000	15000	1.6:1

Table 2: Yield and Economics

Crop	Technology		Area (ha)		Yield (q/ha)		Yield increase (%)	Net return (Rs/ha)		Net return increase (%)	B:C ratio	
Blackgram var. PU-31	2016	2017	2016	2017	2016	2017		2016	2017		2016	2017
	Broadcast	Line sowing	20	40	5.00	8.57	41.65	15000	33560	55.30	1.60:1	1.96:1

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Agricultural Co-operative Societies: A Boon for Farmers

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Growth of Indian economy is not possible without the progress of its rural areas. Slogan like "Jai Jawan - Jai Kisan" raised from these regions only. For fulfilment of needs and development of these rural areas, government as well as private organizations play their part. Government and private banks, charitable trust companies, non-government organization, joint firms and co-operative societies are to name the few. Co-operatives originated in the West during the middle of the last century and were introduced to India in 1904 with the promulgation of the 'Indian Co-operative Societies Act'. Rural indebtedness was the key trigger behind the formation of co-operatives in India. Initially these were just to provide credits to the farmers. Non-credit societies came in 1912. With the formation of the Reserve Bank of India (RBI) in 1935, the development of more co-operative societies was prioritized. Main aim of the co-operative was to get the poor and indebted farmers out of poverty and out from the clutches of money lenders. Within short span of time, role of co-operatives extended beyond agricultural credit. It started covering activities such as production, farming, marketing and processing. Co-operatives are now playing a very significant role in the socio-economic development of our country especially the rural India. Co-operatives cover more than 97 per cent of Indian villages. These societies are autonomous societies which work on their own where farmers work together to achieve their economic, social, and cultural needs. These societies are the organizations in which its members have the ownership and control to utilise the facilities/services of the society. The main function of these societies is to help its members in the form of kind or cash. People come forward in group in these societies and utilise the resources in the best possible way to gain maximum profit.

Types of co-operative societies

Apart from agriculture, co-operative societies work in other areas where instead of working alone, resources and services can be utilised efficiently by working together.

1. **Co-operative Credit Society:** These kinds of societies provide financial help to the members in the time of need. This society keep the deposits of members money and provide credit on reasonable interest rates whenever it is required by the members. For example, village level or primary co-operative society and urban co-operative banks.
2. **Housing Co-operative Society:** These societies provide residential plots, houses or flats to their members. These societies provide loan on lesser interest rate for construction of the house. For example, Employee's Housing Society, Metropolitan Housing Co-operative Societies, etc.
3. **Consumer Co-operative Societies:** By providing daily needs products on affordable and reasonable prices, these societies protect the rights of common consumers.
4. **Producer Co-operative Society:** This society provides raw material inputs implements. Machinery, etc. To small farmers to safeguard their interest.
5. **Co-operative Marketing Society:** These societies are made by those small producers and manufacturers who face difficulty in serving their produce.

6. **Co-operative Agriculture Society:** The main objective to build these societies is to work in collaboration with farmers so that they can get maximum gain from agriculture.
7. **Co-operative Training Societies:** These societies impart training to different co-operative employees under corporation.
8. **Co-operative Societies for Women:** In these societies, women work together on different fields like stitching, pickle making, etc.

Table 1: Agricultural Co-operative/Credit Societies and Banks in Punjab

S. No.	Particulars	Number
1.	Total co-operative societies of all type	18948
2.	Primary Agricultural Co-operative/ Credit Societies	3961
3.	Primary Agricultural Development Banks (PADB)	89
4.	State Agricultural Development Bank (SADB)	1
5.	Punjab State Co-operative Bank (PSCB)	1
6.	Joint Collective Farming Societies	83
7.	Primary Marketing-cum-Processing Societies	82
8.	Apex Marketing Federation, Punjab (Markfed)	1
9.	Primary Co-operative Milk Producers' Societies (Milkfed)	6521
10.	Poultry Co-operative Societies	91
11.	Sugarcane Supply Co-operative Societies	7

In Punjab state, total number of co-operative societies are 18948, out of which 3961 societies are Primary Agricultural Co-operative/Credit Societies (PACS). The co-operative societies include Joint Collective Farming Societies, Primary Marketing and Processing Societies, Milkfed, Markfed, Poultry Cooperation Society and Sugarcane Supply Co-operative Societies. Besides, State Agricultural Development Bank (SADB) and Primary Agricultural Development Banks (PADB) are also there to help farmers. It is important to mention that nearly 52 per cent PACS are running in profit and about 37 per cent in loss. The remaining ones are running in almost no profit no loss condition. There is a dire need for improvement in the condition of these societies.

Co-operative societies can help in improvement of farmers' economic and domestic conditions if they work independently. It is difficult for small farmers to survive in present days' expensive agriculture. Co-operative societies can purchase farm inputs in bulk at comparatively low prices which can help reduce cost of cultivation. In Punjab, there are many co-operative societies which not only provide farm inputs but also other services like agriculture credit, agri machinery, implements and create employment to agricultural labour. The interference by politicians and other influential persons may cause loss to the societies as well as its member farmers. In Punjab, 3961 co-operative societies are working, out of which, the societies which are running autonomously showed an exemplary progress and they have their own petrol/diesel pumps and agro-processing complexes. These also take land on lease by which they create employment to other fellow farmers. To improve the financial condition of farmers, only co-operative societies are the hope. These may be proved successful if these are allowed to work autonomously and independently. The marginal (up to 2.5 acre) and small (2.5 to 5 acres) farmers constitute 33 per cent of total operational holdings in the state which have only 9.7 per cent of total agricultural land. They are unable to bear huge farm expenses on purchase of modern machinery and implements. So, in such a situation, with the help of co-operatives using agricultural machinery and implements collectively is the only best option. Co-operative societies may help in eradicating

poverty, enhancing food security and creating new job opportunities. Where public and private sector fails, co-operative societies become a saviour. This is our uttermost responsibility to look after our village societies and make these successful and profitable organization because profit to co-operative is profit to farmers.

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Nitrogen Symbiosis in Cereals

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Increasing global population, which is 7.5 billion today, is predicted to rise to over 9 billion by 2050 (UN DESA, 2013) and changes in diet are driving up the need for food. Cereals are the important staple food throughout the world, especially rice, wheat and maize. Intensive agricultural systems that derive much of global food production are far from sustainable and a 'business as usual'. Approaches to meet the increased demand for food will lead to significant depletions in natural resources. The production and application of chemical fertilizer is the major source of pollution as well as the major use of energy in agricultural systems.

Nitrogen is an essential plant nutrient. It is the nutrient that is most commonly deficient, contributing to reduced agricultural yields throughout the world. Broadly nitrogen supply can be done through external inputs as organic or inorganic nitrogen, mainly as fertilizers or through naturally occurring biological nitrogen fixation. Typical nitrogen-use efficiencies for wheat, rice, and maize indicate that around 66% of this nitrogen is lost to the environment (Raun and Johnson, 1999), either in the form of nitrous oxides, which are potent greenhouse gases, or as soluble nitrates that find their way into aquatic systems (Glendining et al., 2009). Considering losses it is better to reduce dependency on nitrogen fertilizers. Molecular nitrogen or dinitrogen (N_2) makes up four-fifths of the atmosphere, but is metabolically unavailable directly to higher plants or animals. It is available to some microorganisms through biological nitrogen fixation (BNF) in which atmospheric nitrogen is converted to ammonia by the enzyme nitrogenase.

Loss of nitrogen can be overcome by various processes like fertilizer nitrogen management, organic nitrogen management, nitrogen use efficient genotypes and biological nitrogen fixation. But loss in case of BNF is less compared to other management processes. Since, in agricultural ecosystems, the BNF usually does not exceed the nitrogen requirement of the ecosystem, the fixed nitrogen gets used up by the system and does not add to the pollution.

Extending the process of BNF to cereals is of immense research interest because nitrogen derived from fixation is considerably more economical and ecofriendly as the fixed nitrogen is not as susceptible to losses as that of fertilizer N. Major limitation of associative nitrogen fixation IN cereals is that bacteria in the rhizosphere of plants utilise the products of nitrogen fixation for their own growth, but release little while they are alive (Berkum and Bohlool, 1980) which is in contrast to symbiotic associations like legume- rhizobium symbiosis.

The possibilities of extending the host range of Rhizobia to non-legumes were encouraged by the discoveries that *Rhizobium* forms nodules in *Parasponia* spp.

Approaches for achieving nitrogen fixation in cereals

Non nodular approaches

This improves the associations between cereals and nitrogen-fixing soil bacteria which includes achieving colonization and invasion of cereals roots by suitable diazotrophs.

a) Endophytic association- screening of germplasms for colonization by diazotrophs.

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The culturable bacterial diazotrophs were isolated from endophytic tissue of maize: seed, root, stem, and leaf. All isolates were able to grow on N-free semisolid medium. Eleven bacteria isolates showed nitrogen- fixing capacity which was measured by acetylene reduction assay (Montanez *et al*, 2009).

b) Investigation of root morphogenesis in relation to invasion

As we know that root nodule formation is closely related with lateral root formation, investigations were carried out by many scientists to

observe morphogenesis and lateral root formation in many cereals upon inoculation with strains of rhizobia.

c) Use of rhizobial inoculants which nodulate crops

The study of the interaction of *Azorhizobium caulinodans* (ORS571) with both rice and wheat has shown significant levels of nitrogen fixation, as assessed using acetylene reduction assay, and there was a correlation of this nitrogen fixation with the invasion of emerging lateral roots by 'crack entry' and the initiation of lateral root nodule formation (Cocking *et al*., 2001).

Nodular Approaches

a) Interactive responses between flavonoids and rhizobia.

The flavanone, naringenin, when applied at both 10^{-4} and 10^{-5} M concentrations, significantly stimulated the colonization of LRCs (lateral root cracks) of wheat by *Azorhizobium caulinodans* ORS571, but both daidzein and luteolin had no effect (Webster *et al*., 1997).

***nif* gene transfer**

To ensure expression of nitrogenase, protection of nitrogenase from inactivation by oxygen, and an energy supply for N_2 fixation without compromising yield, transformation of nif genes in cereals is one of the options.

The engineering of plants capable of fixing their own nitrogen requires the coordinated expression of 16 *nif* genes. Plastids may provide a favourable environment for *nif* gene expression. The introduction and expression of one of nitrogenase components, the Fe protein, in transgenic tobacco was achieved although results were not encouraging, they do provide important clues for future approaches (Dixon *et al*., 1997).

Significant progress has been made towards the induction of rooting modifications in cereals that resemble legume root nodule organogenesis. These findings will enable the cereals to fulfil part of their N requirements leading to savings in fertilizer inputs and consequently the environment.

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Nano Fertilizers: An Overview

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After the introduction of fertilizer responsive and high yielding crop varieties, fertilizers are found to have a prominent role in improving the food production in developing countries especially. Synthetic fertilizers greatly impact the world's food security and without which, there would be only half of the amount of food production that we are producing now. "About 35-40% of the crop productivity depends upon fertilizer". The applied fertilizers are also subjected to various types of losses such as leaching, volatilization, denitrification, fixation etc. which reduces their efficiency. Based on recent fertilizer use efficiency studies it is identified that the efficiency of fertilizer nitrogen is only 30-40% in rice and 50-60% in other cereals, while the efficiencies of fertilizer phosphorus, Potassium and sulfur are 15-20%, 60-80% and 8-12% respectively in most of the crops. With regards to micronutrients, the efficiency of most of them is observed to be below 5%. Therefore, there is an emergent necessity to adapt sustainable alternative strategies to enhance crop production.

Raising the rate of fertilizer utilization and reducing the contamination caused by illogical fertilization were the key steps for the sustainable development of agriculture. However, the progression aims of the fertilizer were slow/controlled release, precision, and eco-environmental health in the world. There has been an interest in the use of nanotechnology in agriculture for nearly 15 years identified various promising opportunities for applying nanotechnology to improve sustainable agri-food systems. Latest technologies such as controlled release technique and targeted delivery of agrochemicals (fertilizers and pesticides) for plant nutrition and pest control and thus, increase food safety and security and sensors for assessing specific conditions or analytes of interest in plant systems. Considering the resource use efficiency and safety, nanotechnology can precisely detect and deliver accurate quantity of nutrients to crop thereby reducing the residual effect in soil.

Table. Causes for low efficiency

Nutrient	Efficiency	Cause for low efficiency
Nitrogen	30-35%	Immobilization, volatilization, denitrification, leaching
Phosphorous	15-20 %	Fixation in soils Al
Potassium	60-80 %	Fixation in clay lattices
Sulphur	8-10 %	Immobilization, leaching with water
Micronutrients (Zn, Fe, Cu, Mn, B)	2-5 %	Fixation in soils

Nano fertilizers

Nano materials which can supply one or more nutrients to the plants when are fortified with nutrients. The synthesis of nano fertilizers is done by fortification of nutrients with nano-dimension singly or in combination on to various adsorbent materials. Nano-fertilizer can be defined as nano particles encapsulated materials which slowly delivers nutrients to crops. Different kinds of encapsulation methods include:

(a) encapsulation of nutrients with nanomaterials like nanotubes or nanoporous materials,

(b) coating of nutrients with a thin protective layer of polymer and

(c) formulations which can deliver nutrients as particles or emulsions of nanoscale dimensions

IFFCO Nano Urea

It is a nanotechnology based revolutionary Agri-input which provides nitrogen to plants. When compared to conventional urea prill, it has a desirable particle size of about 20-50 nm and more surface area

(10,000 times over 1 mm urea prill) and number of particles (55,000 nitrogen particles over 1 mm urea prill).

Table. Conventional fertilizers vs. nano-fertilizers

Index	Nano-fertilizer	Conventional fertilizer
Solubility	High	Low
Dispersion of mineral micronutrients	Improved dispersion of insoluble nutrients	Lower solubility due to large particle size
Soil adsorption and fixation	Reduced	High
Bioavailability	High	Low
Efficiency of nutrients uptake	Increased uptake ratio; saves fertilizer resource	Conventional fertilizer is not available to roots and the nutrients uptake efficiency is low
Controlled release	Release rate and pattern precisely controlled	Excess release leading to toxicity and soil imbalance
Effective duration of release	Extended effective duration	Used by the plant at the site and time of application; the rest is converted into insoluble form
Loss rate	Reduced loss of fertilizer nutrients	High loss rate due to leaching, drifting, run-off

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

IFFCO Nano DAP is an efficient source of available nitrogen (N) and phosphorus (P2O5) for all the crops and helps in correcting the Nitrogen & Phosphorus deficiencies in standing crops. Nano DAP formulation contains Nitrogen (8.0% N w/v) and Phosphorus (16.0 % P2O5 w/v).Nano DAP (Liquid) has advantage in terms of surface area to volume as its particle size is less than 100 Nanometre (nm). This unique property enables it to enter easily inside the seed surface or through stomata and other plant openings. Nano clusters of Nitrogen and Phosphorus in Nano DAP are functionalised with bio-polymers and other excipients. Better spread ability and assimilation of Nano DAP inside the plant system leads to higher seed vigour, more chlorophyll, photosynthetic efficiency, better quality and increase in crop yields. Apart from this, Nano DAP through precision and targeted application fulfils the nutritional requirement of crops without harming the environment.

Nano Zinc Fertilizer: Nano Zinc Fertilizer is a customized liquid zinc nutrient mix containing particulates of ionized zinc embedded in a colloidal amino acid matrix; for use in agricultural fertilization programs and animal feed supplements. It is an important component of various enzymes that are responsible for driving many metabolic reactions in all crops.

Ethical and safety issues of nano-fertilizers application

Undoubtedly nanotechnology has incredible potential to revolutionize many aspects of human life. However, the advancement of this multidisciplinary branch of science, especially the benefits from the practical application of nanoparticles have to be considered with some precautions.

The major concern at world scale is whether the unknown risks of nanoparticles involving their environmental and health impact prevail over their potential benefits. Thus, the risks associated with the application of nanoparticles are yet to be evaluated before the application of nanoparticles is fully accepted and implemented. Hence, "nanotoxicology" has been developed, which is responsible for assessment of the toxicological potential and promoting safe design and use of nanoparticles. Due

to the thorough quantitative analysis of the potential health impacts, environmental clearance, and safe disposal of nanoparticles, improvements in the design of further applications of nanotechnology can be anticipated.

No direct human disease has been linked to nanoparticles so far. Nanoparticles, which constitute a part of ultrafine particulate matter, can enter in the body of humans/animal through the oral, respiratory or intradermal route. Currently, there is a common assumption that the small size of nanoparticles allows them to easily enter tissues, cells, and organelles and interact with functional biomolecular structures (i.e. DNA, ribosomes), since the actual physical size of an engineered nanostructure is similar to many biological molecules (e.g. antibodies and proteins) and structures (e.g. viruses).

Merits of nanofertilizers

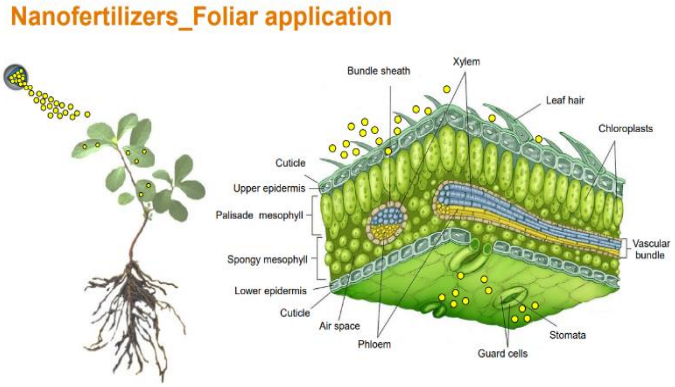
- Increased nutrient use efficiency
- Extended fertilizer release period
- Reduce the usage of chemical fertilizers by 50%
- Nutrient mobilization increased by 30%
- Increase in crop yield by 15-30%
- Reduced soil toxicity
- Reduces frequency of application
- Minimize the effect of over dosage.

Demerits of nanofertilizers

- Reactivity and variability are different under different conditions.
- This raises safety concerns for farm workers who may become exposed to xenobiotics during their application.
- It is reported that inhalation of nanoparticles during application caused chronic lung effects and exposure to metal based nanoparticles caused skin irritation, rashes, headaches. These include not only those exposed to nanofertilizer manufacturing but also nano fertilizer application in the field.
- The accumulation of nanoparticles in plants and potential health concerns.
- Some studies have reported phytotoxic effect of nanoparticles due to bioaccumulation.

Future Prospects

- Evaluation of the effect of nano fertilizers in the soils with different physio-chemical properties is necessary in order to recommend a specific nanofertilizer for a specific crop and soil type.
- Biosynthesized nanoparticle-based fertilizers and nano biofertilizers should be explored further as a promising technology in order to improve yields while achieving sustainability
- Accumulation of NPs in edible parts of crops and bioavailability of the accumulated NPs to the next trophic level. In this regard, specific studies of NPs bioavailability in edible parts are urgently needed to use nanofertilizers safely.
- Understanding nanoparticles in agro-ecological ramification (plant specificity, dose dependency and bio toxicity)
- Physiological explanation of mechanism of



uptake and translocation by plants • Influence of nanoparticles in rhizosphere and on root surface

- Accounting possible interactions of nanoparticles with the biotic or abiotic environment and their possible amplified bioaccumulation effects
- Effect on environment and human health

- Minimising the residual effect
- Lab to land.

Conclusion

Nanofertilizers mainly delays the release of the nutrients and extends the fertilizer effect period. Obviously, there is an opportunity for nanotechnology to have a significant influence on energy, the economy and the environment, by improving fertilizers. Hence, nanotechnology has a high potential for achieving sustainable agriculture. Nano-fertilizers have opened up new opportunities to improve inputs use efficiency, minimize costs and environmental deterioration in some aspects. Therefore, the scope for application of nanofertilizers in agricultural system needs to be prioritized in 21st century to accelerate the productivity of crops and sustain soil health and environmental quality through promoting use of nanoparticles in fertilizers and nano-sensors in soil microbial activity.

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Lumpy Skin Disease (LSD)

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LSD is one of the economically most important viral diseases of cattle and Asian water buffaloes after foot-and-mouth disease (FMD). LSD typically reduces milk yield, causes severe emaciation, permanent damage to hides.

Due to the impacts of global climate change and changes in trading patterns of animals and animal products, LSD has become an emerging disease threat. Initially the LSD was thought to be an allergic response to insect bites which was supported by the prevalence of the condition after the rains, when biting insect populations were at their highest. Subsequent studies showed that a transmissible agent was involved. Lumpy skin disease (LSD) is one of the most serious poxvirus diseases of cattle caused by lumpy skin disease virus (LSDV) within the genus *Capripoxvirus*. It causes acute to subacute systemic disease characterized by mild to severe symptoms including fever, nodules on the skin, in the mucous membranes and in the internal organs, skin edema, lymphadenitis and occasionally death.

Host

Lumpy skin disease virus can infect cattle and possibly other closely related wildlife such as the Arabian oryx, but does not cause clinical disease in sheep or goats. LSDV has a limited host range and does not infect non-ruminant hosts. Both sexes and all ages of cattle breeds are susceptible to LSDV. However, younger animals may be more susceptible to the severe form of the disease. Breeds of *Bos taurus* with high milk production are more susceptible than African/Asian indigenous cattle. Even in close contact with infected cattle, sheep and goats never developed LSD

Vectors and other environmental risk factors

LSDV can remain viable for long periods in the environment at ambient temperatures, especially in dried scabs. It is reported that the virus persists in necrotic skin nodules for up to 33 days or longer, in desiccated crusts for up to 35 days and for at least 18 days in air-dried hides.

The main sources of infection are considered to be skin lesions as the virus persists in the lesions or scabs for long periods. The virus is also excreted via the blood, nasal and lachrymal secretions, saliva, semen and milk (transmissible to suckling calves) which is responsible for direct transmission.

Pathogenesis

The incubation period of the LSD is 2-5 weeks. The major clinical signs of the disease are characteristics circular skin nodules of over the body, fever, palpable enlarged subscapular and prefemoral lymph nodes, lacrimation, keratitis, nasal discharge, drop in milk yield, off-fed, emaciation, depression and reluctance movement. Morbidity and mortality of the disease is 5-45 and 1-5%, respectively.

The illness can affect cattle of any breed and age. However, depending on the virulence of the strains and the sensitivity of the cow breed, the severity of the clinical indications of LSD ranges from asymptomatic to lethal.

Viremia (fever) is seen usually after 6 days of infection as the virus continues to multiply. Peaks of viremia are reflected as intermittent rise and fall in body temperature. The virus exhibits a tropism towards keratinocytes and brings about various pathological changes. Initially, there is hyperplasia and ballooning degeneration, later epidermal micro-vesicles develop and the released chemokines attract inflammatory cells to the site.

At around the 7th day, nodular lesions start to appear on the skin of the affected animal. Such lesions are also evidenced in various tissue containing epithelial cells. Later on, the micro-vesicles join each other and form large vesicles, and the lesions begin to ulcerate and exude serous discharge. These nodular sites become necrotic enclosing a typical grey to a pink-colored conical area that gets separated from the

adjoining tissue and these lesions are known as 'sit-fasts'. There are congestion, hemorrhages, and edema in the neighboring zone of tissue. The necrotic zones of tissue are invaded by bacteria in the mean course of time which further complicates the pathogenesis. The lymph nodes become enlarged. The host factors such as younger animals may be more susceptible to the severe form of the disease. Breeds of *Bos taurus* with high milk production are more susceptible than African/Asian indigenous cattle.

Diagnosis

Clinical Diagnosis: Lesions include skin nodules observed on the forehead, eyelids, ears, muzzles, nostrils, udder, limbs. A sample taken from the skin can used in biopsy for further confirmation of the disease

Post-mortem findings: The epidermal and mucosal lesions described above will be apparent at post-mortem. Ulcerations may be found in the lining of the trachea and gastro-intestinal tract. Lung lesions consisting of pale grey nodules may also be seen

Gross pathological findings: LSD has well-described gross lesions. Skin nodules are usually uniform in size, firm round and raised, but some may fuse into large irregular and circumscribed plaques. The cut surface of the nodules is reddish-gray, in addition, to the accumulation of the reddish grey serous fluid and edema in the subcutis layer. The resolved lesions appear as indurated which is called "sitfasts" or seclude or may form deep ulcers. The typical circular necrotic alimentary lesions may also be seen on the muzzle, nasal cavity, larynx, trachea, bronchi, inside of lips, gingiva, dental pad, forestomach, abomasum, uterus, vagina, teats, udder and testes (Ali et al 1990). Regional lymph nodes are grossly enlarged and can be 3-5 times their usual size, oedematous and having pyaemic foci, in addition to local cellulitis. Muscle tissue and the fascia over limb muscle may be show nodular lesion that are grey-white surrounded by red inflammatory tissue. The same nodules are distributed throughout the carcass. It is about 10-30 mm diameter in the kidney. Interstitial or bronchopneumonia associated with 10-20 mm diameter lesions are also scattered in the lungs. These lesions result from infiltration of the large epithelioid 'celles claveleuses', described by Borrel for sheep pox. The lesions are separated from the necrotic epithelium far from the healthy tissue. The necrotic tissue sloughs away to leave an ulcer that slowly heals by granulation. Severely infected animals may show secondary bacterial pneumonia, tracheal stenosis, acute and chronic orchitis, mastitis with secondary bacterial infection, and similar lesions in the female reproductive tract.

Confirmative diagnosis of LSD

Diagnosis of LSD mainly depends on the typical clinical signs, differential diagnosis, and application of various diagnostic laboratory techniques for detection and confirmation of the disease, such as electron microscopy examination, virus isolation (VI), serological tests (serum neutralization test, agar gel immune diffusion, indirect enzyme-linked immunosorbent assay, and indirect fluorescent antibody technique [IFAT]), and real-time or conventional polymerase chain reaction (PCR). Viral isolation and identification as well as PCR methods are the most sensitive methods for detecting LSDV in skin samples. However, viral isolation is a gold standard for LSDV diagnosis; it is time-consuming as the protocol takes several weeks to isolate LSDV in tissue cultures or chorioallantoic membrane (CAM) of embryonated chicken egg (ECE). Immunohistochemistry (IHC) is an essential tool for diagnosing many animal diseases, including LSDV; several authors have reported it as a direct method for detecting the pathogenic antigen distribution using specific anti-LSDV antibodies in skin nodules of infected cattle

Differential diagnosis

There are many diseases causing similar signs of LSD. It is important to obtain a definite diagnosis to ensure the best preventative and control measures for susceptible herds. LSD can be confused with the following diseases:

- Pseudo-lumpy-skin disease
- Bovine virus diarrhoea/mucosal disease
- Demodicosis (Demodex)
- Bovine malignant catarrhal fever (Snotsiekte)
- Rinderpest
- Besnoitiosis
- Oncocercariasis
- Insect bite allergies.

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TPS 5 – A High Yielding Non-Lodging Rice Variety with Large Scale Adoption in Tamil Nadu

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Rice is one of the major crops cultivated in Kanyakumari District. It occupies more than 12000 ha in two seasons (*Kharif* and *Rabi*). ASD 16 is the popular rice variety cultivated by the farmers in *Kharif* season since 1980. As the harvesting of kharif crop coincides with north east monsoon, farmers experience yield loss to an extent of 20-30% in ASD 16 due to lodging. Frequent cyclones and flash floods affects rice crop in Cauveri delta region which ultimately reduced rice production in the state apart from financial losses to the farmers. Hence farmers of Tamilnadu need high yielding and non-lodging rice varieties.

Scope

A new rice variety TPS 5 was released from Agricultural Research Station, Thirupathisaram in the year 2014. It matures in 118 days with short bold grains as that of ASD 16. It has high yield potential of 6300 kg/ha which is 10% increase over ASD 16. It is non-lodging and moderately resistant to major pest and diseases especially stem borer, leaf folder, blast, BLB and sheath rot. This variety may fulfill the requirement of farmers.

KVK interventions

The new rice variety (TPS 5) was introduced to the farmers by KVK, Kanyakumari and ARS, Thirupathisaram through FLDs and training programmes. Created mass awareness by distributing leaflets, folders, Air Message, live programmes and print media. Integrated Weed Management and ICM practices for this variety were imparted through FLDs, trainings and special programmes.

Trainings and Frontline Demonstrations were conducted in TPS 5 rice variety with preemergence herbicide and early post emergence herbicide for effective weed management in direct sown rice cultivation. FLDs were conducted during 2014 at Ramapuram village of Agastheswaram block. FLDs on Integrated Weed Management in direct sown and puddled transplanted (TPS 5) rice were conducted during 2015-16 at Ramapuram and Manavalakurichi villages. FLDs on Integrated Crop Management in TPS 5 rice were conducted during 2016-17 in Manavalakurchi village of Kurunthankodu block. On and off campus trainings, Field days, extension functionaries trainings, special programmes, seminar, exhibitions were also conducted since 2014. The details of extension programmes conducted by KVK since 2014 is furnished in Table 1.

Impact

During 2014-15, TPS 5 rice variety performed better with 20-25 number of productive tillers/plant, 200-250 filled grains/panicle than ASD 16. TPS 5 rice recorded higher grain yield of 70.1 q/ha compared to ASD16 (56.5 q/ha). The yield increase was 26 per cent. Similarly, higher net return (Rs. 83389/ha) and BCR (2.69) were recorded with TPS 5 compared to ASD 16 which recorded net return of Rs. 59119/ha and BCR of 2.24.

During 2015-16, the TPS5 rice variety was demonstrated with IWM practices in direct sown condition and results indicated that TPS 5 recorded 54.9 q/ha compared to the ASD 16 (46.66 q/ha). The straw yield was also higher (50 q/ha) in TPS 5 while it was 35 q/ha in ASD 16. Hence farmers got higher gross income, net income and B:C ratio.

Frontline demonstration on integrated crop management practices in rice with TPS 5 during 2016-17 was conducted in Manavalakurichi village. The higher yield in TPS 5 was due to high productive tillers and grain yield/ panicle. The per cent yield increase ranged from 10.5 to 32.2. TPS -5 rice variety resulted in an additional income of Rs. 7000 to 12500/ha.

Spread

The farmers of Thovalai, Thuckalai, Agestheswaram, Kurunthencode and Rajakagamangalam blocks of Kanyakumari district started cultivating TPS 5 since 2015 and the area under cultivation of TPS 5 gradually extended to an extent of

2000 ha (Table 2). TPS 5 rice variety gradually replaces ASD 16 and occupies nearly 50% area of rice cultivation in Kanyakumari district in kharif season. (Fig.1 & 2). TPS 5 rice is also extensively cultivated in all districts of Tamil Nadu since 2020 due to its desirable attributes and adaptability to all regions of Tamilnadu. In Tamilnadu TPS 5 is cultivated in an area of 1.60 lakh ha (Table 3).

The supply of sufficient quantity of quality seeds of various classes *viz*.,breeder seed, foundation seed and certified seed aids in further expansion of area under TPS 5.

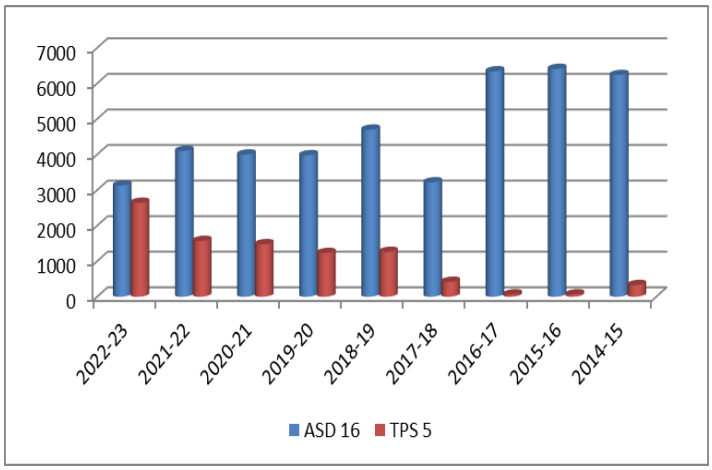

Fig. 1. Replacement of ASD 16 rice variety by TPS

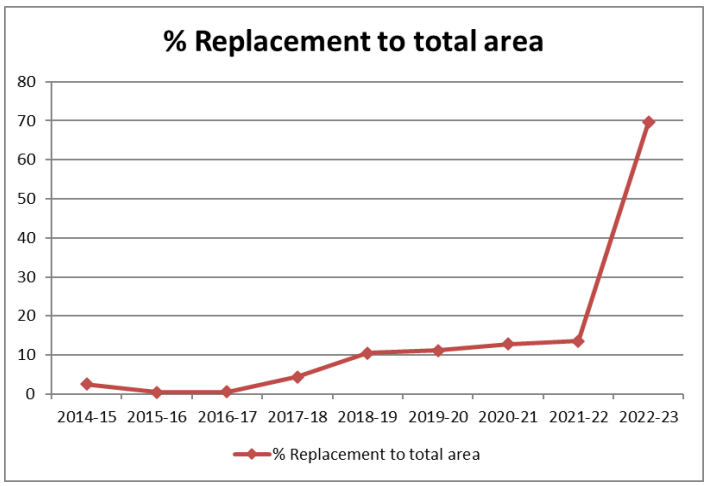

Fig. 2. Per cent area replaced by TPS 5

Table 3. Area under TPS 5 rice cultivation in Tamil Nadu

Sl.No.	Districts	Area in ha
1.	Thanjavur	30000
2.	Thiruvarur	35000
3.	Cuddalore	16000
4.	Thirunelveli	15000
5.	Erode	14986
6.	Dindigul	9069
7.	Thenkasi	6000
8.	Viruthunagar	5320
9.	Nagapattinam	4194
10.	Thoothukudi	4129
11.	Kancheepuram	1498
12.	Thiruvallur	596
13.	Thirupur	3887
14.	Madurai	2597
15.	Coimbatore	1093
16.	Namakkal	563
17.	Kanyakumari	1918
18.	Thiruchi	1741
19.	Theni	1559
20.	Kallakurichi	1312
21.	Pdukottai	1113
22.	Villupuram	891
23.	Ariyalur	693
24.	Thiruvannamalai	101
	Total	**160000**

The technology has spread to more than 2000 hectares in the district and nearly 1.6 lakh ha in Tamil Nadu. The seed requirement of the farmers is satisfied by KVK, ARS, Thirupathisaram as well as Department of Agriculture.

Table 1. FLDs, Trainings and Extension activities conducted

S. No.	Title	Nos.	Total Participants	Extension Functionaries (Nos.)
1.	FLDs on new variety TPS-5 with Integrated Crop Management practices	50	50	0
2.	On and Off campus training programmes	42	1260	160
3.	Field days	3	160	24
4.	Extension functionaries trainings	22	660	440
5.	Pre–*rabi* and pre-*kharif* training programmes, seminar, Exhibitions and *melas*	5	1800	120
6.	ATMA trainings	74	2960	296
7.	FFS	10	30	4
8.	Vocational training	1	25	0
9.	Demonstration on production, protection technologies and mechanization	53	1690	32
	Total	**260**	**8635**	**1076**

Table 2. Area expansion of TPS 5 in Kanyakumari district since 2014

(Area in Ha)

Rice Variety	2022-23	2021-22	2020-21	2019-20	2018-19	2017-18	2016-17	2015-16	2014-15	Year of introduction
ASD 16	3128	4100	4000	3980	4700	3217	6339	6407	6236	1986
TPS 5	2170	1570	1477	1230	1262	420	65	65	329	2014

Table 3. Successful farmers cultivated TPS -5

Thiru. Sundaramani of Manavalakurichi cultivated TPS 5 since 2017 and reported 7.5 tonnes/ ha of yield which is 1.5 tonnes more than ASD 16. He got additional income of Rs.48000/ha.	

Mr. A. Krishnakumar of Muthalakurichi cultivated TPS 5 instead of ASD 16 and got an additional yield of 1.0 tonnes/ha with an increased revenue of Rs.30000/ha.	
Thiru. Krishnamurthy of Cuddalore district started seed production of TPS 5 since 2020 and produced 7 tonnes/ha of foundation seed and earned net revenue of Rs.2.0 lakhs/ha.	
Thiru. Anbu from Kumbakonam recorded the highest yield of 10.0 tonnes /ha in Thanjavur district and got the award for highest yield in Rice in the year 2021.	

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Oeko-Textiles: Creating a Sustainable Future

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The interaction between textile materials and the environment is a complex one taking two distinct forms. Firstly, the effect of a change in properties that the environment can bring about in the textile, generally classed as degradation. Secondly, there is the manner in which the production or use of textiles can impinge on the environment, generally classed under the term' pollution for the negative impact', but also including environmental protection by pollution reduction where, a landfill liner is used to prevent leaching. Daily 150 million tons of waste is generated in India and only 10-20% of it is recycled, compared to 60-70% in developed countries. There is a need to increase consciousness of the community about the need for sustainable development and waste recycling and there is an urgent need to set standards, higher level of definitiveness and create synergy between Industry and Government to increase the use of Oekotech group of technical textiles.

Oekotech also known as Eco-friendly Textiles or Ecotex. They are used in environmental protection applications - floor sealing, erosion protection, air cleaning, prevention of water pollution water cleaning, waste treatment/recycling, depositing area construction, product extraction, domestic water sewerage plants. Major applications of Oekotech are for landfill waste management. It includes products used to prevent leakage of municipal or hazardous waste in landfills and suitable use of waste. The consumption of these technical textiles products remains limited despite their perceived benefits. With rapid urbanisation, the waste management has become major issue in India and Oekotech applications provide an effective way of managing the waste in an environment friendly manner. The article deals with discussing on the need for eco-friendly textile production. The new generation ecofriendly fibers, the different eco-norms and labelling available are enumerated in a crisp fashion. This can pave way for thinking about researches in the area of waste management and green fashion.

Technical Textiles: Oekotech

The latest coined term technical textiles has been a collective domain that encompasses of various applications of textiles grouped and linked to technical textiles. Among the different branches, Oekotech deals with ecofriendly textiles products. This generic term explains interesting concepts of environmental protection, waste disposal and recycling. In view of the increased interest worldwide in environmental and ecological issues, it is not surprising that Oekotech shows by far the fastest growth rates of around 7%.

Features of Okeotech

- Processed with less damaging inputs.
- The processing units are equipped with good sewage treatment.
- The fabrics are of good quality and long lasting.

Need for Oeko Textiles: This is an individual certification given after testing of the fiber to fabric for tor the items sold in retail stores.

OEKOTECH: Market Drivers

- Protection and preservation are leading many ecological and technological changes.
- Disposal and recycling of technical textiles.
- Increased environmental pressure against certain chemicals for e.g. azo dyes and formaldehyde.

Market Trend

- Dominated by synthetic woven
- Fitration textiles
- Insulation products
- Geotextiles

- Treatment of oil spills
- Low formaldehyde linnings
- Eco friendly diapers.

Oekotech Market Size

As an important part of the textile industry, industrial textiles are different from general clothing and household textiles, but refer to specially designed textiles with engineering structure characteristics, high technical content, high added value of products and high labor productivity. And the characteristics of industrial penetration are wide. The global Oekotech Textiles market size is projected to reach USD million by 2026, from USD million in 2020, at a CAGR of during 2021-2026.

Geotextiles in Land and Water Pollution Management

Land pollution can arise when a textile, or a substance used during its production, is thrown away on a landfill site. Fibres or chemicals can be harmful if their decomposition under the influence of air, water or sunlight produces a toxic agent. A range of toxic breakdown products from materials such as polyester, nylon, or other polymers which have been discarded into the waste stream and find their way into a landfill site. Steps taken to render them 'biodegradable' include the use of starch as a source of bacterial nutrition or the incorporation of a substance decomposed by ultraviolet radiation, both of which facilitate disappearance of the waste material.

Technical textiles in the form of barriers to this transfer may well prevent serious escape of pollutants from taking place. Geotextiles are engineered permeable fabrics which play an invaluable role in improving the durability of the civil engineering infrastructure through improving the stabilisation of road and highway systems, reducing the erosion along our coastline providing drainage and lining layers in a waste containment structure; and promoting revegetation by stabilising the soil to allow a root system to develop.

Geotextile Fabric for Separation

A geotextile acts as a separator by preventing the intermixing ofsoil materials and pollutants whilst allowing the free flow of wateracross the geotextile. Geotextile is placed between the subsoil and the granular sub- base of an unpaved road, it prevents the aggregate from being punched down into the soil during initial compaction. Industrial waste in harbours and oil spills near sensitive coastal regions have been prevented from causing irreparable damage by the effective use of geotextile membranes to prevent widespread dissipation of the polluting substances, while ditch liners, landfill liners and stabilization fabrics for banks of vegetation have prevented the loss of valuable topsoil and the movement of soil containing pesticides or other harmful reagents into water supplies. A geotextile made from natural fibres such as jute, coir, etc. would be more suitable for such applications, because it would be biodegradable and hence more environmentally friendly.

Geotextile Fabric for Erosion Control

The main aim is to control erosion whilst helping to establish vegetation which will control erosion naturally. The geotextile is then surplus to requirements and can degrade, enriching the soil. Geotextiles can reduce runoff, retain soil particles and protect soil which has not been vegetated, from the sun, rain and wind. Erosion control can be applied to riverbanks and coastlines to prevent undermining by the ebb and flow of the tide or just by wave motion.

Geotextile Fabric for Drainage (fluid transmission)

The strength of soil is determined by its water content as the water content decreases its strength increases and vice versa. A geotextile can convey fluids or gases within the plane of the geotextile to an egress point. The drainage system allows dissipation of excess pore water pressure, thus consolidation can take place and the soil strength is increased. The rate of dissipation of excess pore water pressure can be enhanced by using temporary drains in the soil so that the drainage path is reduced. This type of drain is only required to perform for a limited time period, until consolidation has taken place.

Filters used for Air and Water Pollution

Industry filtration and separation systems includes bag house filter sand vibratory shifters. Coal washing and oil deep well water and gas injection filter systems bring us fuel for energy. Filters used in nuclear power plants remove particles from cool ant and wastewater. Mist eliminator cartridges purify air entering turbines and compressors. Coalescing filters extract water from every gallon of aviation jet fuel. Aviation fuel is also filtered for particulate removal and ultimately tested by passing samples through filter disks to determine whether it is adequately clean before dispensing it to the aircraft. Environmental water treatment and waste management, metal plating, textile processing, desalination, analytical laboratory filters. Australian technical and non woven textile firms produce a wide range of complex fabrics for use in air, gas and water filtration which reduce greenhouse gas emissions and prevent ground water contamination by toxic chemicals, eg: gas collector systems in coal fired power stations and landfill, mining and industrial leachate filtration and collection systems.

Noise Insulation

High noise levels are generated in, for instance, twisting, spinning and weaving processes. Unpleasantly loud noise can also arise from the use of vehicles or other equipment in loading, shipping or handling raw materials or finished goods. Technical textiles can be of service in controlling the effects of noise pollution. Widespread use of acoustic absorbent materials are use to reduce the annoyance of high sound levels for human beings. Insulation materials for engine compartment, wheel arches and foot wells have developed.

Recycling

Recycling, in the sense of making a new product from the waste of an old one (rather than just reusing an old product) needs heat, thus using energy. This brings about resource depletion and produces pollution, even if (a highly unlikely presupposition) that pollution is only carbon dioxide, a greenhouse gas. Environmentally friendly recycling is practised within the textile industry. This is the process by which surplus fibres or fibre assemblies are returned to the production train for reprocessing instead of merely being discarded. Unfortunately, there may be a diminution of properties (such as fibre length, yarn evenness or fabric strength) as a result, which can lower the quality of goods that can be produced from this recycled material. The effects of using reworkable waste on yarn quality, for instance, include a significant reduction in yarn tenacity. Production of wovens is the solution of the above problem. Environmental responsibility, sustainability and reduced raw material consumption have become key concepts in cutting-edge nonwovens production.

Whatever technology is applied to form a web, new requirements are in focus including reduced water, energy and raw material consumption. Traditional disposables, like hygiene and medical products, are in real trouble because of tighter environmental laws. There soon will be no more

landfills to handle used disposables. The industry is challenged: Every production stage, from fiber to finishing, must reinvest heavily in new production technologies. Therefore, the big disposable products labels are looking more and more for biodegradable products.

Biodegradable Fibres

The fiber-producing industry is heavily active in research for new fiber types that are derived from renewable sources. New and advanced fiber types like polylactic acid (PLA), derived from corn. Lenzing AG, Austria, produces the generic man-made cellulosic fiber lyocell. Tencel® lyocell fibers are made from wood grown in managed forests. Cellulose from wood pulp is dissolved in an organic solvent, and the resultant viscous solution is extruded into an aqueous spin bath. During the process, the cellulose is not changed chemically. The spinning process is a closed-loop solvent spinning system in which the solvent is recovered for reuse. As a result, there is virtually no release into the environment from the process. The result is a pure cellulose fiber with good moisture handling, thermal properties, microbiological effects and biocompatibility. It is biodegradable for safe disposability.

Tencel is better placed than competing fibers for medical applications due to its combination of properties. The hydrophilic fiber has a smooth surface with a rounded cross-section, giving fabrics that are smooth, have low friction and feel good. It is highly absorbent and provides excellent moisture management. Tencel C is a new product that is being assessed for applications including apparel, hygiene and active sportswear. It is produced by treating Tencel with chitosan during manufacturing. Chitosan is deacetylated chitin - the main structural polymer in the shells of many shellfish and other invertebrates. Chitosan has been shown to influence wound healing and in the right presentation performs well as a hemostat. It is also in use for antibacterial products. Clinical tests have shown the new fiber gives a positive effect on wound healing, morphology and cell proliferation at the wound margin. One of the main observations with regard to chronic wounds is that they show a significantly reduced rate of cell proliferation. Lenzing claims Tencel C has better performances compared to other dressing materials tested.

Sustainable clothing

Sustainable clothing refers to fabrics derived from eco-friendly resources, such as sustainably grown fibre crops or recycled materials. It also refers to how these fabrics are made. Environmentally conscious towards clothing meant- buying clothes from thrift stores or any shops that sell secondhand clothing/donating used clothes to shops previously mentioned, for reuse or resale. In modern times, with a prominent trend towards sustainability and being 'green', sustainable clothing has expanded towards/reducing the amount of clothing discarded to landfills, and decreasing the environmental impact of agro-chemicals in producing conventional fibre crops (e.g. cotton).

Eco-fibers

Bt cotton, to reduce the use of pesticides and other harmful chemicals, companies has produced genetically modified (GMO) cottons plants that are resistant to pest infestations. Among the GMO are cotton crops inserted with the Bt (Bacillus thuringiensis) gene. Bt cotton crops do not require insecticide applications. Insects that consume cotton containing Bt will stop feeding after a few hours, and die, leaving the cotton plants unharmed. Organic cotton is grown without the use of any genetically modification to the crops, without the use of any fertilizers, pesticides, and other synthetic agro-chemicals harmful to the land. A new type of organic cotton, soft to the touch and at the same time, grown without chemicals.

Soy fabrics are derived from the hulls of soybean-a manufacturing by product. Soy fabrics can

be blended (i.e. 30%) or made entirely out of soy fibres. Soy clothing is largely biodegradable, so it has a minimal impact on environment and landfills. Although not as durable as cotton or hemp fabrics, soy clothing has a soft, elastic feel. Soy clothing is known as the vegetable cashmere for its light and silky sensation. Soy fabrics are moisture absorbent, antibacterial, and UV resistant. Hemp, like bamboo is considered a sustainable crop. It requires little water to grow, and it is resistant to most pests and diseases. Unlike cotton, many parts of the hemp plant have a use. Hemp seeds, for example, are processed into oil or food. Hemp fibres are durable and are considered strong enough for construction uses. Compared to cotton fibre, hemp fibre is approximately 8 times the tensile strength and 4 times the durability. Hemp fibres are traditionally coarse, and have been historically used for ropes rather than for clothing. However, modern technology and breeding practices have made hemp fibre more pliable, softer, and finer.

Bamboo fabrics are made from heavily pulped bamboo grass. Making clothing and textile from bamboo is considered sustainable due to the lack of need for pesticides and agrochemicals. Naturally disease and pest resistant, bamboo is also fast growing. Compared to trees, certain varieties of bamboo can grow 1– 4 inches long per day, and can even branch and expand outward because of its underground rhizomes. Like cotton fibers, bamboo fibers are not naturally yellowish in color and are bleached white with chemicals during processing.

PET plastics are also known as Polyethylene terephthalate (PETE). PET's recycling code within the three chasing arrows, is a number one. These plastics are usually beverage bottles (i.e. water, soda, and fruit juice bottles). Recycling plastic reduces air, water, and ground pollution. Recycling is only the first step; investing and purchasing products manufactured from recycled materials is the next of many steps to living sustainably. Clothing can be made from plastics. Seventy percent of plastic derived fabrics come from polyester, and the type of polyester most used in fabrics is polyethylene terephthalate (PET). PET plastic clothing come from reused plastics, often recycled plastic bottles. The Coca Cola Company, for example, created a "Drink2Wear" line of T-shirts made from recycled bottles. Main benefit of making clothes from recycled bottles is that it keep the bottles and other plastics from occupying landfill space. Another benefit is that it takes 30% less energy to make clothes from recycled plastics than from virgin polyesters.

The organic & ecological textiles is continuing to grow, led by the increasing awareness of the consumers who are now informed of the risks conventional textiles pose to health and the environment. For ensure the customer in your responsible project, it is important to ask for a control of your goods or activities in order to guarantee the organic or ecological propriety.

For that, Ecocert offers you to certify according to:

- **GOTS** (Global Organic Textile Standard) for a social and environmental responsibility.
- **OCS** (Organic Content Standard) to guarantee the traceability of organic textiles .
- **Ecological & Recycled Textiles** (Ecocert Standard) to claim the environmental quality.

Eco-Labels

- **Eco-Tex:** it is the label of Eco-Tex Consortium.
- **EPG**: The European product guarantee of ELTAC (European largest textile and apparel companies)
- **GuT**: label of environmentally sound carpet association
- **GuW:** label of environmentally sound furnishing fabrics association
- **Oko-Tex Standard:** label of the international association for research and testing in the field of textile ecology.

Conclusion

Textile industry plays a vital role in the Indian economy and constitutes nearly 30% of India's exports. Globalization of Indian textile industry makes it necessary to analyze its production techniques,

procedures and product qualities to satisfy all international eco-standards. In different textile production processes, steps should be taken to ensure that these processes are done chemically, but do not create any toxic effects. For making sure that the effluent created complies with the standards set by effluent control authorities, appropriate changes in recipes should be made, effluent treatment plants should be set and re-use of effluent wherever viable should be made.

The process of management should be designed in such a way that proper control on choosing and purchase of input materials are inbuilt in the system itself. The cost of effluent treatment is measured as inevitable. Any effort to decrease this cost should not be made by diluting' eco-standards. Suitable audit system should also be introduced by textile units, which ensure that eco-standards are realized. Sustainable clothing has a huge potential and growing market share with very good business opportunities. More researches are done in creating new products and techniques and reduce the carbon foot print. World-wide sorting of the disposed wastes is given attention. Collecting bins in retail outlets and public areas has kindled the spirit of safe disposal among the consumers. Plethora of options are available in this eco-system which can be a wonderful option for a greener path for future.

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A Beginner's Guide to Organic Dairy Farming in India

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Organic farming is a comprehensive approach to production management that promotes and improves the health of the agro-ecosystem and biodiversity. It mainly focuses on the use of management practices above the usage of off-farm inputs while considering the need for regionally adapted systems according to regional conditions. Organic animal husbandry is a type of production system which intentionally avoids the synthetic inputs and uses the organic and biodegradable elements from the ecosystem in terms of animal nutrition, animal's health, animal housing and breeding. It such as feed additives, drugs, and genetically engineered breeding activities.

What is organic dairy farming?

Organic dairy farming means raising milch animals on organic feed (pastures cultivated without the use of fertilizers or pesticides), having access to pasture or outside, along with restricted usage of hormones and antibiotics. The products obtained from organic dairy farming are called organic dairy products. Ideal features of organic dairy farming:

- Cows and calves are fed only organic food.
- Fodder crops used for feeding animals are grown without the use of synthetic fertilizers.
- Prior to the first harvest, the land used for cultivating organic crops must be devoid of all prohibited minerals for at least three years.
- No use of genetically modified organisms.
- Calves must be fed on organic milk only. Use of synthetic milk replacers is not permitted.
- Natural behaviours of animals should not be altered. All animals (above six months of age) must have access to outdoor pastures.
- Use of slaughterhouse by products, urea is strictly prohibited.
- The welfare of the animals is given prime importance for which certain procedures like tail docking are prohibited and other managemental procedures like dehorning, must be done under minimal stress to the animal.
- All records should be up to date and sufficient records should be available to verify the compliance with the standards when inspected.

Organic Certification

Farms that want to produce organic milk must sign up with a natural control organization and adopt a generation framework that meets with organic standards. There are 468 organization worldwide which offers Organic Certification Services (Yadav, 2008) and most of the confirmation bodies are in Europe (37%) trailed by Asia (31 %) and North America (18%) (Yadav, 2008). In India NPOP (National Program for Organic Production) and its regulatory body APEDA (Agricultural and Processed Food Products Development Authority), Participatory Guarantee System (PGS -India) under Ministry of Agriculture and Farmer's Welfare are the apex authorities involved in organic production. There are 28 Accredited Certification bodies under NPOP and 562 regional councils under PGS in the country. All products that is organic certified displays the **'India Organic'** logo for customer to easily identify certified products and the certificate issued will be valid for 3 years only and must be renewed after expiry.

Certifying bodies in India:

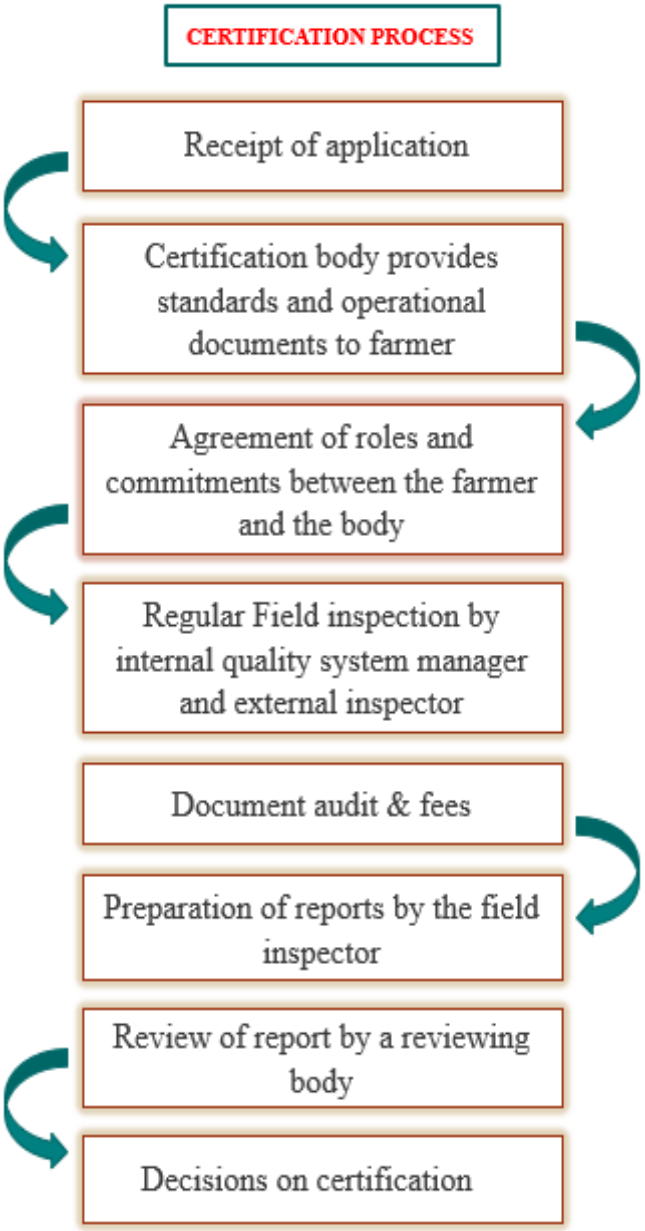
Name of certifying agencies	**Address**
National Organic Certification Association (NOCA)	Pune, Maharashtra
International Resources for Fair Trade (IRFT)	Mumbai, Maharashtra

Indian Organic Certification Agency (INDOCERT)	Cochin, Kerala
Ecocert International	Aurangabad, Maharashtra
Association for promotion of Organic Farming (APOF)	Bengaluru, Karnataka
Indian Society for Certification of Organic Products (ISCOP)	Coimbatore, Tamil Nadu
Lacon Quality Certification Pvt. Ltd.	Thiruvalla, Kerala
Skal Inspection and Certification Agency	Bengaluru, Karnataka
IMO Control Pvt. Ltd.	Bengaluru, Karnataka

Labeling

Single ingredient products labelled as "Produce of organic agriculture". Mixed ingredient products are labeled as "Certified Organic" if minimum of 95% of the ingredients used are of certified organic origin, "organic" if more than 70% of the ingredients used in the product are of organic origin. And products containing less than 70% organic ingredients are not considered organic.

Recommendations that can be considered



1. **Conversion from traditional farming to organic farming:** To convert the land to organic status, at least two years are needed. From the day that land achieves full organic status, organic milk can be produced. Herd likely started nine months before the anticipated date of organic milk production and feeding probably started six months before that.
2. **Feeding:** From the start of transformation, all feeds used on the farm must be confirmed to meet organic standards. Both compound ratios

and acquired mixtures must be entirely organic. Supplementing with minerals is only permitted in cases when organic farming practices fall short of fulfilling certain requirements. However, only with the control body's permission and some synthetic vitamins could be used.

3. **Health:** Before heading to organic production all animals which were companions or offspring to the animal infected with Bovine Spongiform Encephalopathy should be culled. Use of antibiotic and other synthetic drugs should not be done as a preventive measure but can be done to anticipated problems in the event of disease or injury with a withdrawal time period that is at least twice as long as the stated withdrawal time period. Vaccination is allowed in risk prone areas. Except for vaccination, eradication schemes and parasitic treatment if the herd receives more than three courses of treatment its organic status will be lost.
4. **Housing:** Space requirements may differ among the control bodies however, loose housing with good bedding material is preferred with minimum space allowance of 6m² for adult animals and 1-1.75m²/100kg live weight of calves.
5. **Herd replacements:** Cattle should not be purchased from the stock which had cases BSE in the past five years. During conversion if old stocks are retained, milk and calves from them can be sold as organic only after the completion of conversion period. Each year breeding stock can be replaced from conventional herd at 10% rate. Up to 12 weeks of age calves should be fed with ration in which at least 51% is of whole organic milk. Bulls used for breeding should also meet organic standards. Artificial insemination is also permitted.
6. **Livestock Manure:** Manure for fodder cultivation can only be procured from organic farms. However, application should not exceed 250kgN/ha/yr.

Constraints:

- Lack of knowledge and awareness.
- Limited availability of organic feed ingredients for formulating compound organic feed.
- Problem of maintenance of proper records.
- limited reach of certification services .
- lack of proper procurement, processing and marketing infrastructure and network.

Opportunities

- Consumers are willing to pay premium price.
- Native breeds are more resistant to stress and diseases thereby decreasing the dependency of allopathic medication.
- Increased awareness about benefits of organic products through social media platforms.
- Increased number of health-conscious people who are diverting for organic habits.

Conclusion

Growing public awareness on food safety issues has fueled the expansion of organic farming over the past few years. Organic farming can provide high-quality food without having a negative impact on the environment or the health of the soil. A number of considerations must be made in order for organic livestock farming to be successful, including minimizing the paperwork and certification fees, obtaining organic feeds and fodder.

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Impact of Online and Direct-to-Consumer Sales Channels on Agricultural Marketing and Consumer Preferences

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Online and direct-to-consumer (DTC) sales marketing refers to the strategies and techniques used by businesses and agricultural producers to promote and sell their products directly to consumers through online channels and platforms that bypass traditional intermediaries like wholesalers or retailers. These sales channels offer numerous benefits. They provide consumers with access to fresh, locally sourced products, create opportunities for farmers to earn a fairer share of the profits, and foster a sense of community engagement. Additionally, they can promote sustainability by reducing the carbon footprint associated with long-distance distribution. However, they also come with challenges such as the need for effective marketing, maintaining product quality, and managing online platforms or physical retail spaces.

Online and direct-to-consumer sales channels in agriculture have emerged as innovative ways to connect farmers and producers directly with consumers. Here's a brief overview of these channels:

Online Sales Channels

- Websites and E-commerce Platforms: Farmers and agricultural producers create websites or use e-commerce platforms to showcase their products, allowing consumers to browse, order, and pay for goods online. Example: BigHaat, AgroStar, GreenMyLife, RML AgTech (CropIn), Agricart, DeHaat, Farmkey etc.
- Mobile Apps: Some farms and agricultural businesses develop mobile apps, making it convenient for consumers to access their products and place orders via smartphones and tablets. Example: Bigbasket, Grofers, Nature's Basket, Spencers, Reliance Fresh etc.
- Social Media: Platforms like Facebook, Instagram, and Twitter are used by farmers to market their products directly to consumers. They may utilize these platforms for advertising, accepting orders, and providing updates.
- Online Farmers' Markets: Virtual farmers' markets have gained popularity, where multiple producers come together on a website to sell their products to a wider customer base. Example: FarmersFZ, Farm2Kitchen, FarmerUncle, KrishiDirect, GreenSoul Farmers Market etc.

Direct-to-Consumer Sales Channels:

- Farm Stands: In various parts of India, we can find farm stands or small roadside stalls where local farmers sell fresh produce, such as fruits, vegetables, and dairy products, directly to consumers.
- Farmers' Markets: These have become increasingly common in India's urban centers. Cities like Mumbai, Bengaluru, Delhi, and Pune host regular farmers' markets where local farmers sell their products directly to consumers.
- Community Supported Agriculture (CSA): CSA programs have gained popularity in India. Farmers offer subscription-based models where consumers can receive regular deliveries of fresh, seasonal produce directly from the farm. Examples: Sahaja Samrudha in Karnataka and Annadana in Tamil Nadu.
- Pick-Your-Own Farms (U-Pick): While not as common as other models, there are U-Pick farms in India, particularly for fruits like strawberries and blueberries. Customers can visit the farm and pick their own produce.
- On-Farm Retail Stores: Some progressive farmers have set up on-farm retail stores where customers can purchase a variety of products produced on the farm, including fresh produce, dairy, and processed goods. These stores are often found in regions with a strong farm-to-table culture.

Factors that influence consumer preferences in online and direct-to-consumer channels

- Price and Value: Consumers often consider the pricing and perceived value of products in online and DTC channels. Competitive prices and special offers can attract buyers.
- Product Quality: The quality and freshness of products play a significant role. Consumers prefer products that meet their quality expectations, especially in the case of food and agricultural products.
- Product Variety: The availability of a diverse range of products can influence consumer preferences. A wider selection allows consumers to find products that suit their specific needs and preferences.
- Convenience: Online and DTC channels are valued for their convenience. Consumers appreciate easy ordering, home delivery, and flexible payment options.
- Transparency: Transparency in sourcing, production practices, and product information can build trust and influence consumer preferences positively.
- Brand Reputation: Established and trusted brands often have an advantage in attracting consumers. Brand reputation and recognition can be a significant influencing factor.
- Reviews and Recommendations: Consumer reviews, ratings, and recommendations from peers play a crucial role in decision-making. Positive reviews can boost confidence in a product.
- Customer Service: Responsive and helpful customer service can enhance the overall shopping experience and influence preferences.
- Sustainability: Increasingly, consumers are considering the environmental and ethical impact of their purchases. Products and brands with sustainable practices can attract environmentally conscious buyers.
- Transparency in Pricing: Clear and transparent pricing, including any additional costs (e.g., shipping fees), helps consumers make informed decisions.

How transparency and information sharing affect consumer trust

- Building Trust: Transparency in online and DTC channels involves openly sharing information about product origins, production methods, and pricing. When consumers have access to this information, it builds trust in the brand or seller.
- Confidence in Product Quality: Transparency regarding quality control and safety measures reassures consumers about the quality and safety of the products they purchase.
- Reducing Skepticism: In an online environment where consumers cannot physically inspect products, transparency helps reduce skepticism. When consumers feel they have complete information, they are more likely to trust the seller.
- Fostering Loyalty: Transparency and information sharing create a sense of honesty and authenticity. This can lead to greater customer loyalty as consumers choose to return to brands or channels they trust.
- Competitive Advantage: In a competitive market, businesses that prioritize transparency can gain a competitive advantage by standing out as trustworthy options.

When consumers have access to clear and honest information about products and business practices, they are more likely to make informed choices and build lasting relationships with brands and sellers.

Impact of Online and Direct Sales on Traditional Grocery Stores and Markets

- Competition and Market Share: Online and direct sales have introduced increased competition for traditional grocery stores and markets. Consumers now have more options for purchasing groceries, including from the comfort of their homes.
- Changing Consumer Behavior: The convenience of online shopping and direct-to-consumer models

has altered consumer behavior. Some customers have shifted their shopping habits from physical stores to online platforms.

- Pressure on Pricing: Online platforms often offer competitive pricing, which can put pressure on traditional retailers to adjust their pricing strategies to remain competitive.
- Increased Focus on Convenience: Traditional retailers are adapting by enhancing the convenience factor. They may introduce online ordering with home delivery or curbside pickup services to meet customer expectations.
- Diversification of Product Range: Traditional stores are expanding their product range to include more unique or specialty items to differentiate themselves from online and direct sales competitors.
- Technology Integration: Many traditional retailers are adopting technology, such as mobile apps and loyalty programs, to improve the in-store shopping experience and gather customer data for personalized marketing.
- Emphasis on In-Store Experience: Traditional retailers are highlighting the in-store experience, including factors like product presentation, sampling, and customer service, to attract and retain customers who prefer physical shopping.
- Regional and Local Focus: Traditional grocery stores and markets may emphasize their local and regional connections, promoting locally sourced products and supporting the community.
- Partnerships: Some traditional retailers collaborate with online platforms to expand their reach. They may offer their products through online marketplaces while maintaining a physical presence.
- Customer Engagement: Engagement with customers through loyalty programs, discounts, and personalized offers can help traditional retailers compete effectively and build customer loyalty.

Strategies that should be adopted by traditional retailers to compete with online and direct sales:

- E-commerce Integration: Many traditional retailers have embraced e-commerce by launching their online platforms, offering customers the option to shop online and have groceries delivered to their homes.
- Curbside Pickup: Curbside pickup services allow customers to order online and collect their groceries from the store without entering. This provides convenience while retaining a physical presence.
- Loyalty Programs: Traditional retailers often offer loyalty programs that reward repeat customers with discounts, special offers, and personalized recommendations.
- In-Store Technology: Integration of technology within physical stores, such as self-checkout kiosks and digital signage, enhances the shopping experience and efficiency.
- Customer Service: Exceptional customer service remains a key differentiator. Traditional retailers invest in well-trained staff to provide assistance and expertise to shoppers.
- Product Diversity: Expanding product offerings to include niche, organic, and gourmet items attracts customers seeking unique products not readily available through online channels.
- Sustainability Initiatives: Addressing environmental and sustainability concerns can resonate with consumers who prefer to support retailers with eco-friendly practices.
- Partnerships with Local Producers: Collaborating with local farmers and producers to source fresh, locally grown products can help traditional retailers appeal to consumers looking for authenticity and freshness.
- Marketing and Promotions: Effective marketing campaigns and promotions, both online and offline help traditional retailers reach and engage with customers.

- Adaptation to Trends: Staying attuned to consumer trends, including dietary preferences and health consciousness, allows traditional retailers to adjust their product offerings accordingly.
- Omni-channel Approach: Combining online, mobile, and in-store experiences into a seamless shopping journey, known as an Omni-channel approach, is increasingly adopted by traditional retailers.

Technological innovations shaping the future of these channels:

- Internet of Things (IoT): IoT devices will provide real-time data on crop conditions, allowing farmers to optimize production and supply chains.
- Blockchain: Blockchain technology will be used for transparent and tamper-proof record-keeping, ensuring traceability and food safety.
- Artificial Intelligence (AI): AI will improve supply chain management, predict demand, and enhance personalized recommendations for consumers.
- Automation: Increased automation in farming practices and distribution will improve efficiency and reduce labour costs.
- Drone Technology: Drones will play a significant role in crop monitoring, pest control, and product delivery in remote areas.
- Precision Agriculture: Advanced sensors and data analytics will enable precision agriculture, optimizing resource use and increasing yields.
- Sustainable Farming Tech: Innovations in sustainable farming practices, such as vertical farming and aquaponics, will gain traction.
- Robotics: Agricultural robots will be used for tasks like harvesting and weeding, reducing the need for manual labour.
- Mobile Apps and Platforms: Mobile apps will continue to evolve, offering farmers and consumers easy access to information, advisory services, and purchasing options.
- 5G Connectivity: Enhanced 5G connectivity will support faster and more reliable data transfer in rural areas, facilitating online transactions and data sharing.

These technological innovations reflect the on-going transformation of the agriculture industry, with online and direct-to-consumer sales playing an increasingly significant role in shaping its future.

Conclusion

Online and DTC sales channels have transformed agricultural marketing and consumer choices by offering convenience, transparency, and personalized experiences. Adapting marketing strategies to meet evolving consumer preferences and technology trends is crucial for success in this dynamic landscape. These channels offer consumers unprecedented convenience, enabling them to access agricultural products easily and on their terms.

Another major takeaway is 'Transparency Matters'. Consumers increasingly value transparency in sourcing and production. Businesses should provide clear information about their products, farming practices, and sustainability efforts to build trust. Also it can be concluded that personalization is key. Personalized marketing strategies, driven by data and technology, can significantly influence consumer choices. Tailoring product recommendations and offers to individual preferences is crucial. DTC models create a direct link between consumers and farmers, which foster trust, support local agriculture, and ensure fair compensation for producers. The online marketplace is highly competitive. Agricultural businesses must invest in effective marketing strategies to stand out and attract consumers.

Technology, including AI, data analytics, and e-commerce platforms, plays a pivotal role in shaping consumer choices and marketing strategies in the digital age. That's why adaptation is essential. Adapting marketing strategies to evolving consumer preferences and technology trends is vital for staying relevant and competitive in the agricultural industry. Also, consumers are increasingly concerned about

sustainability and ethical practices. Businesses that address these concerns can gain a competitive edge. They should find ways to balance the convenience of online shopping with sustainability efforts, such as eco-friendly packaging and reduced food waste. Educating consumers about these benefits of DTC models, organic farming, and sustainable agriculture can enhance consumer choices and support businesses' marketing efforts.

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Pesticide Poisoning is Killing Honey Bees: Warning for Ecosystem

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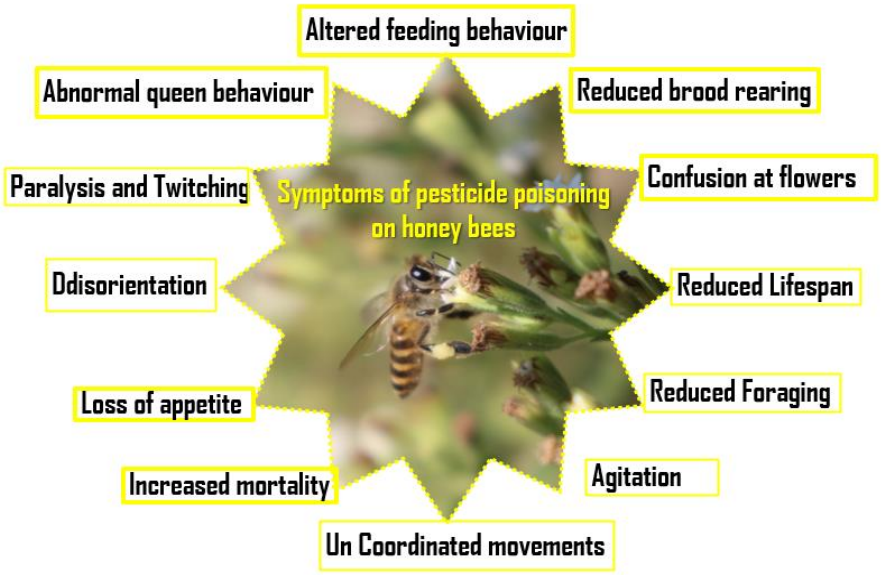
In our fragile ecosystems which support our food production, a disturbing phenomenon has emerged, casting a shadow over the foundation of our agricultural system. The intricate partnership between honey bees and crop pollination, which underpins the growth of countless fruits, vegetables, and nuts, is facing an unprecedented threat: pesticide poisoning. As the delicate balance of nature is disrupted by the unintended consequences of chemical warfare against pests, the silent toll of pesticide poisoning is ringing alarm bells for both environmentalists and farmers alike. This article sheds light on the grim reality of pesticide poisoning and its catastrophic impact on honey bees, highlighting the urgent need for sustainable agricultural practices that safeguard the invaluable contributions of these pollinators. From exploring the mechanisms behind pesticide toxicity to outlining the far-reaching consequences for crop production and ecosystem health, navigate the intricate web of this crisis, seeking solutions that can restore harmony to the vital interplay between agriculture and the environment. As we delve deeper into this serious issue, it becomes evident that change is necessary and that we must take steps to control pests in a way that respects the fragile balance of our interconnected planet.



Honey Bees as an Input in Crop Production

Pollinators and pollination play a crucial role in the functioning of almost all terrestrial ecosystems including those dominated by agriculture because they are in the front line of sustainable productivity through plant reproduction and serve as basic pillars for crop production. Pollination is simply the transfer of pollen from the anther of one flower to the stigma of another or the same flower. It is achieved by biotic and abiotic means. Among, biotic agents, bees are the most valuable pollinators in agriculture, especially honey bees, bumble bees, stingless bees, mason bees, solitary bees, etc. The biology of honey bees is well known and they can be managed in easily transportable boxes for pollination of many crops. On 03/08/2021, the Ministry of Agriculture and Farmers Welfare, considering the importance of honeybees in enhancing crop productivity, beekeeping/honeybees decided to be included in the package of practices for a particular crop and region as **Input in Agriculture,** which will boost agricultural production through enhancement in crops in a sustainable manner in our country.

Pesticide Poisoning in Honey Bees

Modern insecticides have an awful lot decrease toxicity to people, wild mammals and birds and are carried out in decrease amounts, however they're even greater poisonous to invertebrates. Several studies show the higher toxicity outweighs the lower volumes, leading to extra lethal standard effect on pollinators and waterborne bugs inclusive of dragonflies and mayflies. The use of several crop protection chemicals, such pesticides, fungicides etc. makes bees vulnerable to poisoning and death.

Pesticide poisoning has been recognized as a significant threat to bee populations worldwide, particularly to honeybees and other pollinators. Bees play a crucial role in pollinating many of the crops that make up a large portion of our global food supply, so their decline can have serious implications for agriculture and ecosystem health. Pesticides, including neonicotinoids and other chemical classes, have been associated with various negative effects on bees:

1. Lethal and Sublethal Effects: Pesticides can cause direct mortality among bees. High doses of certain pesticides can quickly kill bees by targeting their nervous systems or other physiological processes. Even when bees are not killed outright, exposure to sublethal doses of pesticides can have significant impacts on their behavior, physiology, and overall health.

2. Impaired Foraging Behavior: Pesticides can disrupt the ability of bees to navigate, forage for food, and return to their hives. This can result in reduced food collection and compromised hive health.

3. Disruption of Reproduction: Pesticides can interfere with the reproduction of bees. For example, they can affect queen bee development, egg-laying behavior, and the overall reproductive success of the colony

4. Reduced Immune Response: Pesticide exposure can weaken the immune systems of bees, making them more susceptible to diseases and pathogens. This can lead to increased mortality and decreased overall colony health.

5. Colony Collapse Disorder (CCD): Although the exact cause of CCD is complex and multifactorial, pesticide exposure has been identified as one of the contributing factors. CCD refers to the sudden and unexplained disappearance of worker bees from a colony, leading to the collapse of the entire colony.

To address these concerns, there has been growing interest in adopting more sustainable agricultural practices and developing alternative pest management strategies that minimize the impact on pollinators. This might involve reducing or eliminating the use of certain classes of pesticides, implementing integrated pest management techniques, creating pollinator-friendly habitats, and improving pesticide regulations and labeling to safeguard pollinators.

Sources of Bee Poisoning

Bees can be exposed to pesticides through various sources, both in agricultural and non-agricultural settings (Fig 1(a); 1(b). In agricultural areas, there is a negative relationship that was found between pesticide use on agriculture sites and pollinator abundance, group richness, and diversity. Pollinators in agriculture areas can be exposed to plant protection products in two ways:

i) By direct exposure to either drift droplets, which are scattered during the foliar spraying of crops, dust from seed drilling at planting, or inhalation of volatile pesticides during or after application to the crops

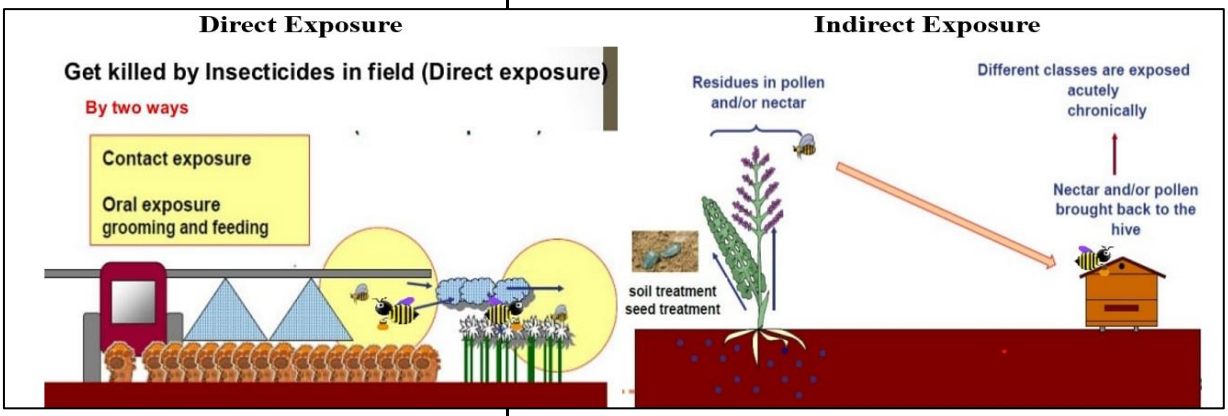


Fig 1 (a) Sources of Bee poisoning

(Source: Thompson, 2009; Christian et al, 2012)

ii) By exposure to residues present in pollen, wax, nectar, honey, and guttation drops, which may result either from direct spray contamination of flowers, or direct contamination during treatment of the combs (for honey bees only)

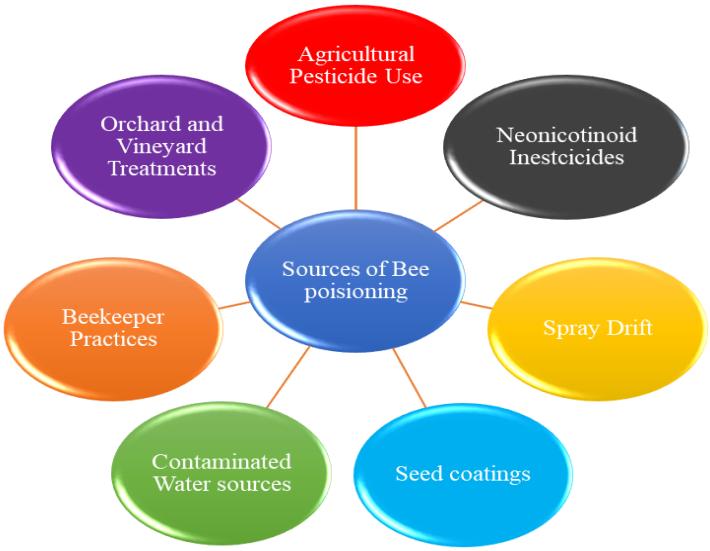


Fig 1 (b) Sources of Bee poisoning

To mitigate bee poisoning, it's important to use pesticides responsibly, following recommended application guidelines and considering their potential impact on pollinators. Integrated pest management practices, which prioritize minimizing pesticide use through targeted and sustainable strategies, can help reduce the risk to bees and other beneficial insects. Additionally, promoting pollinator-friendly habitats, reducing the use of systemic pesticides like neonicotinoids, and advocating for stronger pesticide regulations can contribute to protecting bee populations.

Management Practices against Pesticidal Hazards

Effective management practices to mitigate the hazards of pesticides on bees and other pollinators involve a combination of strategies aimed at reducing exposure, promoting pollinator health, and using pesticides responsibly. Here are some key practices:

1. Integrated Pest Management (IPM): Implement IPM strategies that focus on preventing pest problems through a combination of cultural, biological, and chemical control methods. This approach helps reduce the reliance on pesticides and minimizes their impact on non-target organisms like bees.

2. Selective Use of Pesticide: Choose pesticides that are less harmful to bees and other pollinators. Opt. for products with lower toxicity and shorter residual effects. Use narrow-spectrum pesticides that target specific pests rather than broad-spectrum ones that affect a wide range of insects.

3. Time Pesticide Applications Carefully: Apply pesticides when pollinators are less active, such as early morning or late evening, when bees are less likely to be foraging. Avoid applying pesticides during peak flower blooming periods.

4. Communication: If you are an agricultural producer or land manager, communicate with local beekeepers and other stakeholders about your pesticide application plans. This can help beekeepers take measures to protect their colonies during pesticide treatments.

5. Habitat Enhancement: Create pollinator-friendly habitats around agricultural fields and in non-agricultural areas. Plant native flowering plants that provide food and shelter for bees. This can help support healthy pollinator populations and reduce their reliance on treated crops.

6. Buffer Zones: Establish buffer zones between treated areas and areas with high bee activity. These zones can serve as a physical barrier that reduces the risk of pesticide exposure to pollinators.

7. Cover Crops and Trap Crops: Use cover crops or trap crops to deter pests away from main crops, reducing the need for pesticide use. These strategies can help manage pests while preserving pollinator health.

8. Pesticide-Free Zones: Designate specific areas or refuges on your property where no pesticides are used. This provides safe havens for pollinators to forage and reproduce.

9. Monitoring and Thresholds: Regularly monitor pest populations to determine if and when pesticide treatments are necessary. Establish economic or pest

population thresholds to guide the timing and necessity of pesticide applications.

10. Education and Training: Educate farmers, land managers, and the public about the importance of pollinators and the potential risks of pesticides. Provide training on proper pesticide application techniques and how to minimize harm to non-target insects.

11. Regulations and Labeling: Support and advocate for stronger pesticide regulations that take into account pollinator health. Ensure that pesticide labels provide clear information on potential risks to bees and other non-target organisms.

12. Research and Innovation: Invest in research to develop safer pest management alternatives and new technologies that reduce the need for pesticides while maintaining crop productivity.

Conclusion

By combining these practices, it's possible to reduce the negative impacts of pesticides on pollinators while still effectively managing pests and protecting agricultural yields. Both beekeepers and growers can take steps to help encourage safe pollination and manage the risk of bee poisoning. Most bee poisoning events occur because of a lack of communication and coordination between the chemical user and beekeepers. Collaboration among farmers, beekeepers, researchers, policymakers, and the public is essential to implement these practices and promote sustainable coexistence between agriculture and pollinators.

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Goat Milk: A Nutrient-Rich Elixir for Health and Wellness

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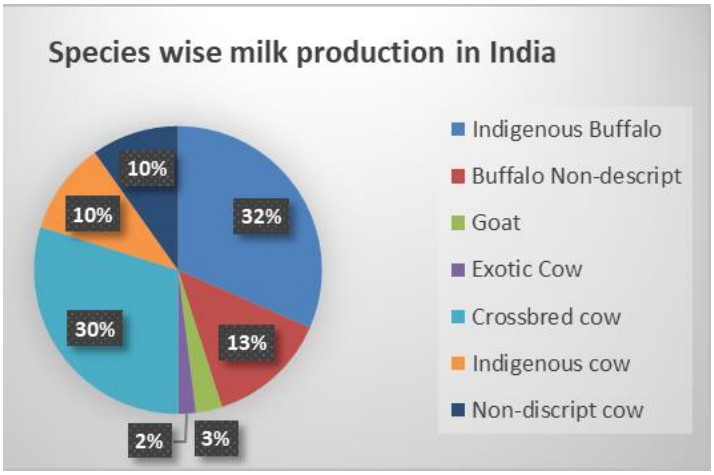
Milk, often referred to as "nature's elixir," has been an integral part of human civilization for thousands of years. Cow's milk is typically the first choice for many of us when we think of milk, and goat's milk often doesn't come to mind as readily. However, increased health consciousness of the consumers after covid-19 pandemic goat milk has gained importance. Further due to cow milk protein allergy seen in infants has created the need for searching an alternative to cow milk which brings goat milk into picture which is having nutritional similarities with human milk.

Indian scenario

Usage of goat milk for therapeutic purpose is not a new concept for Indians. Medicinal properties of goat milk are stated in many of our ancient Ayurvedic scriptures like Charaka Samhita which date back to the fourth century. "Mahatma Gandhi" acknowledges goats as "poor man's cow" which play important role in Indian rural economy.

Today, India occupies the first position in global goat milk production (6.09 million tonnes) and in India goat is 3rd (3% of total milk) largest milk contributing species (DAHD 2019). The top five goat milk producing states are Rajasthan, Uttar Pradesh, Madhya Pradesh, Gujarat and Maharashtra accounting for 79.5% of total goat milk production. The amount of milk produced by goats in the country is probably more than what is stated in the official statistics as a significant portion is consumed at home and is not reported.

With 37 different goat breeds spread across, India is home to immense caprine resources. Indian dairy goat breeds include the Beetal, Jamunapari, Jakhrana, Surti, and Zalawadi, which are native to the north and northwestern regions and produce 150 to 500lts of milk/year



(Source: BAHS, 2022)

Indian goats are raised primarily on communal pasture, unlike their European counterparts who feed their goats a diet high in concentrate, so the milk obtained by Indian goats is relatively rich in health-promoting nutrients like phenolic compound, fat-soluble vitamins, unsaturated fatty acids, medium chain fatty acids, and bioactive peptides.

Currently, there is no established structure for marketing goat milk in the country, and milk in rural areas is sold for very little price (between 25 and 35 cents per litre). However, organised dairy goat farming could expand quickly by providing reasonable price of goat milk to farmers.

Peculiarities of goat milk

1. Has higher content of β-casein and lower α-s_1
2. Biological value of goat milk is 89.29
3. Digestibility Coefficient of goat milk is 92.42
4. Low allergenicity
5. Naturally homogenized with fat globule size 2-2.5µm
6. Rich in Vt A, C and B complex.
7. Contain bioactive components.
8. Rich in oligosaccharides and ash content

Composition of goat milk

Due to genetic polymorphism, resulting from variations in amino acid arrangement and altered

protein chains, goat milk's composition is distinct from that of other species and is therefore considered beneficial for human health.

Parameter	Goat	Cow	Human
Protein (%)	3.6	3.2	1.2
Fat (%)	4	3.4	3.8
Lactose (%)	4.5	4.6	7
Minerals (%)	0.8	0.7	0.2
Total solid (%)	13.2	12.3	12.4
Energy (Kcal)/100gm	70	66	63
Casein %	2.9	2.5	0.4
Whey protein	0.61	0.65	0.7

Source: (Alichanidis and Polychroniadou 1996)

Health benefits of goat milk

Anti cow milk Allergy: Due to higher concentration of β-casein and lower concentration of αs1- casein when compared to cow milk, goat milk is easily digested which helps in reducing allergenicity. Hence, used as alternative to cow milk for people having cow milk allergy.

High Digestibility: Smaller fat globules in goat milk make it naturally homogenized and highly digestible. Unlike cow milk, goat milk forms soft curd upon acidification in stomach which is readily digested. Because of its efficient digestive capabilities goat milk is used as alternative to mother's milk for young ones of many species including humans hence, called as universal foster mother. Medium chain fatty acids such as capric, caprylic and caproic acids present in goat milk have potential pharmacological effects against malabsorption syndromes.

Pre-biotic effect and gut health: In comparison to cow and sheep milk, goat milk has higher oligosaccharides content which is known to have prebiotic property by stimulating intestinal bifidobacterium and lactobacilli. Addition to this, it is also known to exhibit anti-inflammatory effects on gut there by improving mineral absorption and prevent chances of colic cancer.

Maintain blood pressure: Goat milk is a rich source of potassium and nitrogen, which are essential to maintain blood pressure and prevent cardiovascular diseases. Taurine is high in goat milk, being 20–40 folds higher than cow milk which is involved in osmoregulation. Recent studies have confirmed that goat milk and milk products have a significant effect on ACE inhibition which is the principal hormone in blood pressure regulation.

Bone strength: Higher content of phosphorus and calcium in goat milk enhances bone mineralization and goat milk is also known to provide bio-organic sodium that is known to prevent arthritis.

Antibacterial – Antiviral property: Goat milk contains a higher proportion of medium-chain fatty acids, i.e., caproic, caprylic and capric which are known for anti-bacterial and antiviral properties.

Anti-carcinogenic: Goat milk is a rich source of conjugated linoleic acid (CLA), which helps in reducing oxidative stress, atherosclerosis, improves blood lipids profile and protects the growth of tumors of mammary gland and skin.

Infant growth: The goat milk-based infant formula contains a level of nucleotides similar to human milk, which facilitates the immune system of the milk-fed offspring.

Immunomodulatory: High content of β casein in goat milk is known to provide immune peptides thereby increasing immunity.

Goat milk products

Special beverage - The goat milk standardized to 2% fat and 10.5% SNF was fortified with Vitamin A and D to label it as protein fortified low fat goat milk.

Chhana - Goat milk has been used to make high-quality chhana, which has been utilised to make Sandesh and Rasagolla.

Paneer- Good quality paneer free from goaty odour can be prepared using goat milk.

Infant Foods: Goat milk is offered for sale as e vaporated or spray dried form for pediatric usage in the USA and South Africa.

Khoa mawa- Mawa made from goat milk is sticky, no release of fat occurs during preparation.

Ice-cream- A good quality ice cream can be prepared using goat milk.

Commercially available goat milk and milk products in India:

Product	Brand	Price
Liquid milk	Countryard farms (New Delhi)	Rs. 140/300 ml
	Quidditaswhole (Kalaburagi)	Rs. 145/200 ml
Ghee	Shree Radhey (Rajastan)	Rs. 1500
	Countryard farms (New Delhi)	Rs. 688/200 g
Milk powder	Aadvik Goat milk powder	Rs. 999
	Nutra Vita Freeze Dried Goat	Rs. 974
	As fresh freeze-dried goat milk powder	Rs. 950
	Urban Platter Freeze-Dried goat milk powder	Rs. 1150

Goat milk based Cosmetic products:

Product	Brand	Price
Soap	Al essentials	Rs. 169/100 g
Double nourishing shower cream	Fruiser	Rs. 445/1000 ml
S.L.S and paraben free goat milk with protein shampoo	Vagad's Khadi	Rs. 280/210 ml

Yoghurt- Fermented product of goat milk.

Cheese- Soft and semi hard varieties of cheeses are made from goat milk. In European countries, these cheeses are marketed as Premium Cheese.

Ghee – Ghee prepared from goat milk is greasy and difficult for preparation due to small fat globules.

Conclusion

Goat milk may not be as ubiquitous as cow's milk, but its significance cannot be understated. Its nutritional benefits, environmental advantages, and culinary versatility make it a valuable addition to our diets and agricultural practices. Whether you're lactose intolerant, health-conscious, or environmentally aware, goat milk stands as a compelling choice, offering a sustainable and nourishing alternative to traditional dairy products. So, consider adding goat milk to your shopping list and enjoy its wholesome goodness while contributing to a more sustainable future.

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Application of Polymer Nanocomposites in Textile Industry

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Composites are two-material combinations in which one of the elements, referred to as the reinforcing phase, has been incorporated in the other material, known as the matrix phase.

The matrix is often a ductile or tough material, whereas the reinforcing components are typically strong with low densities. If the composite is properly planned and constructed, it combines the reinforcement's strength and the matrix's toughness to generate a combination of desired attributes not found in any one conventional material.

Polymer nano composites

A polymer (or monomer) is combined with other substances or additives which possess either one or more dimensions that are on the nanoscale scale to create polymer nano composites. A composite material made of nanomaterials and a polymer matrix is called a polymer nanocomposite. The three dimensions of the nanomaterials under consideration must all fall within the Inm-100 nm range. By choosing an appropriate manufacturing technique, polymer nanocomposites are created by distributing nanoparticles into the polymer matrix. Nanomaterials like nano clays, carbon nanotubes, nanofibers and nano-oxides are used in their production, as well as polymers like epoxy resin, polyamide, polyethylene and polypropylene. Compared to synthetic polymers and composites, polymer nanocomposites have enormous advantages.

When nanoparticles are properly added to a polymer matrix, the performance can be significantly improved. Better nomenclature for such materials would be nano filled polymer composites. Controlled nanostructure in the composite can bring novel behavior and new physical properties (not present in the empty matrices), such as flame-retardancy and faster biodegradability.

Advantages of polymer nanocomposites

- ✓ High modulus and glass transition temperatures
- ✓ the ability to modify characteristics for a variety of applications
- ✓ light weight (perhaps with a very high strength-to-weight ratio)
- ✓ good fatigue resistance
- ✓ Low thermal expansion and easy to shape and bind to a range of substrates or other composites

Disadvantages of polymer nanocomposites

- ✓ The cost of raw materials for advanced composites is considerable
- ✓ complex manufacturing procedures are frequently needed to assure low voids and porosity
- ✓ long development durations
- ✓ limited ductility, damage susceptibility
- ✓ the possibility of hidden damage (difficult to examine)

Application areas of polymer nano composites in textiles

Automotive sector: The automobile industry, which accounts for 85% of the market and is the primary consumer of technical textiles, is dominated by polyester and polyamide fiber. Since 30% of the total polymers used in component parts are textiles—such as seat fabrics, interior upholstery, airbags, filters, bands, etc.—the automobile industry is extremely important to the textile industry.

When woven fabrics need qualities like high strength and elongation, homogeneity, dimensional stability and superior abrasion resistance, technical threads are employed in the manufacturing process. Glass, aramid and carbon fibers are frequently

employed as reinforcement in polymer matrix composites, which are frequently used in the construction of aesthetic components such side panels, trays, etc.

Medical devices: Use as biodegradable "threads" or sutures that dissolve harmlessly after a predetermined amount of time, which can be modified based on the material's molecular structure, without removing the patient.

Components used in a variety of medical devices, including wheelchairs, prosthetic limbs, MRI scanners, C-scanners, X-ray couches, mammography plates, tables and surgical target instruments. When both patient and provider protection is important, wear medical apparel.

Home textiles: Hollow thermally insulating fibers used in beds and sleeping bags, soundproof curtains and darkening curtains are some applications of polymer nanocomposites in the home. Customers seeking soundproofing and/or darkening performance from their curtains in the instances above favor such curtains for their technical qualities over drapes with equivalent aesthetic or decorative qualities.

Industrial equipment: Filters, conveyor belts, abrasive belts, casings and reinforcements for equipment parts are a few examples. Almost all industries make use of equipment that incorporates such polymer nanocomposites. Nets, ropes and lines are products that use polymer nanocomposites.

Sporting goods: Technical textiles are those that are utilized in performance clothing and footwear because they are primarily chosen because of their technical and performance qualities. In particular, excessive moisture, which encourages the growth of germs and fungi, is one risk posed by using sports equipment that can be mitigated by biologically resilient or reactive polymers and composites.

Due to its low weight, high strength, numerous design options, ease of manufacturing and ease of forming, fiber-reinforced composites are employed as building materials for high-performance sports equipment. Such composites are commonly utilized in sporting equipment like skis, baseball bats, golf clubs, tennis rackets and bicycle frames.

Sailcloth, parachutes, balloon textiles, paraglide fabrics and other sports gear and equipment also use polymer nanocomposites.

Agriculture and horticulture: Applications for covering, safeguarding and containment include polymer nanocomposites. They could be knit, woven, or nonwoven in construction. Examples include sunblock, bird nets, plant and crop nets, ground covers, windshields, root ball nets, insect meshes, turf nets, many mats, monofilament nets, tape nets, cherry covers, pallet nets, packing materials for agricultural products and geotextiles that have uses in agriculture.

Building, construction and civil engineering: Building, construction and civil engineering projects can benefit from geotextiles, which are beneficial in these fields. Examples include glass and polyester fabrics used in roofing applications, breathable membranes that stop moisture from penetrating walls, composite walls and composite panels.

Clothing components: Polymer nanocomposites are used extensively as components in practically all types of clothing, in addition to being used in personal protective equipment (including protective clothing). These applications include materials for thermal insulation, wadding, linings and sewing threads. However, using polymer nanocomposites as the primary building blocks for a wide variety of performance sportswear is the most significant application of these materials in the garment industry.

Polymer nanocomposites in textile finishing

The form and characteristics of these materials are dominated by fundamental length scales, which makes polymer nanocomposites intriguing for textile applications. For the profitable utilization of functional textiles for specialized applications, polymer nanocomposites can change the chemical composition of textiles to produce a variety of textile functions.

Conductive fibers and fabrics

Application of polymer nanocomposites can impart conductivity in textiles. Developing coating materials for conductive polyester, polyamide and acrylics is conceivable by incorporating conductive nanoparticles into the polymer system.

Superhydrophobic, self-cleaning textile

Due to their great water resistance, superhydrophobic surfaces have a lot of technological potential for textile applications. High contact angle finished surfaces may also have a self-cleaning quality. Using the combination of the hydrophobicity of the polymer matrix and the nanoparticle roughness, extremely water-repellent superhydrophobic surfaces can be created. Hydrophobic substances like organic silicon and organic fluorine have been successfully included into the produced materials. By using such techniques, the finished surface's contact angle can easily reach 120 degrees.

Moisture management/hydrophilic textile

Since sportswear and underwear, which require perspiration absorbency, lack such hydrophilic finishings, the utilization of polymer nanocomposites is anticipated to benefit synthetic textiles particularly well.

Antimicrobial textiles

Textile characteristics are supposed to be enhanced by polymer nanocomposites incorporating silver nanoparticles. Smart functional textiles with a lot of potential for usage as antibacterial materials can be created by depositing silver polymer nanocomposites on textile surfaces.

Uv protective textiles

Numerous polymer nanocomposites can be added to textile material to provide UV protection. ZnO, TiO_2, SiO_2 and Al_2O_3 nanoparticles are the most often used materials. By diffusing, absorbing, or reflecting dangerous UV, they offer protection. The light scattering dominates at about 1/10 of the dispersed light's wavelength because of the tiny size of the particles. As a way to avoid particle agglomeration and improve the stability of ZnO nanoparticle/polymer composites, a number of innovative synthetic techniques have been devised. The nanoparticles must be disseminated uniformly in the various polymer matrices.

Fire retardant textiles

Flame-resistant and thermally anisotropic materials include polymer nanocomposite. Such fabrics are non-flammable due to the heat transmission through polymer nanocomposite. Compared to raw textiles, polymer infused textile materials are thermally stable and flame resistant. Highly effective flame-retardant fabrics with increased thermal and non-flammability qualities have been produced using the polymer nanocomposite.

Market and future of polymer nanocomposite

The Polymer Nanocomposites Due to increasing government support for lightweight vehicles in rising economies like China, India, Japan and Indonesia, the market size, which was estimated to be over USD 8.66 billion in 2021, will rise at a pace of over 19.1% CAGR from 2022 to 2028. The sector is anticipated to grow at an average CAGR of 20.2% over the projection period, reaching 1,420.1 Kilo Tons.

Conclusion

According to technological advancements and the use of nanomaterials, the need for technical textiles that serve a specific purpose in our economic and social activities will increase. These textiles can be used as security or reinforcing elements. As a result, many textile manufacturers are focusing more and more on trying to offer goods with novel "technical properties" that could significantly increase their worth.

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Moonlighting Proteins: Unveiling the Multifaceted Functions of Biomolecules

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Proteins, the molecular workhorses of life, have long been recognized for their crucial roles in various cellular processes. Traditionally, proteins were believed to have singular, well-defined functions within the cell. However, as our understanding of cellular biology has advanced, it has become evident that many proteins possess a hidden talent – they moonlight. Moonlighting proteins, also known as multifunctional or pluripotent proteins, are a captivating class of biomolecules that serve multiple distinct roles in the cell, often extending beyond their originally discovered functions. In this comprehensive article, we will delve deep into the intriguing world of moonlighting proteins, exploring their mechanisms, significance, and implications in meticulous detail.

Unmasking the Moonlighters

Moonlighting proteins are akin to versatile actors who excel in multiple roles on the cellular stage. They are typically renowned for their primary function but continually astonish scientists with their secondary functions. These secondary roles can encompass a wide spectrum of cellular processes, spanning metabolism, signaling, structural support, and regulation. The phenomenon of moonlighting proteins challenges our conventional understanding of protein structure and function.

Examples of Moonlighting Proteins

1. **Enolase**: Originally identified as an enzyme involved in glycolysis, enolase has also been found to play a pivotal role in cell adhesion, transcriptional regulation, and even as a receptor for certain pathogens.
2. **Actin**: Actin, a well-known cytoskeletal protein, is primarily associated with muscle contraction. However, it also participates in cell motility, intracellular transport, and cell division.
3. **Heat Shock Proteins (HSPs)**: HSPs, such as HSP70, were initially recognized for their role in protein folding and cellular stress responses. Yet, they have been found to have additional functions in apoptosis regulation and antigen presentation.
4. **Glyceraldehyde-3-phosphate dehydrogenase (GAPDH)**: GAPDH, a key enzyme in glycolysis, has been implicated in nuclear tRNA export, DNA repair, and apoptosis regulation.

Mechanisms of Moonlighting

Understanding how moonlighting proteins achieve their diverse functions is crucial to unravel this phenomenon fully. Several mechanisms underpin their multifaceted nature:

1. **Structural Plasticity**: Moonlighting proteins often possess structurally flexible regions that enable them to interact with different partners or adopt various conformations, facilitating different functions. These regions may serve as molecular switches, enabling the protein to transition between roles.
2. **Subcellular Localization**: Proteins can exhibit distinct functions depending on their location within the cell. Moonlighting proteins may change their subcellular localization to perform different roles. For instance, a protein predominantly localized in the nucleus may have a distinct function when translocated to the cytoplasm.
3. **Post-Translational Modifications**: Modifications such as phosphorylation, acetylation, or glycosylation can switch a protein's function on or off by altering its activity or binding partners. These modifications can be context-dependent, allowing the protein to toggle between functions based on cellular conditions.
4. **Protein-Protein Interactions**: Moonlighting proteins can engage in different protein-protein interactions to serve multiple functions, depending on their cellular context. They may

form complexes with different partners, leading to a wide array of functional outcomes.

Significance and Implications

The discovery of moonlighting proteins holds profound significance for various fields of biology and medicine:

1. **Evolutionary Perspective**: Moonlighting proteins challenge the classical notion of "one gene, one function." Their multifunctionality provides a mechanism for organisms to adapt to changing environments and evolve new functions without the need for additional genes. This can significantly influence the diversity and complexity of life on Earth.
2. **Drug Development**: Understanding the various functions of moonlighting proteins can greatly aid in drug development. Targeting a secondary function of a protein may provide novel therapeutic approaches for various diseases. Moonlighting proteins can be potential drug targets for conditions where their secondary functions are implicated.
3. **Disease Mechanisms**: Dysregulation of moonlighting proteins has been associated with various diseases, including cancer, neurodegenerative disorders, and autoimmune diseases. Studying their multifaceted roles may lead to insights into disease mechanisms, potentially revealing new avenues for diagnostics and treatment.
4. **Cellular Regulation**: Moonlighting proteins underscore the complexity of cellular regulation. They exemplify how cells can efficiently utilize a limited set of proteins to perform a wide array of functions, optimizing resource allocation and energy efficiency.

Conclusion

Moonlighting proteins are a captivating and dynamic aspect of cellular biology, challenging our traditional notions of protein function. They unveil the remarkable complexity and adaptability of living systems at the molecular level. As research in this field continues to advance, we can expect to discover more moonlighting proteins and gain deeper insights into their roles in health, disease, and evolution. The study of these multifunctional biomolecules represents an ongoing exploration of the mysteries of life, highlighting the intricate interplay of proteins in cellular processes and their far-reaching implications for the biological sciences and medicine.

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Carbon Sequestration Through Conservation Tillage

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Carbon is one of the several constituents of soil organic matter. The sequestration of carbon in soils involves the availability of the other building blocks. Carbon sequestration refers to the provision of long-term storage of carbon in the terrestrial biosphere, underground, or the oceans so that the build-up of carbon dioxide (the principal greenhouse gas) concentration in the atmosphere will reduce or slow. Transfer of atmospheric CO_2 into other long-lived pools so that it is not re-emitted into the atmosphere is called carbon sequestration. Carbon sequestration by agriculture may be one of the most effective ways to slow down the processes of global warming.

Over 60 per cent of the World's carbon is held in both soils (more than 41 per cent) and the atmosphere (20 per cent) (as carbon dioxide). However, soil disturbance is redistributing the carbon, augmenting the atmospheric carbon pool. Thus, a part of carbon dioxide increase in the atmosphere is thought to have come from agriculture, affecting not just climate change but also productivity and sustainability of agriculture and natural resources.

Agriculture must undergo a significant transformation in order to meet the challenges of food security and climate change. Changes in climate can be expected to have significant impacts on crop yields through changes in temperature and water availability.

The purpose of mitigation and adaptation measures is therefore to attempt a gradual reversal of the effects caused by climate change and sustain development. There are several mitigation and adaptation practices that can be effectively put to use to overcome the effects of climate change with desirable results. These methods fall into the broad categories of under crop/cropping system-based technologies, resource conservation-based technologies and socio-economic and policy interventions. The mitigation and adaptation practices includes i) carbon sequestration in soils and on-farm emissions reductions, ii) resource conservation-based technologies are in situ moisture conservation, rainwater harvesting and recycling, conservation agriculture covering no-till agriculture, or conservation tillage, etc,. contingency crop planning to minimize loss of production during drought/flood years.

In modern highly mechanized intensive cropping systems, CO_2 is also emitted from a number of fuel-consuming operations. In contrast, soil organic carbon sequestration in agricultural lands has recently drawn growing attention for its promise in mitigating rises in atmospheric CO_2 concentrations. In principle, agricultural soils can provide a large carbon sink and their SOC can be increased through the implementation of efficient agronomic practices.

Depending on the land use and management options, agriculture can be a source or sink for atmospheric CO_2. Agricultural practices with impact on atmospheric chemistry include production and management of crop residue, tillage systems, soil fertility and pest management, and supplemental irrigation. With the impending threat of climate change, there is a strong need for a critical appraisal of land use and soil management practices, including crop residue production and management in conjunction with the appropriate tillage methods, nutrient and pest management, water conservation and supplemental irrigation.

Conservation Agriculture (CA) is defined as a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment. It is premised on three key principles, namely, minimum mechanical soil disturbance, permanent soil cover and diverse crop rotations. Conservation tillage practices include, amongst others, strip tillage, cover cropping,

contour farming, zero or chemical tillage, mulch tillage, and reduced tillage, with the ultimate being low disturbance no-till or direct seeding.

Tillage

Sequestered carbon is stored in soils, resulting in increases in soil organic carbon (SOC). Estimates indicate that tillage reductions on global cropland could provide a full "wedge" of emissions reductions upto 25 Giga tonnes over the next 50 years.

Conventional tillage practices decrease soil organic carbon concentration while conservation tillage improves SOC concentrations and water storage reduces soil erosion. Deep tillage increases CO_2 release from the soil, the implementation of conservation tillage (no till or reduced tillage) appears to be a practice that can enhance soil C sequestration.

The principal mechanism of C sequestration with conservation tillage is the increase in micro-aggregation and deep placement of SOC in sub-soil horizons Continuous C input to the soil through crop residue return and manure application is a crucial practice for enhancing crop yields and soil C sequestration. Soil disturbance through tillage is a major cause of reduction in the number and stability of soil aggregates and subsequently organic matter depletion. The differences among tillage practices, we use the following terms:

- *Conventional tillage* leaves less than 15 percent residue cover after planting through intensive tillage.
- *Conservation tillage (con-till)* covers 30 percent or more of the soil surface with crop residue after planting.
- *Reduced-till* leaves 15 to 30 percent residue cover after planting.
- *No-till* leaves the soil undisturbed from harvesting to planting except for nutrient injection.
- Planting and fertilization are done with row cleaners and slits in the soil for placing seed and
- nutrients. Weeds are controlled with herbicides except when doing emergency weed control.
- *Ridge-till (stale seed bed)* leaves the soil undisturbed from harvesting to planting except
- for nutrient injection, but rows are rebuilt during cultivations for next year's crop. Permanent
- rows and traffic patterns are important to the success of this system.
- *Mulch-till* disturbs the soil before planting with chisels, field cultivators, disks or sweeps. Weeds are controlled by cultivation/and or herbicides.
- *Strip-till and zone-till* are not separate systems, but are variations of systems. A fertilizer

knife or mole knife is typically run in the row in the fall, early winter or late spring to loosen the soil and inject fertilizer. The soil usually is tilled with sweeps or disks over the row only, leaving the soil in between the rows untilled. The width of the tilled area can vary, and a bed may or may not be formed. Performing strip-till or zone-till occasionally is the best compromise between conventional tillage and no-till. Yield with these systems is comparable to that of conventional tillage — without the cost.

Crop residue

Crop residue is defined as the non-edible plant parts that are left in the field after harvest. Some researchers also include remains that are generated from crop-packing plants or that are discarded during crop processing into the generic category of crop residue. Principal benefits of retaining crop residue include soil erosion control, maintenance of soil structure, moderation of soil moisture and temperature regimes, energy source for soil biota and maintenance of soil organic matter (SOM) content. Crop residue and tillage cultivation on agricultural land are regarded as techniques for carbon sequestration through their ability to increase SOC. Increasing the total C input from plant residue biomass is crucial to soil C sequestration. Global annual production of crop residues is about 3.4 Pg/yr.

Soils are a major reservoir of carbon (C) and an important sink. The soils of the world contain more C than total amounts occurring in vegetation and the atmosphere combined. Farming activities in many

parts of the world have resulted in large declines in soil organic matter (SOM) and concomitant degradation of soil fertility, resulting in reduced crop yields and lower quality.

Addition of crop residues on conventionally tilled soils did not increase soil organic matter content, while minimum tillage coupled with crop residue addition increased the soil organic matter content of the surface soil horizon. Removal of crop residue from the fields is known to hasten SOC decline especially when coupled with conventional tillage. Minimum tillage systems, which maintain high surface soil coverage, have resulted in significant changes of soil physical properties, especially in the upper few centimetres. Crop residue strongly impacts both C and N cycles, and there is a great potential to enhance the sequestration of C and N in soils with the implementation of appropriate tillage methods and crop residue management.

Crop residues are an important resource, with numerous competing uses. However, the most appropriate use of crop residue is to enhance, maintain and sustain soil quality by increasing the soil organic carbon pool, enhancing activity and species diversity of soil fauna, minimizing soil erosion and non-point source pollution, mitigating climate change by sequestering C in the pedosphere and advancing global food security through enhancement of soil quality. There exists a direct relation between the amount of residue retained and soil organic matter content on the one hand, and between soil organic matter content and crop yields on the other.

Conclusion

Reduction in soil disturbance combined with residue retention increased the C retained in the small and large macro-aggregates of the top soil due to greater aggregate stability and reduced the emissions of CO2 compared with conventional tillage without residues retention. The retention of residues increased the C in aggregates of the top-soil and the reduction in soil disturbance resulted in a decrease in emissions of CO2.

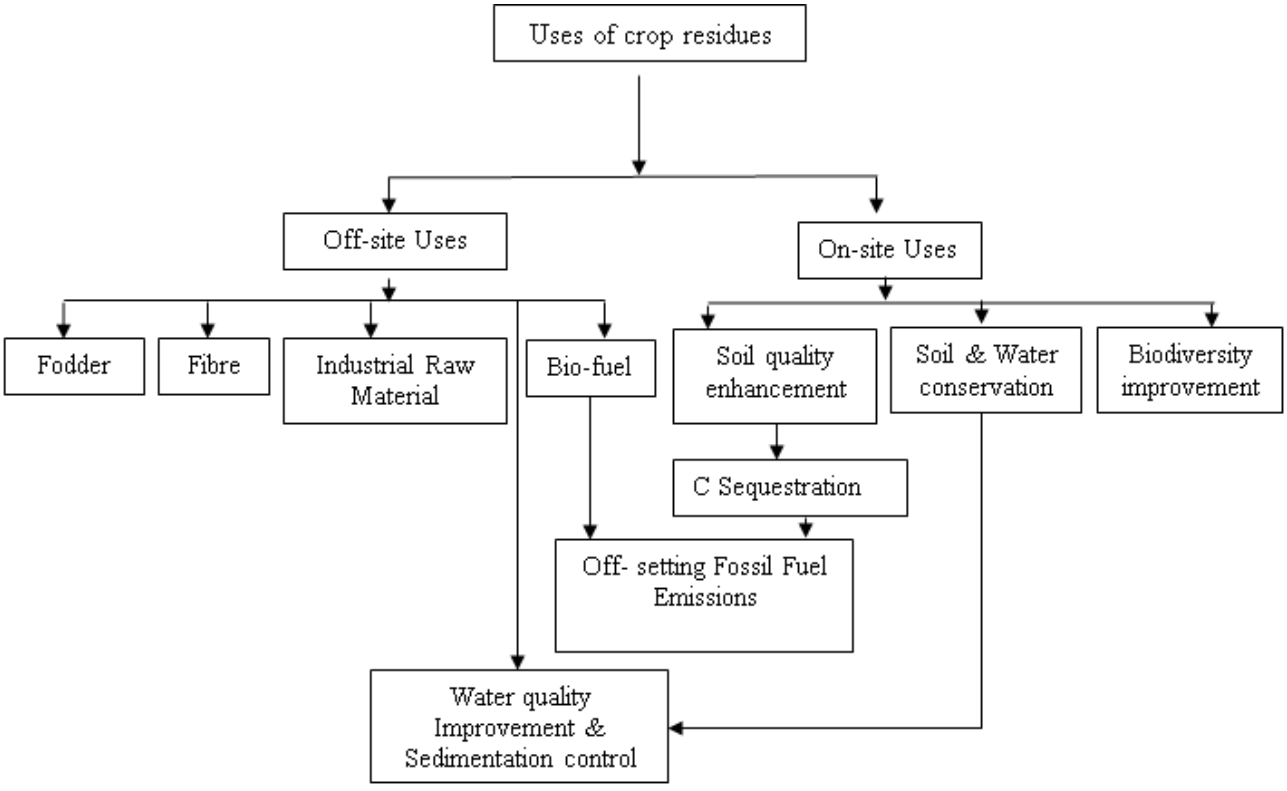

Fig 1. Alternative and competing uses of crop residues.

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Pesticide Residues Contamination in Vegetable Crops

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Pesticides are a necessity for crop production whether they may be of chemical or natural origin. They aid farmers to grow more food on less land by protecting crops from pests, diseases, and weeds as well as increasing productivity. Without pesticides, more than half of the crops grown would be lost to pests and diseases. More than 600 kinds of agrochemicals are used around the world. Though, they boosted agricultural production, low amounts of some residues may persist in the food chain, air, water, and soil and could make up a significant exposure pathway for humans. Since the early part of the 1900s, the agricultural industry has been using chemical pesticides. An organochlorine insecticide, dichlorodiphenyltrichloroethane (DDT) was banned the publication of Silent Spring by the biologist Rache l Carson in 1962 (Carson, 1962). Other insecticides like ethylene dibromide in 1983, methyl bromide in 2005, and endosulfan in 2011. During Second World War, German chemists developed a new class of pesticides, organophosphorus (OP) compounds for agricultural use and chemical warfare agents. OP compounds are extensively used in plant protection. They represent up to one-third of world pesticide consumption. It has been reported that compounds which belong to OPs groups are dangerous to human life, owing to their toxic effects such as mutagenic, teratogenic, and carcinogenic effects. OPs exposure is linked to Leukemia, Lymphoma, and Parkinson's diseases. OPs were replacing the more persistent organochlorine compounds which were suspected to be bio-accumulated up the food chain. Due to direct and indirect exposure to pesticides, various forms of contamination in the environment may occur.

Contamination in air

Pesticides contaminate the atmosphere either by application drift, post-application vapor losses, or wind erosion of pesticide-treated soil. Liquid sprays drifted through nozzles from pesticide application providing metering, atomization, and uniform distribution of the pesticide mixture. Breaking the liquid into droplets with the use of hydraulic pressure as the energy source, droplet sizes are usually below 150 µm. It can be used as an indicator of drift potential because these small droplets are most prone to movement under windy conditions. Pesticides treated on the soil surface may be susceptible to transport through wind erosion of soil. Most organochlorine insecticides are found in the air. Atmospheric pesticides are the source of exposure to pesticides through inhalation and the source of contamination of surface/groundwater through dry deposition and precipitation. Atmospheric movement may cause the transportation of pesticides from application sites to sensitive areas and the accumulation of pesticides in the environment.

Effects of pesticides on water

Pesticides can contaminate water bodies via diffuse or point sources and pose a significant threat to aquatic ecosystems and drinking water resources. Surface outflow drain, baseflow seepage, surface and subsurface runoff and soil erosion from pesticide-treated fields, spray drift at application, and deposition after volatilization are the point sources of agricultural pesticides in aquatic systems (Cessna 2009). Even from atmospheric deposition, pesticides are subjected to transport over distances. At any point during transport, they are also subject to the removal processes of wet and dry deposition, both of which contaminate surface waters. Surface waters consist of streams, rivers, lakes, reservoirs, and oceans. Streams and reservoirs supply approximately 50% of the drinking water in the world. Surface waters receive a portion of their water from snow melt or rainfall runoff. Pesticides susceptible to surface runoff are those within the runoff-soil interaction zone or the top 0.5 to 1 cm of soil. Spray drift is the airborne movement of spray droplets of pesticides away from a treated site during application. It is affected by spray droplet size, wind speed, and distance between the nozzle and the

target. It can contaminate water in ponds, streams, and ditches and spoil aquatic life.

Fig 1: Vegetable Sample collection from Ima Market, Imphal, Manipur

Groundwater may be contaminated when pesticides leach from treated fields, mixing sites, washing sites, or waste disposal areas. Pesticides may move with runoff as compounds dissolved in the water or attached to soil particles. The amount of pesticide runoff may leach down or accumulate somewhere. Leaching can be increased when the pesticide is water soluble, the soil is sandy, a rain event occurs shortly after spraying, and the pesticide is not strongly adsorbed to the soil.

Effects of Pesticides on Soil

The adsorption of the number of pesticides in soil depends on the type of pesticide, soil, moisture, soil pH, and soil texture. Soils that are high in clay or organic matter content, adsorbed pesticides strongly. Most soil-bound pesticides are less likely to give off vapors or leach through the soil and are less easily taken up by plants.

Pesticides that are sorbed to soil particles are more likely to remain in the root zone where they may be available for plant uptake and microbial or chemical. Sorption describes the attraction between a chemical and soil, vegetation, or other surfaces. Soils high in clay and organic matter, have a high potential to sorb pesticides. Clay content is also important for holding organic matter degradation (Kerle et al. 2007).

However, microbial degradation of pesticides is the breakdown of pesticides by microorganisms such as fungi, bacteria, and other soil microorganisms. Microbial activity usually is greatest in warm, moist, well-aerated soils with a neutral pH. As the pH of the soil becomes too acidic or alkaline, microbial activity usually decreases. Some portion of the pesticides

Effects of pesticides on plant

Different factors like physicochemical behavior, formulation, droplet size and application technique, precipitation or rainfall and relative humidity, temperature, sunlight, plant species, and physiological differences, e.g. stomata, upper/lower leaf surface, hairs, waxes, and time of application influence leaf uptake and metabolism of pesticides. The degree of plant uptake is determined partially by the pesticide's water solubility. Plant uptake of pesticides prevents runoff or leaching. After treatment, pesticide residues may be broken down or remain inside the plant or animal and be released back into the environment when the animal dies or as the plant decays. Some organochlorine pesticides may remain in the soil long enough to be absorbed by plants grown in a field years later.

Effects of pesticides on human health

All chemical pesticides are toxic when not used in recommended doses in respect of their appropriate crops and pests. Most of organochlorine (OC) is carcinogenic and neurotoxic. They act as endocrine-disrupting chemicals by interfering with molecular circuitry and the function of the endocrine system. The OC, Dichlorodiphenyltrichloroethane (DDT) is still found to be present and it is believed that every living organism on earth has a DDT body burden, mainly stored in the fat cells. The residues of DDT and its highly toxic metabolites, dichlorodiphenyldichloroethylene (DDE) have been associated with neurodevelopmental effects in children. The hazardous nature of organochlorines like endosulfan, which remains in the environment for longer periods and bio-accumulates in plants and animals leads to contamination of food consumed by humans. It affects mainly the central nervous system,

the disproportion of thyroid hormones, etc. OCs were also reported to increase the risk of hormone-related cancers including breast, prostate, stomach, and lung cancer.

Organophosphorous (OPs) compounds have also harmful effects on the nervous system of the affected organisms where they inhibit acetylcholinesterase. OPs compounds or their metabolites are related to cardiovascular diseases and the reduction of the fertility of human beings, which is often linked to a decrease in the level of testosterone.

Carbamate pesticides, such as aldicarb, carbofuran, carbaryl, etc. are also associated with endocrine-disrupting activity which possibly affects reproductive disorders, effects on cellular metabolic mechanisms, and mitochondrial function. It has the ability to cause neurobehavioral effects, increased risk for dementia, and non-Hodgkin's lymphoma.

Synthetic pyrethroids, such as fenvalerate, permethrin, cypermethrin, etc. have also the ability to display endocrine-disrupting activity and affect the reproductive behavior in experimental animals. The insecticides are also associated with DNA damage in human sperm. Neonicotinoid pesticides, such as imidacloprid, thiacloprid, and thiamethoxam, have possible effects on the endocrine and reproductive systems of animals. There are various reports affecting the bee population. The increased expression of the enzyme aromatase, which is engaged in breast cancer was also reported from neonicotinoids.

Acceptable Daily Intake (ADI)

Acceptable daily intake (ADI) is a measure of the amount of a specific substance (originally applied for a food additive, later also for a residue of a veterinary drug or pesticide) to which a person can be exposed on a daily basis over an extended period of time (usually a lifetime) without suffering any detrimental effect. It is expressed in milligrams (of the substance) per kilogram of body weight per day. It relates to daily ingestion because accepted additives should not accumulate in the body. It is based upon the scientific judgment of all facts known at the time of assessment in order to define a limit, below which no harmful effects would be expected. More simply, it may be defined as an intake that is believed to be "without appreciable risk". The higher the ADI, the larger amounts of a compound are harmless for regular ingestion. The ADI does not take into account allergic reactions that are individual responses rather than dose-dependent phenomena. The ADI value can be measured from long-term studies on animals and humans.

No-observed-adverse-effect level (NOAEL) is the highest dose at which there was not an observed toxic or adverse effect. Usually, the studies are performed with several doses including high doses. However, the lowest NOAEL is usually taken. The NOAEL is then divided by a safety factor, conventionally 100, to account for the differences between test animals and humans (factor of 10) and possible differences in sensitivity between humans (another factor of 10).

Maximum Residue Limit (MRL)

MRLs are defined as the maximum concentration of pesticide residue (expressed as milligrams of residue per kilogram of food/animal feeding stuff) that is expected to remain in or on food when the pesticides are used according to good agricultural practice (GAP), i.e. when the pesticide has been applied in line with the product label recommendations and in keeping with local environmental and other conditions. The MRL is generally set at a value determined from supervised field trials. The trial field crop has to be treated with a pesticide. Samples of the crop have to be analyzed to determine pesticide residue levels. If there is no detection of residue as expected, a residue level can be set at the limit of determination (LOD). It is the lowest level at which reliable quantitative analysis can be performed.

Present status of chemical Pesticide Residues in Vegetable Crops

Vegetables like tomato, cabbage, and cauliflower, brinjal, pea, broad beans, French beans, and cowpea were collected from major local markets of Manipur. It has been found that the pesticide residues of chemical insecticides like imidacloprid, fipronil, and chlorantraniliprole above MRL (FSSAI) were detected in vegetable samples. There is a need of creating awareness among the public for the safe use and consumption of raw vegetables by following the available on-farm decontamination techniques. Time has also come forward to apply only the recommended doses at the right time of application by identifying the specific insect pests and their related host crop.

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Vermicompost – An Effective Option for Recycling Organic Waste

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Vermicomposting is a basic biotechnological composting process in which certain earthworm species are utilized to enhance waste conversion and provide a better final product. In some aspects, vermicomposting varies from composting. It is a mesophilic process that employs microorganisms and earthworms that are active at temperatures ranging from 10-32°C. Because the material passes through the earthworm gut, a significant but not fully understood transformation occurs, whereby the resulting earthworm castings (worm manure) are rich in microbial activity and plant growth regulators, and fortified with pest-repellent attributes as well. In short, earthworms are capable of transforming garbage into 'gold' through a type of biological alchemy (Vikram reddy *et al*., 2009).

Vermiculture:

Vermiculture is a scientific way of raising earthworms under controlled conditions. Species include *Perionyx excavatus, Eisenia foetida, Eudrilus eugeniae, and Lampito marutii* are predominately utilised for compost preparation.

Vermi technology

Vermi technology combines vermiculture with vermicomposting. Earthworms will be utilised in the following applications.

1. To promote the growth of fertile soils, soil turnover, plant organic matter decomposition and better aeration and drainage

2. To produce useful goods such as vermicompost, animal feed and vermin wash.

3. To enhance environmental quality, maintenance and environmental monitoring for soil fertility.

Inputs required for vermicompost:

Basic raw material: Any organic material generated in the farm like straw, leaf fall etc.

Starter: Cow dung, Biogas slurry or urine of cattle

Earth worms (Species like *Eisenia foetida*).

Favourable conditions of earth worms in the composting material:

a. pH : Range between 6.5 and 7.5.

b. Moisture: Waste/residues should have 60-70 % moisture.

c. Aeration: 50 % aeration from the total pore space.

d. Temperature: Range between 18°C to 35°C.

Method of Preparation

It is mostly prepared in either pit or heap method. The dimensions either heap or pit are generally 10 x 4 x 2 feet. The length and width can be increased or decreased depending on the availability of material but not the depth because the earthworm's activity is confined to the 2 feet depth only. Shade should be provided above the beds either with a thatched roof or net.

The raw material is spread in layers in the pit. The 1st layer is a bedding material 1" thick with soft leaves/ coir /cane trash, the 2nd layer is 9" thick organic residue layer with finely chaffed material like shed waste, vegetable waste and crop residues while the third 3rd layer is with starter material (dung + water mixture) equal of 2" layer. The waste may be pre-incubated with dung slurry before filling into the pit.

Continue to add the layers up to pile to ground level to protect the worms against natural enemies like ants, lizards, snakes, frogs, and toads etc., Maintain proper moisture and temperature by turnings and subsequent staking. After completely filling, worms are introduced into the pit [$1m^2$=1000 worms or 1kg per tonne of residue]. The pit should be covered with old gunny bags or rice straw and maintained moist by regular sprinkling the water and moisture content of the pit should be maintained at 30-40%. In two months, the entire raw material will be turned into the vermicompost. The turnover of the compost is 75 %

[the total material accommodated in the pit is 1000 kg; The out turn will be 750 kg]. The method preparation as outlined by

Harvesting of the vermicompost from the pit

Stop watering before one week of harvest. All the worms spread across the pit come in close and penetrate each other in the form of balls in 2 or 3 locations. Heap the compost by removing the balls and placing them in a bucket, then the material is sieved in a 2 mm sieve, the material passed through the sieve is called vermicompost which is stored in polythene bags.

Conversion rates: 1000 earthworms may convert 5 kg of waste material per day. 1000 worms weigh about a kilogram

Precautions to be taken

1. Vermicomposting is done under a thatched roof to protect worms against rain and sun.
2. Plastic and glass should be carefully sorted out while adding waste into the pit.
3. Vermicompost should be harvested at the appropriate time
4. Pre-incubated waste may be preferred for filling the pit.
5. Care and protection should be provided against ants, rats and other natural enemies

Advantages of vermicomposting:

1. There will be no immobilization in compost because of the narrow C: N ratio.

2. Vermicompost is rich in nutrients when compared to FYM. Nutrient composition of vermicompost

3. Besides the above nutrients the vermicompost also contains the enzymes like Protease, Lipase, Amylase, Cellulose and other growth-promoting hormones

4. Application is easy because the compost is humified and has a structure of crumb and granular.

5. It is hygienic; pathogens and weeds seeds are destroyed.

6. No loss of nutrients

7. Provides buffering against soil acidity and alkalinity.

8. It improves physical properties better than compost on soil application and Improves water holding capacity of the soil

9. Quality, fragrance and shelf life of flowers and fruits are improved

10. Imparts disease and pest resistance to crops

11. Improves the yield

12. Helps in reducing environmental pollution and ecologically safe.

Application/dosage

The vermicompost recommended dosage for field crops @ 1 t/ha, for horticultural crops @ 5-10 kg/tree and floriculture @ 200g/pot is beneficial for getting good results. The following table displayed the nutritional status of the prepared vermicompost.

S. No.	Nutrient	Content
1	Organic carbon	9.15 to 17.98 %
2	Total nitrogen	1.5 to 2.10 %
3	Total phosphorus	1.0 to 1.50 %
4	Total potassium	0.60-0.80 %
5	Ca and Mg	22.00 to 70.00 m e / 100 g
6	Available S	128 to 548 ppm
7	Copper	100 ppm
8	Iron	1800 ppm
9	Zinc	50 ppm

(Source: Theunissen *et al*., 2010)

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Beauveria bassiana: A Potential Entomopathogenic Fungi for Sustainable Insect Pests Management

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An important environmental issue nowadays is the indiscriminate use of chemical pesticides on crops. Chemical pesticide usages have been steadily rising worldwide along with rising crop productivity and human population. This has led to a negative impact on the ecosystem and raised human health risks. The indiscriminate use of chemical pesticides against insect pest in agriculture has resulted in problems such as pest resurgence, resistance and threat to the environment as well as health of humans. The development of alternate methods of insect-pest management has been greatly accelerated by the growing urge to reduce chemical inputs in agriculture and the rise in pesticide resistance. Emphasis is now being placed on alternative pest management methods. Under such scenario the Entomopathogenic fungi (EPF) are an alternative to manage insect pests. Fungi that infect, invade, and ultimately kill insects are known as entomopathogenic fungi. The ability of the enzymatic activity, which includes the presence of lipases, proteases, and chitinases, allows entomopathogenic fungi to exhibit a wide spectrum of pathogenic activity. These enzymes disintegrate the integument of the insect, with lipases being the first enzyme produced by entomopathogenic fungus (Maravi *et al*., 2018). Entomopathogenic fungi are highly effective in managing various insect pests and play a crucial role in pest management. These fungi have been successfully used in crop production systems as microbial agents against pests. In order to regulate insect pest populations without putting non-target insects in danger, entomopathogenic fungi are recognised as a viable biocontrol strategy. They are essential in pest management due to their effectiveness in managing a wide range of insect pests. They can be used in combination with other biocontrol tactics in integrated pest management programs, providing environmentally safe alternatives to chemical insecticides.

More than 1000 species of pathogenic protozoa and over 800 species of entomopathogenic fungi have been characterised and identified. The ecofriendly control of various insect pests involves the use of entomopathogenic fungi based on *Beauveria bassiana*, *Metarhizium anisopliae, Verticillium lecanii* and *Paecilomyces fumosoroseus* (Mahankuda and Bhatt, 2019). Among these, the entomopathogen *B. bassiana* has shown great potential in managing insect pests. *B. bassiana* belongs to the kingdom- fungi, phylum-ascomycota, class -sordariomycetes, order-hypocreales and family -clavicipitaceae. It was discovered by Bassi Agostino of Lodi, Italy, in 1835.

Currently, six species namely *B. bassiana*, *B. clade*, *B. brongniartii*, *B. caledonica*, *B. vermiconia,* and *B. amorpha* has been recognized worldwide (Goettel *et al*., 2015; Rehner and Buckley, 2015). Out of all the species, *B. bassiana* has been the most thoroughly researched, widely used and commercially available as a biopesticide worldwide for the management of insect pests (Meyling and Eilenberg, 2007). The toxins produced by *B. bassiana*, such as beauvericin, bassianin, bassianolide, beauverolides, tenellin, oosporein, and oxalic acid, play a crucial role in the parasitization and killing of insect hosts (Wang *et al*., 2021). The high genetic diversity of *B. bassiana* also contributes to its importance. Recent research has demonstrated that specific genes and molecules in *B. bassiana* can change its virulence depending on the host and infection stage (Wang *et al*., 2021). This genetic diversity provides opportunities for the development of strategies to enhance the efficacy of *B. bassiana*. Identifying and targeting these genes and molecules can lead to the development of more effective and sustainable pest management strategies. The demand for chemical-free residue on foods, a reduction in the use of chemical pesticides, the growth of organic agriculture, and the expansion and consolidation of integrated pest management (IPM) programmes are all driving a significant global upswing in the use of microbial biopesticides. Further research and understanding of the ecology of these

fungi will enhance their utilization in pest management strategies.

Mode of action

The mode of action of *B. bassiana* involves several mechanisms that contribute to its insecticidal activity. One of the key factors is the production of various toxins. These secondary metabolites play a crucial role in the parasitization and killing of insect hosts. The toxins can disrupt the physiological processes of the insects, leading to their death (Wang *et al*., 2021). Another important aspect is its ability to penetrate the insect cuticle. The fungus produces enzymes, such as chitinases and proteases, which degrade the insect's cuticle and facilitate the entry of *B. bassiana* into the host's body. Once inside, the fungus proliferates and colonizes the insect, leading to its eventual death. Furthermore, it can also produce extracellular enzymes, such as lipases and esterases, which are involved in nutrient acquisition from the insect host. These enzymes help *B. bassiana* to utilize the insect's tissues as a nutrient source, supporting its growth and development within the host. These mechanisms collectively contribute to the insecticidal activity of *B. bassiana* and its effectiveness as a biological control agent.

Symptoms

The symptoms of *B. bassiana* infection in insects can vary depending on the specific host and the stage of infection. Here are some general symptoms observed in infected insects:

1. Infected insects may exhibit reduced mobility or become sluggish. This is often one of the early signs of infection.
2. Infected insects may show discoloration, such as a change in the color of their exoskeleton. This can range from a slight darkening to more noticeable discoloration.
3. Visible growth of the fungus on the insect's body. Infected insects may develop a white or grayish powdery coating, which is the fungal mycelium.
4. *B. bassiana* can cause dehydration in infected insects. This can lead to desiccation and shrinkage of the insect's body.
5. Infected insects may exhibit reduced feeding or loss of appetite. The fungal infection can disrupt the insect's feeding behavior and nutrient uptake.
6. In severe cases, the infection can lead to the death of the insect. The fungus proliferates within the insect's body, causing damage to internal organs and eventually leading to the death of the host.

Host range

B. bassiana is a versatile entomopathogenic fungus with a broad host range, infecting and managing numerous insect pests. The host range extends to various insect orders, including Lepidoptera, Hemiptera, and Diptera (Meyling *et al*., 2009). Its ability to infect and parasitize a wide range of insect species makes it a valuable biocontrol agent in agriculture and pest management. Some examples of susceptible hosts belonging to different orders are Coleoptera- *Holotricha spp*., Lepidoptera- *Spodoptera litura, Helicoverpa armigera*, Hemiptera- *Aphis craccivora*, *A. gossypii*, *Bemisia tabaci,* Diptera- *Leria serrata* and Orthoptera- *Schistocera gregaria*, *Locusta migratoria* (Keswani *et al*., 2013).

Advantages

B. bassiana offers several advantages as a biological control agent for insect pests.

1. Broad-spectrum: It has a broad spectrum insecticidal activity, which allows it to target a wide range of agricultural pests. This makes it a versatile and effective tool for pest management in various settings.
2. Adaptability: It has the ability to persist and establish populations in both agricultural and semi natural habitats. This adaptability allows it to effectively target pests in different environments, including agricultural fields, greenhouses, and natural ecosystems.
3. Mode of action: It has a unique mode of action compared to chemical insecticides. It infects insects through contact and ingestion, leading to the colonization and eventual death of the pests. This mode of action reduces the risk of resistance

development in target pests, as it targets multiple physiological pathways and mechanisms.

4. Compatibility: It has the potential for integration with other pest management strategies. This integrated approach can provide a more comprehensive and sustainable solution to pest management.

Limitations

While *B. bassiana* has many advantages, there are limitations and factors to consider:

1. Specificity: *B. bassiana* is primarily effective against insect pests and may have limited efficacy against other types of pests, such as mites or nematodes.
2. Environmental conditions: *B. bassiana* requires specific environmental conditions for optimal growth and activity. Factors such as temperature, humidity, and UV radiation can affect its efficacy and persistence in the field.
3. Limited shelf life: Formulations typically have a limited shelf life, and the viability and effectiveness of the fungus can decrease over time.
4. Slow action: Slower mode of action compared to chemical insecticides.

Conclusion

B. bassiana plays a crucial role in sustainable pest management by offering an environmentally friendly alternative to chemical pesticides. Its ability to infect and manage a wide range of insect pests makes it a versatile and valuable tool in integrated pest management programs. Further research and development in understanding the mechanisms of action and improving the virulence of *B. bassiana* will enhance its effectiveness as a biocontrol agent, contributing to the development of sustainable and eco-friendly pest management practices.

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Success Story - Scientific Cultivation of Field Pea Var. Aman in Rice Fallow

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Wahengbam Manichoubi Devi aged 63 years inhabited in Kumbi ward no. 2 village in Moirang block about 25 km from the district headquarter, Bishnupur, Manipur. Her field was located at Wangoo Keirap with 24^{0}41'86.1'' latitude and 93^{0}79'59.9'' longitude covering a total area of 2.0 ha. Because of varied reasons such as lack of irrigation facilities, uneven distribution of rainfall, late onset of monsoon, etc. she was unable to get good benefits from farming despite of her hardworking. Also, she had little knowledge about cropping system that could be successfully planted after paddy, thereby leaving such areas fallow.

KVK Intervention

KVK, Bishnupur provided critical inputs viz. Field pea var. Aman, biofertilizer and pesticide. During the crop period, Senior Scientist & Head as well as scientist of Agronomy, Plant Protection and Soil Scientist regularly visited her field in every critical stages of the crop growing period. Also encouraged her to go for seed production and guided her for the availability of market for sale of seeds of *rabi* crops. She followed the technology supervised by SMS(Agronomy). The specific technology she followed was to grow the crop (field pea) with seed rate @ 60 kg/ha at a spacing of 30cm X 10 cm, seed treatment with Carbendazim @ 2g/kg, Rhizobium @ 50g+ 10g sugar per kg of seed.

Success point

The programme has promoted efficient use of cultivated land in fallow areas, optimized use of available resources i.e., water, labour and other inputs. It has not only provided additional yield of pulses averaging 9.21 q/ha but also improved soil health due to fixation of atmospheric nitrogen by root nodules of field pea. Farmers could earn a net income of Rs. 34670.00. They could get a return of Rs. 2.11 when Rs. 1 was invested.

Farmer feedback

She was satisfied with the technology because she could see the difference of her field where before it lies fallow after harvesting of paddy which she had grown last five years and kept her field barren for almost three years due to non-productive of the soil.

Figure 1: Performance of technology vis-à-vis Local check (Increase in productivity and returns)

	Yield (q/ha)	Gross cost (Rs/ha)	Gross income (Rs/ha)	Net income (Rs/ha)	B:C ratio
Farmer practices	785	28500	54950	26450	1.92
Demonstration	941	31200	65870	34670	2.11
% Increase	19.87	9.4	19.87	31.08	9.89

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Integrated Pest Management in Vegetable Crops Using Botanicals

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Integrated pest management (IPM) has emerged as a holistic and sustainable approach to managing pests in agricultural systems. It emphasizes the use of multiple strategies, including cultural, biological, physical, and chemical methods to maintain pest populations below economically damaging levels while minimizing environmental impact. One effective and environmentally friendly component of IPM is the use of botanicals, i.e., plant-derived compounds with pesticidal properties. In vegetable crop production, botanicals offer a natural alternative to synthetic chemical pesticides, promoting both pest control and ecosystem health.

Botanicals in IPM

Botanicals are plant-based substances that contain bioactive compounds, such as alkaloids, terpenoids, phenolics and essential oils. These compounds often act as defensive mechanisms for plants against herbivores and pathogens. When applied properly, botanical extracts can disrupt pest behaviour, feeding, reproduction and development without causing harm to non-target organisms or leaving harmful residues in the environment.

Benefits of botanicals in IPM of vegetable crops

i. **Reduced chemical dependency:** Botanicals provide a viable alternative to synthetic chemical pesticides, reducing the reliance on potentially harmful chemicals and their associated environmental and health risks.

ii. **Targeted pest control:** Many botanicals have specific modes of action that target certain pests without affecting beneficial organisms. This precision minimizes disruptions to natural ecosystems and the agroecosystem's balance.

iii. **Resistance management:** Continuous use of synthetic pesticides can lead to the development of resistant pest populations. Botanicals can help manage resistance by offering a new mode of action that pests are less likely to have encountered.

iv. **Low residue levels:** Botanical pesticides tend to break down more quickly in the environment compared to synthetic chemicals, leading to lower residue levels on harvested crops and a reduced impact on human health.

v. **Biodiversity conservation:** By sparing beneficial insects and predators from harm, botanicals contribute to the preservation of biodiversity and the overall ecological balance.

Common botanicals used in IPM of vegetable crops

Neem (*Azadirachta indica*)

Neem extracts contain azadirachtin, a compound that disrupts insect moulting and feeding, leading to reduced pest populations. It is effective against gypsy moths, leaf miners, whiteflies and mealybugs.

Pyrethrum (*Chrysanthemum cinerariifolium*)

Pyrethrin extracts are known for their rapid knockdown effects on a broad range of insects. They are available under the trade names PyGanic (5% EC) and Ever Green (6% EC), and are particularly effective against aphids, caterpillars and beetles.

Garlic (*Allium sativum*) and onion (*Allium cepa*) extracts

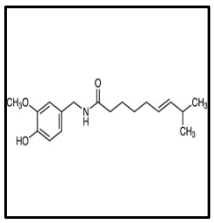
These extracts contain sulphur compounds that repel pests and inhibit their feeding and development. They are commonly used against soft-bodied insects.

Capsaicin (from chilli/hot peppers): Capsaicin disrupts pest feeding and can also act as a repellent or deterrent for various insects.

Essential oils (e.g., rosemary, thyme, eucalyptus): Essential oils have diverse effects on pests, including repellence, growth inhibition and toxicity.

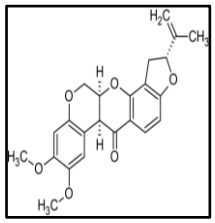
i. **Sabadilla:** It is extracted from seeds of *Sabadilla* lily and is effective against caterpillars, leafhoppers, thrips and bugs.

ii. **Rotenone:** It is resinous compound produced by roots of several tropical and sub-tropical plant species belonging to genera *Lonchocartus* and *Derris*. It is effective against caterpillars, beetles, aphids, flea beetles, weevils and thrips.



Chemical formula of capsaicin

Inflorescence of Sabadilla



Chemical formula of rotenone

Challenges and considerations

While botanicals offer numerous advantages, there are also challenges and considerations to address, viz.

i. **Variable efficacy:** The effectiveness of botanicals can vary depending on factors like pest species, stage of development, and environmental conditions. Proper application timing and dosage are crucial for optimal results.

ii. **Limited persistence:** Botanicals generally have a shorter residual activity compared to some synthetic pesticides. This may necessitate more frequent applications, increasing labour and costs.

iii. **Regulatory hurdles:** Some botanical products may face regulatory challenges, as they need to meet safety and efficacy standards before being approved for use in agriculture.

iv. **Cultural practices:** Successful integration of botanicals into IPM may require adjustments to crop management practices. Farmers need to be educated on proper application techniques and timing.

Conclusion

Incorporating botanicals into integrated pest management (IPM) strategies for vegetable crops presents an opportunity to embrace more sustainable and eco-friendly farming practices. By harnessing the natural defences of plants, farmers can achieve effective pest control while minimizing the negative impacts associated with conventional chemical pesticides. As the world continues to prioritize sustainable agriculture, botanical-based pest management is poised to play a pivotal role in ensuring food security while safeguarding the environment.

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Internet of Things and Remote Sensing

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The modern agriculture sector and food industry face population expansion, climate change, and Phytopathological adversities. Nanotechnologies and IoT can help achieve sustainability (Maksimovic *et al.*, 2017). Modern agricultural innovations include "real-time communication" and "wireless sensing," while "smart farming" uses ICT like remote sensing (Bastiaanssen *et al.*, 2000), cloud (Hashem *et al.*, 2015), and Internet of Things (IoT) (Weber *et al.*, 2010) to help farmers monitor field conditions from anywhere or with in-field high-tech support. Robotics help in seedling and plant management, fruit harvesting, plant protection, and weed control (Ampatzidis *et al.*, 2017). Remote sensing involves gathering qualitative and quantitative data via a satellite, aircraft, UAV/UGV, or probe. How agricultural systems change in location and time and how non-destructive sensing might reduce environmental consequences by avoiding resource depletion are significant to us. We can analyze molecular interactions and crop stress and its biophysical or biochemical characteristics (Mulla *et al.*, 2013), as well as detect (even at early stages) plant stress-induced variations (leaf area index, chlorophyll content, or surface temperature), resulting in a different fingerprinting than the healthy condition (Meroni *et al.*, 2010). Remote sensing for precision farming began in the 1980s with a few visible or near infrared bands, but was later developed as hyperspectral. As summarized in another work (West *et al.*, 2003), plant-related events can be monitored in different spectral regions: pathogen propagules in the VIS (depending on the pathogen), chlorophyll degradation (necrotic or chlorotic lesions) in the VIS and red-edge (550 nm, 650–720 nm), photosynthesis disturbance as fluorescence (450–550 nm, 690–740 nm) and in the TIR (8000–14,000 nm), and senescence. They can detect disease in agricultural crops. A hyperspectral radiometer was utilized to determine photosystem II photochemistry's intrinsic efficiency from leaf reflectance, specifically the ratio Fv/Fm of two leaf ChlF-derived parameters, which represent the variable and maximum fluorescence (Peng *et al.*, 2017). Stressed leaves reduce Fv/Fm substantially (leaf chlorophyll remains same). The slope of reflectance in the 700–900 nm spectral range increased along with this drop, with excellent correlation of the first derivative reflectance in the NIR areas with Fv/Fm.

Agricultural drones, often known as UAVs, can help with surveillance, sowing crops, battling pests, and crop monitoring. The "Sense Fly" (Sensefly *et al.*, 2020) farm drone eBee SQ communicates with eMotion Ag software to analyze multispectral images. The software directly uploads drone multispectral photos to cloud services, encompassing hundreds of acres, for accurate crop monitoring and analysis. Instead, aircraft and satellite technologies are fully characterized (Omasa *et al.*, 2006; Rudd *et al.*, 2017). The former covers satellite and aircraft remote sensors and agriculture applications (landsat and GIS data on land use and nitrogen flow, aerial hyperspatial data for wheat growth estimation or farmland analysis, and aerial Lidar Data for 3-D remote sensing for terrain and forests). The latter emphasizes the pros and cons of satellites, UAS, and ground sensors, emphasizing UAS versatility or the suitability of the two systems for specific applications (such as on-the-go processing for some ground sensors, allowing instant herbicide applications without data processing delays). Low-cost mini-UAVs for thermal and multispectral imaging are an extension of this technology (Bendig *et al.*, 2012). This study used a mini-UAV system (HiSystems' MK-Okto) with a payload of about 1 Kg to carry a handheld low-weight NEC F30IS thermal imaging system and a Tetracam Mini MCA four-band multispectral imaging system. The system acquired thermal and multispectral images with georeferencing for comparability. The 15-minute flight facilitates small-scale applications.

Remote sensing is also used for agricultural land use monitoring, crop yield forecasts, yield optimization, and ecosystem services (Weiss *et al.*,

2020). Remote sensing for environmental monitoring (Huete *et al.,* 2004) covers Earth's surface monitoring and characterisation, ecosystem sustainability, drought mitigation, human health, and other environmental studies.

IoT can help sanitary certification and provide industrial data for traceability. Prunus spp. were identified, stored, and tracked using RFID microchips. plants (Luvisi *et al.,* 2011) and grapevine clonal selection (Pagano *et al.,* 2010). RFID has been utilized to identify all plants through ampelographic, genetic, and sanitary examinations. RFID can also be used to retrieve propagated material (Luvisi *et al.,* 2012), tag mother plant vineyards, and certify products. Video processing, cloud computing, and robotics can detect tomato borer insects with appropriate phytosanitary treatment management (Rupanagudi *et al.,* 2015). Real-time tomato crop video is supplied to a cloud application for processing. Image analysis instructs a robot to spray pesticides totally autonomously to monitor the farm. A vineyard-wide wireless sensor network with self-powered nodes was also proposed (Perez-exposito *et al.,* 2017). Epidemiological models on VineSens' hardware and software platform avoid diseases like downy mildew, helping farmers manage and save money by reducing phytosanitary treatments. The software allows users to collect weather data from various vineyard locations using a web-based interface on desktop or mobile devices. Remote sensed imagery and geospatial image processing using unmanned aerial vehicles (UAVs) with advanced hyperspectral, multispectral, and digital RGB sensors and terrain-based data are also used for crop management and insect pest detection (Vanegas *et al.,* 2018). Systems like "Arable" and "Semios" monitor crops. The former sends weather and plant measurements to the cloud, allowing real-time access to stress, pest, and disease indicators through a software platform (Arable *et al.,* 2020). The letter installs remote-controlled pheromone dispensers, pest camera traps, soil moisture sensors, and leaf-wetness devices in each orchard block using a proprietary mesh network (Semios *et al.,* 2020).

Airborne platforms using multispectral and thermal cameras can monitor pathogens like Xylella fastidiosa (Xf) (Poblete *et al.,* 2020), selecting spectral bands that are sensitive to Xf symptoms (blue bands paired with thermal area). Another study used aerial hyperspectral imagery and Sentinel-2 satellite data to construct a 3D radiative transfer modelling approach (3D-RTM) to assess olive orchard Xf infection dynamics (Hornero *et al.,* 2020). Sentinel-2 time-series imaging indicated spatio-temporal markers for monitoring Xf virus damage across wide areas. Other agricultural uses are discussed (Cheng *et al.,* 2017; Polo *et al.,* 2015; Vazquez-arellano *et al.,* 2016) and current big data analysis research in agriculture is reviewed (Kamilaris *et al.,* 2017). Another study showed how nano-networked small sensors might collect fine-grained data from objects and hard-to-reach regions (Balasubramaniam *et al.,* 2013). A comprehensive overview covers architectures, areas, trends, potential and obstacles (Cruz *et al.,* 2019).

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Wave of Awareness: Revealing the Blue and Grey Water Footprint of the Textile Sector

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The textile industry plays a significant role in our global economy, producing a wide range of clothing and fabrics that we use in our daily lives. However, this industry's growth and production processes come with a considerable environmental impact, particularly concerning water consumption. The water footprint of the textile industry can be categorized into two crucial components: "blue water" and "grey water." Understanding these components is essential for addressing the industry's sustainability and water management challenges. In this discussion, we will delve into the concepts of blue and grey water footprints within the context of the textile industry and explore their implications for water resources and environmental sustainability.

Blue water refers to freshwater that is sourced from surface or groundwater and is consumed during various stages of textile production. It includes water used for irrigating cotton or other crops, dyeing fabrics, and washing textiles during manufacturing. In essence, blue water represents the direct consumption of freshwater resources by the textile industry.

On the other hand, grey water refers to the wastewater generated during textile production. It includes water polluted with dyes, chemicals, and other contaminants from processes such as dyeing, bleaching, and finishing. Grey water is often released back into water bodies or local waterways without undergoing adequate treatment, leading to pollution and potential harm to ecosystems. This improper disposal can have detrimental effects on aquatic life, biodiversity, and even human health if the contaminated water finds its way into drinking water sources. Therefore, addressing the grey water footprint of the textile industry is crucial for preserving water quality and the overall ecological balance.

The textile industry's excessive consumption of blue water and improper management of grey water pose significant challenges in terms of sustainability and water resource management. As the demand for textile products continues to rise, it is vital to examine the industry's water footprint and implement sustainable practices to mitigate its environmental consequences. By exploring the blue and grey water footprints of the textile sector, we can gain a comprehensive understanding of its water-related impact. This insight can further inform the development of strategies aimed at reducing water consumption, improving water efficiency, and implementing responsible wastewater treatment and disposal systems.

In the following sections, we will delve deeper into the specific processes within the textile industry that contribute to its blue and grey water footprints. Additionally, we will examine the potential solutions and innovations that can pave the way for a more sustainable and environmentally conscious textile industry.

Importance of Assessment of Blue and Grey Water Footprint in the Textile Industry

The assessment of the blue and grey water footprints of the textile industry holds paramount importance in today's world, considering the critical environmental and resource challenges we face. Understanding these footprints provides valuable insights into the industry's water consumption patterns and their implications on water resources and ecosystems. Here are some key reasons why examining the blue and grey water footprints is significant:

1. **Water Scarcity Concerns**: With growing global water scarcity, it is essential to identify sectors that heavily contribute to water consumption. The textile industry's water footprint analysis helps policymakers and stakeholders recognize its impact on local and regional water availability. By pinpointing areas with high water stress, sustainable water management strategies can be implemented to ensure water security for both the industry and surrounding communities.
2. **Pollution Management**: The textile industry's processes often involve the release of pollutants into water bodies. By differentiating between blue and grey water footprints, it becomes easier to identify the sources of pollution. This understanding is crucial for implementing appropriate treatment measures to mitigate environmental damage and protect aquatic ecosystems.
3. **Sustainable Production**: As consumer awareness of sustainable practices increases, the textile industry faces pressure to adopt environmentally responsible approaches. Analyzing the water footprint helps identify opportunities for reducing water usage, improving water recycling practices, and optimizing production processes to minimize environmental impact.
4. **Corporate Social** Responsibility (CSR): Companies in the textile sector are increasingly expected to demonstrate their commitment to environmental sustainability. Understanding their water footprints allows them to set meaningful CSR goals, measure progress, and communicate their efforts transparently to consumers and stakeholders.
5. **Global Supply Chain Impact:** The textile industry is often characterized by complex global supply chains, involving numerous stages from raw materials to finished products. Analyzing the water footprint throughout these stages helps identify water-intensive phases and geographical hotspots. This knowledge enables stakeholders to target specific areas for water efficiency improvements and sustainable sourcing practices.
6. **Regulatory Compliance:** Many regions are developing stricter regulations concerning water usage and environmental impact. Being aware of their water footprints enables textile companies to proactively comply with existing and upcoming legislation, reducing the risk of penalties and reputational damage.

In conclusion, understanding the blue and grey water footprints of the textile industry is critical for promoting sustainable practices, conserving water resources, and safeguarding the environment. By addressing these footprints, the industry can work towards a more sustainable and responsible future while meeting the demands of an environmentally conscious global society.

Objectives of Studying the Blue and Grey Water Footprint of the Textile Industry

1. **Quantify Water Usage**: One of the primary objectives is to accurately quantify the blue and grey water footprints of the textile industry. By measuring and assessing the amount of water consumed in different stages of production and supply chains, we can gain a

comprehensive understanding of the industry's overall water usage.

2. **Identify Hotspots**: Understanding the water footprints helps identify specific processes, products, or regions within the textile industry that have the most significant impact on water resources. Pinpointing these hotspots allows for targeted interventions and water management strategies to reduce water consumption and associated environmental impacts.
3. **Assess Environmental Impact:** Another objective is to evaluate the environmental impact of the textile industry's water usage. This includes analyzing the pollution and wastewater generated throughout the production processes, as well as the potential impacts on local ecosystems and water quality.
4. **Understand Water Availability:** The study of blue water footprint enables the assessment of the textile industry's reliance on freshwater resources. By understanding the availability of blue water in different regions, we can determine potential risks related to water scarcity and develop sustainable water sourcing practices.
5. **Differentiate Blue and Grey Water:** Distinguishing between blue and grey water footprints is crucial for comprehending the type of water being used and its origin. Blue water refers to freshwater from surface or groundwater sources, while grey water refers to water polluted by processes but still treatable for reuse. Understanding this differentiation helps in devising appropriate water management and treatment strategies.
6. **Support Sustainable Practices:** The objective is to promote sustainable practices within the textile industry by raising awareness of water usage and its environmental consequences. Armed with this knowledge, stakeholders can develop and implement sustainable water management practices, water recycling systems, and eco-friendly technologies.
7. **Guide Policy and Regulation:** The insights gained from studying the water footprints can inform policymakers and regulators about the environmental impact of the textile industry. This information can influence the development of water-related policies, regulations, and incentives that encourage water-efficient practices and responsible water use.
8. **Encourage Corporate Responsibility:** Assessing the water footprint encourages textile companies to take responsibility for their environmental impact. It allows businesses to set specific water reduction targets, adopt eco-friendly technologies, and incorporate sustainability into their corporate social responsibility initiatives.
9. **Enhance Supply Chain Management:** Analyzing the water footprint across the textile industry's supply chain can help identify inefficiencies and opportunities for improvement. This understanding can lead to better supply chain management practices, including sustainable sourcing, resource optimization, and waste reduction.
10. **Contribute to Global Sustainability Goals:** By addressing water consumption and pollution, the study of the textile industry's water footprint aligns with broader global sustainability goals, such as the United Nations Sustainable Development Goals (SDGs), particularly Goal 6 - Clean Water and Sanitation.

Advantages of Studying the Blue and Grey Water Footprint of the Textile Industry

1. **Informed Decision Making:** Understanding the blue and grey water footprints empowers stakeholders, including industry leaders, policymakers, and consumers, to make informed decisions. By having accurate data

on water consumption and pollution, they can implement effective water management strategies and support sustainable practices.

2. **Resource Conservation:** Analyzing the water footprints helps conserve valuable water resources. By identifying areas of high water usage and wastage, the textile industry can optimize its processes to reduce water consumption, leading to water conservation and improved water availability for other essential purposes.
3. **Environmental Protection:** Studying the blue and grey water footprint allows for a better understanding of the environmental impact of the textile industry. Armed with this knowledge, measures can be taken to minimize pollution, protect aquatic ecosystems, and mitigate the industry's contribution to water-related environmental issues.
4. **Sustainable Business Practices:** The data on water footprints facilitates the integration of sustainability into the textile industry's operations. By adopting water-efficient practices and responsible water sourcing, companies can enhance their reputation, meet consumer demands for eco-friendly products, and strengthen their long-term business viability.
5. **Risk Mitigation:** Knowledge of the water footprints helps the textile industry identify and address potential risks related to water scarcity and pollution. By proactively managing these risks, companies can avoid disruptions in their supply chains, legal liabilities, and reputational damage.
6. **Compliance with Regulations:** Understanding the water footprint ensures compliance with existing and future water-related regulations. By staying ahead of regulatory requirements, the textile industry can avoid penalties and maintain a positive image among consumers and investors.
7. **Cost Savings:** Implementing water-efficient practices driven by insights from water footprint analysis can lead to significant cost savings for the textile industry. Reducing water consumption and wastewater treatment costs directly impact the bottom line, making the business more economically sustainable.
8. **Improved Corporate Social Responsibility (CSR):** Demonstrating a commitment to responsible water usage through reduced blue and grey water footprints enhances a company's CSR profile. Consumers and investors increasingly value environmentally responsible companies, contributing to brand loyalty and attracting socially conscious investment.
9. **Sustainable Supply Chain Management:** The data on water footprints can be used to encourage sustainable practices across the textile industry's supply chain. Suppliers and manufacturers can work collaboratively to optimize water usage, leading to a more sustainable and resilient supply chain.
10. **Global Sustainability Impact:** By addressing water-related issues through water footprint analysis, the textile industry contributes to broader global sustainability goals, such as sustainable water management, climate action, and responsible consumption and production.

Disadvantages of Studying the Blue and Grey Water Footprint of the Textile Industry

1. **Data Complexity and Availability:** Collecting comprehensive data on water footprints can be challenging due to the complexity of supply chains, varying production processes, and limited transparency in the textile industry. Lack of standardized reporting and data availability may hinder accurate assessments.
2. **Cost and Resource Intensiveness:** Conducting detailed water footprint studies requires

significant resources, including financial investments, time, and expertise. Smaller textile companies with limited budgets may find it difficult to carry out comprehensive analyses, leading to uneven representation across the industry.

3. **Limited Scope of Analysis:** Focusing solely on blue and grey water footprints might overlook other environmental and social impacts of the textile industry. An exclusive emphasis on water usage may neglect issues like energy consumption, greenhouse gas emissions, or labor conditions.
4. **Difficulty in Attribution:** Assigning water consumption and pollution to specific stages or products within the textile supply chain can be intricate. The complexity of interactions between different processes may lead to challenges in accurately attributing water footprints to individual components.
5. **Incomplete Life Cycle Assessments:** Water footprint analysis often involves assessing specific stages of a product's life cycle, which might not provide a holistic view of its overall environmental impact. Neglecting other life cycle stages could lead to unintended consequences and inefficient resource allocation.
6. **Trade-offs and Rebound Effects:** Implementing water-efficient measures in one area of the textile industry may inadvertently shift water consumption to other stages or processes. This rebound effect could potentially offset the anticipated water savings.
7. **Reliance on Self-Reporting:** Data collection for water footprints heavily relies on self-reporting by companies, which could lead to underreporting or lack of transparency, particularly if there are no strict verification mechanisms in place.
8. **Regional Variability:** Water availability and quality vary across regions, which can impact the significance of water footprints. A global analysis might not capture the unique challenges faced by specific locations, leading to potential disparities in addressing regional water issues.
9. **Limited Adoption of Findings:** Even if comprehensive water footprint studies are conducted, there might be resistance or slow adoption of the recommended changes within the textile industry. Companies may be hesitant to invest in water-saving technologies or sustainable practices without clear economic incentives or regulatory pressure.
10. **Evolving Industry Dynamics:** The textile industry is constantly evolving, with new technologies, materials, and production processes emerging over time. As the industry changes, the relevance and applicability of past water footprint assessments may diminish, requiring continuous updates and reevaluations.

Future Perspectives of the Blue and Grey Water Footprint of the Textile Industry

1. **Advancements in Water Footprint Assessment:** As technology and methodologies for water footprint assessments continue to evolve, the textile industry can expect more accurate, efficient, and standardized approaches for measuring blue and grey water usage. Improved data collection, remote sensing, and advanced modeling techniques will enhance the reliability of future water footprint analyses.
2. **Integration with Life Cycle Assessments:** The textile industry will likely move towards integrating water footprint assessments with comprehensive life cycle assessments (LCAs). This holistic approach will provide a more comprehensive understanding of the industry's overall environmental impact,

including water usage, greenhouse gas emissions, energy consumption, and other resource inputs.

3. **Circular Economy and Water Recycling:** Future prospects will see the textile industry embracing circular economy principles and implementing water recycling and treatment systems. By adopting closed-loop processes, companies can minimize water waste, reduce freshwater consumption, and mitigate the environmental impact of their operations.
4. **Water Stewardship Initiatives:** Increasing awareness of water scarcity and environmental sustainability will drive the adoption of water stewardship initiatives within the textile industry. Companies will actively engage in collaborative efforts with local communities, NGOs, and governments to ensure responsible water management, especially in water-stressed regions.
5. **Eco-Friendly Materials and Technologies:** Future prospects will witness a growing demand for sustainable and water-efficient materials, production technologies, and dyeing processes within the textile industry. Innovations in eco-friendly fibers, low-water dyeing techniques, and water-saving equipment will become more prevalent.
6. **Transparency and Consumer Awareness:** With heightened consumer awareness and demands for sustainability, the textile industry will be under pressure to provide transparent information about their water footprints. Labels and certifications related to water usage will gain prominence, influencing consumer purchasing decisions.
7. **Policy and Regulatory Support:** Governments and international bodies will likely introduce more stringent regulations and incentives related to water usage and pollution. Compliance with these regulations will become a crucial factor for the textile industry's sustainability and market access.
8. **Collaboration and Industry Standards:** The textile industry will increasingly collaborate with stakeholders across the value chain to establish industry-wide standards and best practices for water footprint management. Collective efforts will drive industry-wide improvements and address common challenges.
9. **Water Risk Assessments:** Companies will conduct comprehensive water risk assessments to identify potential vulnerabilities in their supply chains due to water scarcity or pollution. These assessments will aid in developing resilience strategies and diversifying sourcing options.
10. **Corporate Water Goals:** Future prospects will witness more textile companies setting ambitious water-related goals, such as water neutrality or specific water reduction targets. These goals will align with broader sustainability commitments and showcase the industry's dedication to responsible water stewardship.

Conclusion

The blue and grey water footprint of the textile industry is a critical aspect that demands attention in our pursuit of environmental sustainability and responsible resource management. This comprehensive analysis provides valuable insights into the industry's water usage patterns, pollution levels, and their subsequent impacts on water resources and ecosystems.

Through the study of the blue water footprint, we gain a clear understanding of the textile industry's reliance on freshwater sources. This knowledge allows us to address water scarcity concerns, identify regions facing water stress, and implement effective water management strategies. By promoting water efficiency and responsible water sourcing practices, the industry can help conserve valuable freshwater resources for

future generations. Simultaneously, the examination of the grey water footprint highlights the industry's role in water pollution. Understanding the sources of pollution aids in devising appropriate treatment measures and technologies to minimize environmental harm and safeguard aquatic ecosystems. By adopting eco-friendly production processes and waste treatment systems, the textile industry can significantly reduce its ecological footprint. The significance of studying the blue and grey water footprints extends beyond environmental considerations. Embracing sustainable practices and responsible water usage enhances corporate social responsibility profiles and builds consumer trust. Moreover, the textile industry's compliance with water-related regulations and standards will become increasingly important as governments and consumers prioritize sustainability. As we look to the future, advancements in technology and methodologies will improve the accuracy and efficiency of water footprint assessments. Integration with life cycle assessments will offer a more holistic view of the industry's environmental impact, encouraging comprehensive sustainability efforts. Collaboration among stakeholders, the establishment of industry standards, and policy support will drive progress in responsible water management across the entire textile supply chain. Ultimately, by embracing eco-friendly materials, water recycling systems, and sustainable technologies, the textile industry can forge a path towards a more water-efficient and environmentally conscious future. Together, these efforts will contribute to global sustainability goals and ensure the preservation of our precious water resources for generations to come.

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Terrarium: Living Ecosystem in A Jar

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A terrarium is a glass container that is used to grow small plants that can be opened for maintenance. Terrarium can be called as miniature greenhouse with self sustaining ecosystem. Nathaniel Bagshaw Ward is the man behind the discovery of terrarium. A closed terrarium creates an environment that mimics the natural ecosystem. The transparent glass lets in the light essential for the photosynthesis of plants, and the sealed lid keeps the humidity emitted by the plants in the jar so that there is nearly no need to add water. As long as these plants in glass receives a good initial dose of all the necessary elements to thrive (water, light, nutrients), they can live in this same ecosystem for a long time. Minimum maintenance is required for maintaining a terrarium.

Types of terrariums

1. **Closed terrarium (wet terrarium):** closed terrarium is a glass jar with a lid of glass, cork, plastic or metal lid. The lid helps in maintaining the moisture and can be opened occasionally to remove excess moisture. A transparent or translucent lid is best for use as it allows light to reach the top of the plant. Plants from humid habit can be grown in closed terrarium. Eg. Ficus and ferns.
2. **Open terrarium (dry terrarium):** open terrarium is an open glass jar which do not maintain humidity. In this terrarium plants have access to fresh air and direct sunlight. Plants from arid climate are suitable for growing in open terrarium. E.g. cacti and succulents.

Elements of terrarium

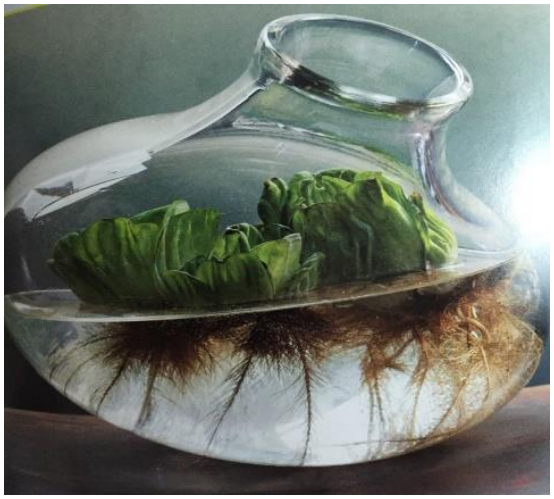
1. **Container:** choosing right type of container is essential for terrarium. Any transparent glass container (to allow full spectrum of light to reach plant) with wide opening can be used for making terrarium.
2. **Small gravels and stones**: laying a bed of coarse gravels and stones will help in drainage of water from soil. Drainage helps in removing excess water from soil so that plant roots can easily breath.
3. **Soil or soilless media**: soil used in the terrarium is small in quantity so it must fulfill the requirement of the plants. Use right type of soil or nutrient rich soilless media as adding fertilizer is not effective in terrarium.

4. **Sand:** sand is used to bury a succulent in a arid landscape.

Table 1: Plants suitable for terrarium

1	**Fern**	*Nephrolepis exaltata, Adiantum raddianum, Nephrolepis cordifolia, Davallia fejeensis, Phlebodium aureum , Adiantum microphyllum*
2	**Peperomia**	*Peperomia rotundifolia, Peperomia tetraphylla, Peperomia caperata, Peperomia prostrate*
3	**Air plants**	*Tillandsia ionatha, Tillandsia bulbosa, Tillandsia stricta*
4	**Foliage**	*Araucaria heterophylla, Syngonium podophyllum, Fittonia albivenis, Tradescantia zebrina, Pilea glauca, Begonia maculata, Calathea orbifolia, Calathea orbifolia, Philodendron hederaceum*
5	**Moss**	*Thuidium delicatulum, Hypnum cupressiforme, Tortula ruralis, Selaginella kraussiana, Leucobryum glaucum*
6	**Bromeliads**	*Neoregilia, Cryptanthus bivittatus*
7	**Orchids**	*Paphiopedilum, Miniature Phalaenopsis, Masdevallia , Pleurothallids, Jewel orchids and Miniature Angraecum*
8	**Succulents**	*Kalanchoe thyrsiflora, Lithops, Aloe hemmingii, Crassula, Sedum, Aeonium*

5. **Plants**: Not all plants will survive in a terrarium. First consider the requirement of the plants and then assemble them in a terrarium.
   - Choose plants that will not compete with each other at root level and at branches level.
   - Choose plants that have the same basic requirements. Eg. We cannot grow moss and cactus together as moss require ample quantity of water and cactus require very less quantity of water. Whereas tree like aralia which grows well in acidic soil can be grown with moss as both having the same requirement in terms of soil type and moisture requirements.
   - Choose plant with vertical growth if the container is slim and plant with a little spreading habit if container is wide.



Water garden terrarium: In this terrarium the container is filled with plants that have their roots visible in the water. Distilled water or rainwater would support the plant's survival, or we can add activated charcoal to keep water fresh.

Plants suitable for floating terrarium

- *Pistia stratiotes* (Water lettuce)
- *Cyperus papyrus* (Dwarf papyrus)
- *Cyperus alternifolius* (Dwarf umbrella palm)
- *Caltha palustris* (Marsh marigold)
- *Eichhornia crassipes* (Water hyacinth)
- *Equisetum hyemale* (Horsetail rush)
- *Sagittaria australis* (Arrowhead)

Maintenance of terrarium

1. **Watering:** check the soil moisture timely and water when soil is dry. As closed terrarium live in self-sufficiency, they require very little water. While open terrarium requires watering weekly in summers and once in two- or three-weeks during winter. Apply soft water (free from calcium carbonate) or rain water with the help of plant mister.

2. **Trimming and pruning:** when foliage grows against the wall of the container either trim leaves or prune branches.
3. **Remove** the rotted leaves and rake the soil to aerate by using fork
4. **Temperature:** terrarium is suitable for indoor environment. Maintain optimum temperature for optimum plant growth. If the temperature rises then open it and add moisture to drop down the temperature as high temperature can cause leaf drop.
5. **Check insects:** timely observe the harmful insects and control them by using biological and chemical insecticide.

Conclusion

Terrarium can be beneficial for urban area where space is limited. They provide a way to enjoy gardening without a garden. They require less maintenance and are easy to take care for, making them suitable for a busy modern lifestyle.

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Popularization of Onion Cultivation in Meghalaya Through Adoption of Good Agricultural Practice-A Success Story

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Onion is an important commercial crop which can improve livelihood of farmers. But in Meghalaya the cultivation of this crop is limited to the kitchen garden mostly to meet the domestic household needs. The tribal farmers of this region grow onion crop following the traditional method of production leading to low- and poor-quality yield. As onion is photosensitive crop the knowledge of choosing the right variety for cultivation is one of the key factor for successful cultivation, which the farmers of this region are unaware. So, with the objective to popularize onion cultivation amongst the farmers through scientific intervention ICAR RC for NEH Region, Umaim Meghalaya in collaboration with DOGR, Rajgurunagar, Pune initiated TSP (NEH component) on popularization of onion cultivation. Under the scheme, a group of 5 farmers (list attached) were selected from Sarikushi, Marngar, Ri-Bhoi district of Meghalaya. These selected farmers were distributed with onion seeds (variety Bhima Super), biofertilizers, irrigation can etc. to conduct demonstration trial at field.

Initiative

Various training programmes and demonstrations on good agricultural practices starting from right choice of the cultivars, nursery raising, interculture operations etc. were conducted under the scheme. These selected farmers along with other beneficiaries were provided training on scientific aspects of onion cultivation (selection of right variety, nursery raising, interculture operations, harvesting and post-harvest handling etc.) through a training cum awareness programme on 'Good Agricultural Practice of onion'. The selected farmers raised the seedlings during November, 2018 in raised nursery bed of 10-15 cm height, 1 m width and 4 m length. The seeds were treated with *Trichoderma viride* @ 4 g/kg before sowing. Seedlings of 40-45 days old were

Fig.1. (a) Nursery bed preparation (b) Healthy seedlings

Fig.2. (a) Main field preparation (b) General view of crop (c) Var. Bhima Super

transplanted at a spacing of 15 ×10 cm (15 cm between the rows and 10 cm between plants). After uprooting of seedlings, 1/3rd part of leaves were advised to cut and the roots were washed with clean water. Irrigation at the time of transplanting and three days after transplanting were done for good establishment. For the main bed preparation, the farmers were advice to apply FYM @ 6 t per ha at the time of last ploughing. Biofertilizers @ 5 kg/ha each Azospirillum and phosphorus solubilizing bacteria were also recommended. Time to time hand weeding and other interculture operations were also advice to the farmers. The crops were harvested when it attains 50% neck fall.

Result

Through this intervention the beneficiaries observed 100 per cent seed germination and were able to maintain good plant population in the nursery. The farmers used to raise the seedlings through traditional method where the seeds are sown in a mixture of wet mud and cow dung over a thatch like structure resulting to low germination and high mortality. The beneficiaries expressed that the seedlings raised through the scientific intervention was very vigorous and field survival per cent after transplanting was appreciable. The farmers recorded an average yield of 330 Q/ha; average bulb weight of 60g; bulb length

Fig.3: Input distribution

Fig.4: Training cum awareness programme

212.05mm; bulb diameter 212.14mm; no of leaves 7.6 and plant height 52.33 cm. With reference to the result of the field demonstration trial a training manual on 'Production Technology of Onion and Garlic' was published by Director, ICAR Research Complex for NEH Region in collaboration with ICAR-Directorate of Onion and Garlic Research, Rajgurunagar, Pune.

The selected group of farmers has earned a net income of Rs. 40,000-50,000 per acre by production of about 100 q bulbs of onion (Bhima Shakti) during *rabi* season. The farmer group expressed happiness that through the selection of right variety and improved method of cultivation they were able to make a good profit with double the income. They also expressed that this variety (Bhima Shakti) withstand heavy downpour and extended monsoon period that is prevailing in the state of Meghalaya very well as compared to the local variety they were cultivating.

Conclusion

Through this study we can conclude that onion cultivation can promise high net return provided the farmers are getting quality seeds of right variety and with proper scientific way of cultivation. There is potential scope for increasing the area under onion cultivation in the State. The major challenges are marketing knowledge and storage problems faced by the onion growers of the state. During the study it is depicted that considerable percentage of the onion growers in the State belongs to marginal group and have less marketing knowledge and storage infrastructure. Fluctuation in market price, high cost of transportation and absence of storage facilities are the major challenges. Establishment of proper storage infrastructure and providing knowledge on post-harvest handling and marketing are the key suggestions to overcome these challenges.

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Proteomic and Metabolomic Insights into Plant Stress Responses

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Agriculture plays a pivotal role in the economic foundations of several nations. In addition to its function in providing nutrition, nourishment, and critical resources, agriculture also plays a crucial role as a major source of employment for a large portion of the world's population. Based on data provided by the Food and Agriculture Organisation of the United Nations (FAO), it is apparent that a majority exceeding 60 percent of the global population relies on agriculture as a primary source of sustenance. In the majority of poor nations, agriculture plays a pivotal role in driving national revenue, although its significance is somewhat less pronounced in affluent nations.

According to projections, the global population is anticipated to see a 30% increase, ultimately reaching a total of 9.7 billion individuals by the year 2050. In order to achieve global food security, the Food and Agriculture Organisation of the United Nations (FAO) has projected that there is a need for a 70% increase in global food production.

India is primarily identified as an agrarian country, wherein a substantial majority of its rural households, over 70%, largely depend on agriculture and its related industries as their main source of livelihood. In the Indian context, it is evident that a considerable percentage of cultivable land, namely 47.3%, is allocated to a majority of small-scale farmers, who constitute around 87.2% of the overall farming population. With over 126 million farmers and an average landholding size of 0.6 hectares, smallholder farmers control more than 74.4 million hectares of land in total.

Biotic and Abiotic stress

As the population grows, there is a corresponding increase in the need for food. The present and anticipated worldwide need for food necessitates a significant expansion in crop production in regions with less favourable agricultural conditions. Biotic and abiotic stresses are substantial limitations that hinder the growth, development, and productivity of plants. Food security is presently a significant problem and source of apprehension for agronomists and plant physiologists on a worldwide scale. Biotic stress in plants is caused by living creatures, including viruses, bacteria, fungi, nematodes, insects, arachnids, and weeds. Abiotic stressors, such as drought, salt, heat, radiation, severe weather conditions, floods, and heavy metals, are significant agricultural limitations that impact plant growth, development, and productivity. Biotic stressors continue to pose the most significant limitation on crop productivity. The investigation of abiotic stress is undertaken because of its prominent role in causing worldwide crop loss, resulting in a reduction in average yields for the majority of agricultural plants by over 50%. Additionally, it hinders plants from attaining their full genetic capacity.

Stress Management Strategies of Plants

Plants, being immobile creatures, have evolved effective response techniques to mitigate, endure, or adapt to many forms of stress throughout their evolutionary history. Plants encounter a wide range of stress stimuli, which frequently trigger common cell signalling pathways and cellular responses. These responses include the synthesis of stress proteins, the enhancement of antioxidant mechanisms, and the build-up of suitable solutes. Stress can be conceptualised as an external stimulus or influence that falls outside the typical boundaries of homeostatic regulation within a specific organism. When the capacity to tolerate stress is surpassed, various mechanisms are triggered at the molecular, biochemical, physiological, and morphological levels. Once the stress is effectively managed, a new physiological state is established, leading to the restoration of homeostasis. When the stress is alleviated, the plant has the potential to revert back to

its original state or adapt to a new physiological condition.

The advent of modern technology has given rise to a range of multidimensional omics disciplines, including proteomics, metabolomics, and others. These disciplines focus on the molecular constituents of cellular life. The progress made in genomic research has facilitated the identification of many gene families and processes that influence the ability to withstand abiotic stresses, ultimately leading to increased crop productivity. The field of systems biology, a very nascent area within the life sciences, is addressing the challenge of integrating many omics approaches to yield substantial biological insights. The integration of systems biology with virtual experiments offers a means to visually represent and understand the mechanisms by which plants adapt to abiotic stress. Furthermore, the development of climate-resilient cultivars for consistent and productive yields in challenging climatic conditions requires the incorporation of diverse areas of expertise from several disciplines.

Proteomics and Metabolomics approaches

Proteomics and metabolomics technologies are employed to investigate alterations in proteins and metabolites in response to stressful conditions. Over the course of the past decade, much study has been conducted to get a comprehensive understanding of the underlying mechanisms by which plants respond to various forms of environmental stress. The current body of research on abiotic challenges is limited due to insufficient investigation into the regulatory mechanisms that activate various genes and pathways in response to abiotic stimuli. The complexity of plant stress response and adaptation processes is evident based on the participation of these genes.

Proteomics

As previously stated, the word "proteome" encompasses the whole set of proteins that are expressed by the genome, including post-translational modifications. The characteristic being discussed exhibits neither constancy nor homogeneity. The primary emphasis of proteomic investigations frequently involves protein identification, quantification, localization, and post-translational modifications (PTMs), as well as the examination of functional, structural, and protein-protein interactions. Proteomics not only provides insights into the complexity of biological systems, but it also has significance in understanding cellular viability and their adaptive responses to diverse environmental conditions. Although the investigation of post-translational modifications (PTMs) has predominantly focused on transcript-level analysis, it is worth noting that assessing protein abundance, which is intricately linked to enzymatic activity, might potentially provide a more dependable signal of protein function.

The measurement of plant stress tolerance was often conducted by assessing the whole proteome. However, later research has expanded the scope of proteome-related investigations to include other aspects such as the organellar proteome, phosphorproteome, nuclear proteome, cell wall proteome, and proteo-genome. Therefore, proteome profiling is conducted using different methodologies, including mass spectrometry (MS), which involves the analysis of protein fragments to determine their charge and mass and identify any modifications in the peptide sequence. Other techniques, such as matrix-assisted laser desorption/ionisation time-of-flight (MALDI-TOF) and two-dimensional gel electrophoresis (2-DGE), are also utilised. Recent advancements in proteomics will contribute to the discovery of more regulatory target proteins, facilitating the development of stress-tolerant crops that exhibit enhanced yield and quality.

Proteomics Applications in Plant Stress Responses

Yousuf et al., 2016 analyzed salt stress-induced modulations in the shoot proteome of salt-sensitive (*Pusa Varuna*) and salt-tolerant (CS-52) genotypes of Indian mustard and total of 320 spots were identified, out of which, only 21 proteins showed more than two-fold change in abundance. Out of these 21, 13 were found to be with increased intensity while 8 were downregulated.

Jia et al., 2015 conducted comparative proteomic analysis of seedling leaves of *Brassica napus* exposed to 200 mM NaCl for 24 h, 48 h and 72 h and found 42 proteins, involving few novel salts stress responsive proteins like Cinnamyl alcohol dehydrogenase (CAD) and N-glyceraldehyde-2-phosphotransferase were showing differential expression.

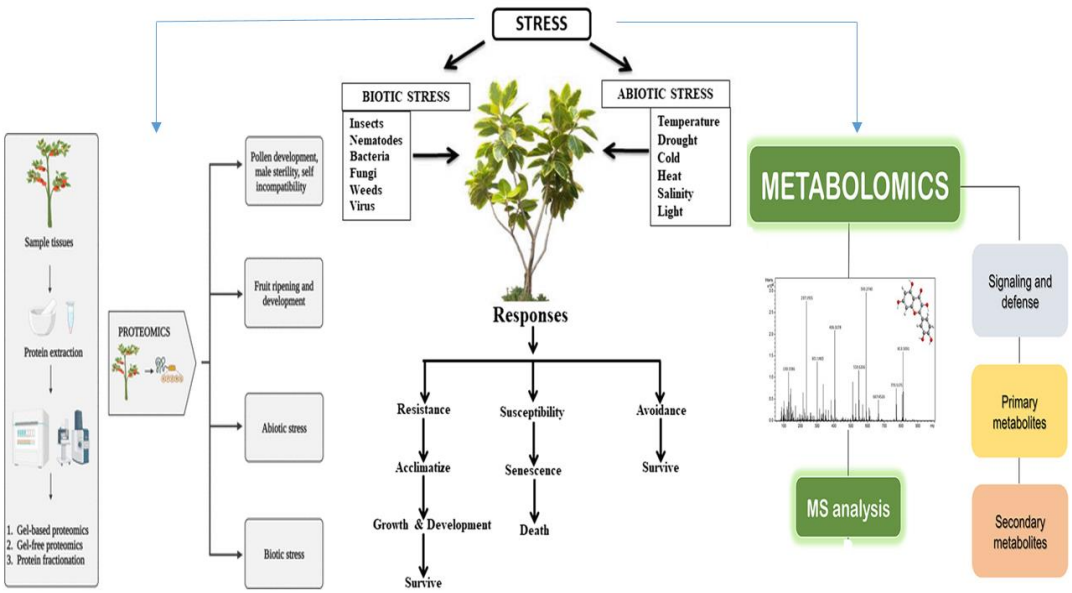
Metabolomics

Metabolomics facilitates the evaluation of biological processes within intricate environmental conditions. The estimated number of metabolites in the plant kingdom, encompassing a wide range of polar to nonpolar, volatile to non-volatile compounds, surpasses 200,000. In order to comprehensively examine the chemical characteristics of a metabolite, it is essential to combine many analytical techniques, given the vast range of its variability.

The utilisation of separation-based techniques, such as liquid/gas chromatography (LC/GC) in combination with mass spectrometry (MS), nuclear magnetic resonance (NMR), and Fourier transform ion resonance (FTIR), has significantly contributed to the analysis and measurement of metabolites in both untargeted and targeted approaches. Targeted metabolomics involves the deliberate selection of a limited number of chemicals, accompanied by reference standards, to ensure accurate analysis and clear identification of metabolites. On the other hand, untargeted metabolomics seeks to characterise a wide array of metabolites that possess distinctive characteristics.

Metabolomics Applications in Plant Stress Responses

The term "plant stress" refers to any modification in growth conditions that disrupts the metabolic balance and requires the adjustment of metabolic pathways through acclimation. Metabolites exhibit spatial distribution within many tissues, organs, and cellular compartments. Plants are subject to several environmental conditions, including both abiotic and biotic stressors, which in turn lead to changes in their metabolite composition. These factors impede the general growth and development of plants and reduce productivity, posing a threat to food security, particularly in light of the challenges posed by the global population expansion. Metabolomics has the potential to provide valuable insights into plant metabolism throughout the developmental process and in response to diverse stressors. This is achieved by identifying a range of substances, including stress metabolism derivatives, stress signal transduction molecules, and molecules associated with the acclimation response of plants. Furthermore, metabolomics can contribute to a more comprehensive understanding of stress biology in plants by facilitating a guided explanation of these processes.



Primary metabolites play a crucial role in the growth and development of plants and exhibit a high

degree of conservation in their molecular structures and abundances across various plant species. In contrast, secondary metabolites and their regulation are more susceptible to environmental fluctuations, such as variations in light intensity, temperature, water availability, salinity levels, exposure to ultraviolet radiation, nutrient deficiencies, the presence of heavy metals, oxidative stress, and interactions with neighbouring plant species.

In a ground-breaking study, *Rodrigues Neto et al. 2023* did a multi-omic integration analysis on Purslane plants (*Portulaca oleracea* L.) that had been exposed to salt stress mitigation. This analysis is of utmost importance owing to the global adaptability of Purslane, which is attributed to its therapeutic benefits.

The study conducted by *Wu et al. 2022* aimed to investigate the effects of shade on blueberries as a means to mitigate the adverse effects of excessive heat stress that occur during the peak production period. The application of moderate shade at a level of 50% was seen to have a positive impact on plant development as well as the enrichment of photosynthetic pathways and the promotion of flavonoid production. This finding suggests that employing this technique might be an efficient method for enhancing blueberry farming under high-temperature conditions.

Conclusion

Various abiotic stressors have been observed to significantly impact the development and production of crops. Various omics-based methodologies, including proteomics, metabolomics, and others, have proven effective in investigating the plant's reactions to stress, either in isolation or in conjunction with one another. Upon the onset of stressful conditions, plants undergo physiological adaptations through modulating metabolic pathways and genetic regulatory mechanisms, eventually resulting in the activation of novel genetic expressions. Therefore, it is important to clarify the genetic composition and its corresponding role in order to unveil the plant's reaction in the face of stress. The feasibility of this outcome is contingent upon advancements in biotechnology and the use of omics tools and procedures.

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Successful Cultivation of Sesame Crop in North India

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Sesame is one of the oldest oil seed crop which grown widely in tropical and subtropical area for its edible oil, proteins, vitamins, and amino acids. The seeds have high oil content around 55% and its oil is used in cooking, preparation of salads and in production of margarine, soaps, pharmaceuticals, paints and lubricants. The residue left after the extraction of oil is used as cattle feed. Sesame production is constrained by various biotic and abiotic stresses, which leads to less productivity in terms of seed yield and oil quality. In this article, valuable tips are shared with respectable famers to increase productivity of sesame crop.

Punjab Til No. 2: This variety has dense, long, non-hairy pods and those are arranged opposite to each other. Its seeds are white, bold, have 49% oil, less crude fibre, soft and better in palatability. It is tolerant to phyllody and cercospora leaf blights with an average yield 2.80 q/ac.

RT 346: The pods are long, non-hairy, arranged alternately. The seeds are white, bold, contain 49% oil. It is moderately resistant to capsule borer with average yields 2.60 q/ac.

Agronomic practices

It requires a well-prepared seedbed with adequate moisture content for good germination and the crop should be sown in the first fortnight of July. The early sown (June) suffers from higher phyllody disease incidence. One-kilogram seed per acre with 30 × 15 cm spacing (4 to 5 cm deep) required for sowing with a pora or tube attached to the desi plough. Apply only 21 kg N (45 kg urea) per acre at the time of sowing. The crop should be harvested immediately when plants turn pale and capsules have just opened to avoid seed shattering. After harvesting, tie the plants into small bundles and stack in upward direction.

Plant-protection measure

Leaf webber and capsule borer: The young larvae roll together a few top leaves with help of silken threads and continue to feed in the webbed mass. The size of this rolled mass increases gradually as the caterpillar grows older. The full-grown larva is greenish in colour with black head. In the early stage of infestation, the plant dies without producing any branch or shoot. The maximum infestation occurs in September–October and infested shoots stop growing. At flowering, larvae feed inside the flowers and on

capsule formation, larvae bore into capsule and feed on developing seeds. To avoid losses from this pest the crop should be sown in the first fortnight of July.

Leaf Webber's incidence

Jassid: Both nymphs and adults suck the sap from leaves and also act as vector for transmission of mycoplasma like organism (MLO), which induces the malformation and inflorescence. Leaves become red or brown and curled up. Avoid early (June) sowing of crop.

Diseases

Phyllody: It is viral disease, caused by a MLO and transmitted by jassids. All floral parts are transformed into green leafy structures followed by abundant vein clearing in different flower parts. In severe infection, short twisted leaves closely arranged on a stem with short internodes replace the entire

inflorescence, abundant abnormal branches bend down. Finally, plants look like witches broom. Therefore, rogue-out the virus-infested plants regularly and need to control the jassid for further spread of disease.

Blight: It occurs at all stages of crop plant. At flowering stage, it appears as dark brown, angular lesions with grey centre on leaves. The diseased plants give blighted appearance followed by defoliation and can be easily pulled out. For preventive measure avoid excessive use of nitrogenous fertilizers and field should keep free from weeds and debris.

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Applications of Biosensors in Food Industries: A Comprehensive Overview

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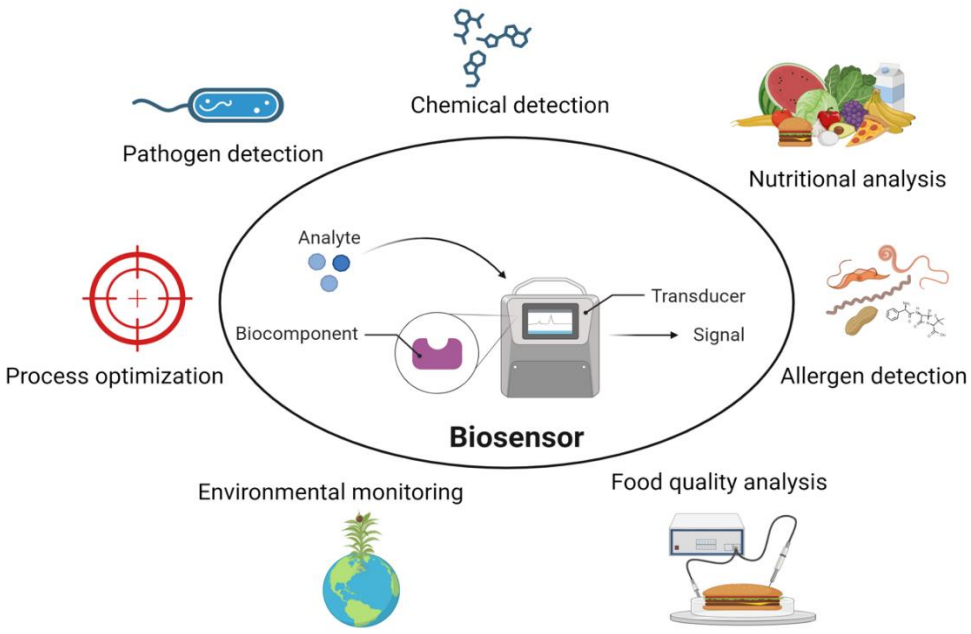
In an era characterized by the relentless pursuit of efficiency, safety, and quality, the integration of cutting-edge technology into various industries has become a cornerstone of progress. The food industry, a vital component of global economies and human sustenance, has not been exempt from this trend. In recent decades, the food industry has witnessed a profound transformation, driven by the growing demand for safe, high-quality, and sustainable food products. One of the key factors contributing to this evolution is the integration of biosensors, cutting-edge devices that leverage biological components to detect and quantify specific substances. Biosensors have emerged as powerful tools for the rapid and sensitive detection of various analytes in food products, allowing for real-time monitoring, early detection of contaminants, and enhanced product quality (Kissinger, 2005).



Source: Infographic created by Poonam Rani using BioRender.com

Fig 1: Application of biosensors in food industries

These miniature devices, capable of detecting and quantifying specific biological or chemical substances, have found an extensive range of applications in the food sector. The applications of biosensors in the food industry have revolutionized various processes, from quality control and safety assessment to production optimization and environmental monitoring.

This article aims to provide a comprehensive overview of the diverse applications of biosensors in the food industry, highlighting their contributions to food safety, quality assessment, and production efficiency.

Biosensor Principles and Types

Biosensors are analytical tools that combine a biological recognition element (e.g., enzymes, antibodies, DNA) with a transducer to convert the biological response into a measurable signal (Mehrotra,, 2016). This integration enables biosensors to offer remarkable specificity, sensitivity, and real-time capabilities. The recognition element, often an enzyme, antibody, or nucleic acid, selectively interacts with the target analyte. The transducer then converts this interaction into a quantifiable signal, such as electrical, optical, or acoustic. Biosensors consist of three main components: the bioreceptor, the transducer, and the signal processor (Mohanty & Kougianos, 2006). Based on the components and functionality, different types of biosensors have been developed to suit different applications in quality

control and monitoring. Several types of biosensors have found utility in the food industry, as discussed below.

Enzyme-Based Biosensors

Enzymes are widely employed as bioreceptors due to their selective catalytic activity. They are used to detect various food components such as glucose, lactose, and amino acids. Most classical electrochemical enzyme biosensors are based on oxidoreductase enzymes coupled with amperometric detection. The most widely used enzyme biosensors are those designed for glucose, lactate, glutamate, urea, and cholesterol (Monteiro & Almeida, 2019).

Immunosensors

Immune reactions are harnessed to detect specific antigens or antibodies. These biosensors are essential for allergen detection, pathogen monitoring, and food authenticity verification.

DNA-Based Biosensors

DNA hybridization is utilized to detect genetic modifications, pathogens, and species identification, ensuring traceability and transparency in the supply chain.

Optical Biosensors

These biosensors exploit changes in light properties to quantify target analytes. Surface Plasmon Resonance (SPR) and Fluorescence Resonance Energy Transfer (FRET) are commonly employed optical techniques.

Electrochemical Biosensors

These biosensors measure electrical changes resulting from a biochemical reaction, making them suitable for monitoring foodborne pathogens and toxins.

Applications of Biosensors in Food Industry

Biosensors play a pivotal role in the food industry, ensuring safety, quality, and efficiency. These innovative devices harness biological recognition elements to detect specific analytes, such as pathogens, allergens, and contaminants, in food products. Rapid and sensitive, biosensors provide real-time monitoring, aiding in early detection and prevention of foodborne illnesses. They enable precise monitoring of freshness, shelf-life, and nutrient levels, contributing to enhanced food preservation and reduced wastage. Additionally, biosensors facilitate on-site testing, simplifying quality control procedures throughout the supply chain. In the food industry, biosensors are indispensable tools, safeguarding consumer health and elevating the standards of food production.

Food Safety and Pathogen Detection:

One of the primary concerns in the food industry is the presence of pathogens and contaminants that pose health risks to consumers. Biosensors play a crucial role in the rapid detection of pathogens like E. coli, Salmonella, and Listeria, allowing for early intervention and preventing outbreaks of foodborne illnesses. These biosensors offer advantages in terms of sensitivity, specificity, and speed compared to traditional methods.

Allergen Detection

With the increasing awareness of food allergies, accurate allergen detection is paramount. Biosensors equipped with allergen-specific antibodies enable the identification of allergenic components in food products, thus preventing accidental exposure and ensuring consumer safety.

Quality Assessment and Shelf-Life Prediction

Biosensors assist in assessing the freshness and quality of perishable food products by detecting changes in relevant parameters such as pH, microbial load, and volatile organic compounds. This real-time monitoring helps in optimizing storage conditions and predicting shelf life of food material which eventually contribute in reducing the food wastage.

Detection of Chemical Contaminants

Biosensors are capable of detecting various chemical contaminants, including pesticides, mycotoxins, and heavy metals, in food samples. These contaminants can compromise both food safety and consumer health. Biosensors offer rapid and accurate

identification, aiding regulatory compliance and ensuring safe consumption.

Nutritional Analysis

Biosensors contribute to nutritional analysis by quantifying nutrients such as vitamins, amino acids, and carbohydrates in food products. This information is crucial for labelling accuracy and meeting dietary requirements.

Monitoring Food Production Processes

Biosensors are integrated into food production processes to monitor parameters like fermentation progress, enzymatic reactions, and pH changes. These real-time insights enable process optimization, leading to consistent product quality and reduced production costs.

Detection of Food Adulteration

The authenticity and purity of food products are essential for consumer trust. Biosensors can detect adulterants and substitutes, ensuring that food products meet quality standards and are free from fraudulent practices.

Quality Control and Safety Assurance

Biosensors have significantly advanced quality control and safety assurance in the food industry. Rapid and reliable detection of contaminants, pathogens, and allergens is paramount to prevent foodborne illnesses and ensure consumer confidence. Biosensors enable real-time monitoring of critical parameters, enhancing the efficiency of quality control processes. For instance, Salmonella and E. coli detection kits based on immunosensors have been integrated into processing plants to ensure the safety of meat and poultry products.

Food Authenticity and Traceability

The issue of food authenticity, encompassing labelling accuracy and origin verification, has gained substantial attention. Biosensors play a crucial role in verifying the authenticity of food products through DNA-based methods. DNA biosensors can identify species-specific sequences, aiding in the detection of fraudulent labelling practices or adulteration. This capability is particularly important in ensuring the legitimacy of high-value products such as premium wines, olive oils, and spices.

Process Optimization and Shelf-Life Extension

The shelf life of food products is a critical aspect of the food industry. Biosensors contribute to process optimization by continuously monitoring parameters such as pH, temperature, and microbial load. This real-time monitoring facilitates timely interventions, reducing spoilage and enhancing product quality. Biosensors can also assess the freshness of food items by detecting volatile compounds produced during spoilage.

Environmental Monitoring

Biosensors have extended their influence beyond the production line to environmental monitoring. Effluents from food processing plants can have detrimental effects on surrounding ecosystems. Enzyme-based biosensors can detect organic pollutants, while whole-cell biosensors monitor toxicity levels in wastewater. This dual functionality aids in complying with environmental regulations and promoting sustainable practices.

Emerging Trends and Future Prospects

Biosensors offer immense potential and play important roles in the food industry but there are remained several challenges which need proper address in future. These challenges include the need for standardization, addressing matrix effects in complex food samples, variation in stability and reproducibility of biosensor components, etc. As technology continues to evolve, so do the applications of biosensors in the food industry. The integration of biosensors with nanotechnology, microfluidics, and smartphone apps has the potential to further revolutionize food safety and quality control. Additionally, the development of portable biosensing devices enables rapid on-site testing, reducing reliance on centralized laboratories. Future prospects involve the integration of nanotechnology, miniaturization, and artificial intelligence to enhance biosensor performance, reduce costs, and enable on-site testing.

Conclusion

The applications of biosensors in the food industry have ushered in a new era of enhanced quality, safety, and sustainability. From ensuring food safety and authenticity to optimizing processes and environmental monitoring, biosensors are a cornerstone of modern food industries. Their rapid and sensitive detection capabilities, coupled with real-time monitoring, have led to significant improvements in food safety, reduced wastage, and enhanced consumer satisfaction. With technical advancement, biosensors are poised to play an increasingly vital role in shaping the future of the food industry. By addressing challenges and embracing innovative solutions, biosensors have the potential to set new standards for food safety and quality assurance.

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An IoT Based Smart Irrigation System for Precision Farming

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Internet of Things (IoT) is an emerging technology in the world. There are numerous advantages gained using IoT in various sectors. Agriculture is an important industry as well as the foundation of the economy. Agriculture automation is a major concern and emerging topic for all countries. The world's population is rapidly increasing, and as the population grows, the demand for food increases. The developing need for food, as well as changing consumer demands, have made it extremely difficult for the agriculture industry to develop techniques and practices that will allow them to fully satisfy the increasing needs and requirements.

Smart irrigation is emerging as new scientific disciplines that use data-intensive methods to increase agricultural productivity while reducing its environmental impact. Modern agricultural operations generate data from a variety of sensors, leading to a better understanding of both the operation environment and the operation activities. The water is conserved when implementing these technologies in irrigation systems such that it plays as an important contributor to Sustainable Development Goals.

The SMART irrigation system enhances the performance and is an emerging technique that automates irrigation systems and conserves water usage. This technique adjusts irrigation based on actual soil and weather conditions; therefore, it allows farmers to meet their demand with a new adopted technique which conserves the water for irrigation process. IoT can be thought of as an extension of the current internet to all devices that can communicate with electronic equipment and are linked to the internet, making devices user friendly and easy to handle. Correspondingly, IoT is linked to automation of all areas of agriculture and farming processes in order to make the entire process more productive and efficient.

Advantages of IoT based automatic irrigation systems

i. **Efficient water usage** – Automatic irrigation systems use sensors and technology to accurately measure and distribute water, reducing water waste and ensuring plants receive the right amount of water they need.

ii. **Convenience and time-saving** – Automatic irrigation systems can be scheduled to run at specific times, saving farmers the time and effort of manually watering their crops.

iii. **Customizable irrigation** – Automatic irrigation systems can be customized to suit different crops, soil types, and weather conditions, providing the flexibility needed for optimal growth.

iv. **Monitoring and control** – Automatic irrigation systems allow farmers to remotely monitor and control their irrigation systems, making it easy to make adjustments as needed.

v. **Cost-effective** – In the long run, automatic irrigation systems can be more cost-effective as it reduces water wastage and labour costs, thus increasing the yield and profitability of the farm.

vi. **Soil and weather monitoring -** Monitoring in the particular context of precision irrigation inculcates collecting data, which adequately leads to reflect the real-time status of the plant, soil, and weather of irrigation areas through the use of the Internet of Things (IoT) and Wireless Sensor Networks (WSN). In order to establish a real-time system of monitoring, IoT has led to establish a low-cost technology

method that leads to improve the control and monitoring system for the irrigation process.

IoT and smart systems used in irrigation

1. Communication technologies

The main technologies that are used in IoT for irrigation could be classified into two categories. One could be regarded as the devices that function as nodes and lead to forward or transmit small data amount at short distances along with having low consumption of energy. Consequently, the other devices are the ones that have the ability to transmit huge amounts of data over long distances, having high-energy consumption. There are various wireless standards that could be used in the communication of IoT devices and they could generally be classified between devices that communicate at long or short distances.

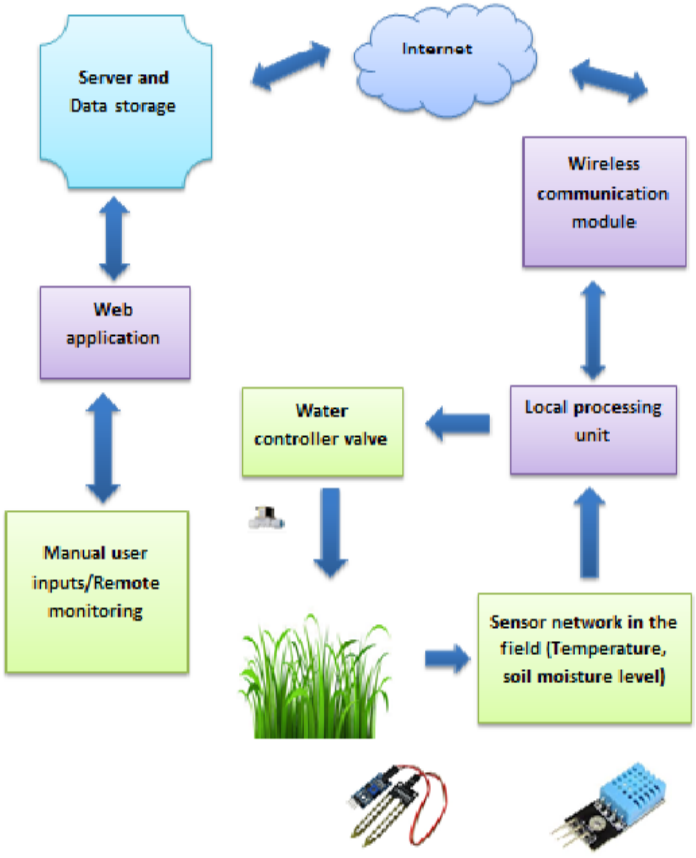
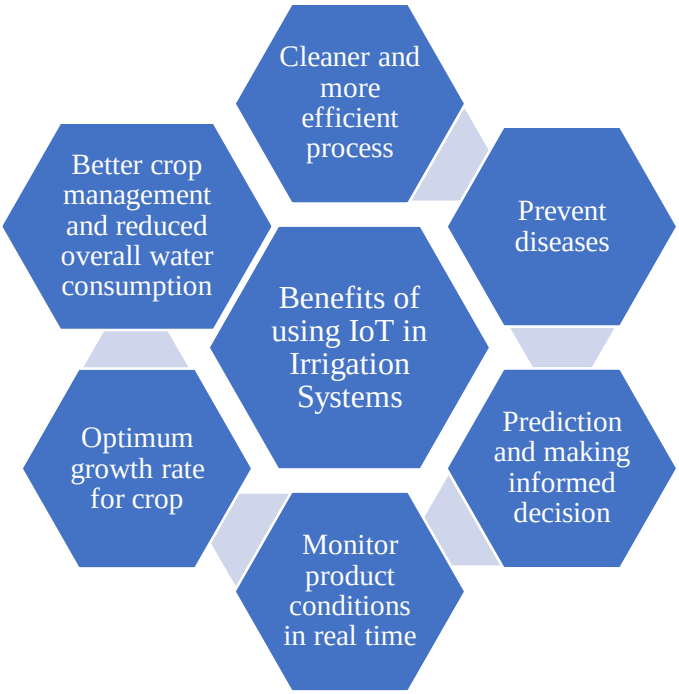


Fig. 1 IoT based smart irrigation systems

Cloud technologies

The usage of cloud in the agricultural sector and specifically in irrigation-based systems, data is gathered and processed by the use of sensors. In several studies, it has further been deduced that the data is processed in the cloud itself, and the users of it are able to view the information by connecting to the cloud. The usage of cloud in irrigation is mainly taken in terms of storing the monitored data and then retrieving it when needed.

Fig. 2 Benefits of using IoT in Irrigation Systems



IoT system in irrigation

One of the main benefits of IoT systems in irrigation is associated with the lower water consumption. In traditional ways of irrigation where most of the handling and operations were carried out manually, an ample amount of water was wasted in the irrigation process where human intervention was required. With Smart irrigation, there is no or less human involvement and the resource of water is only used to the extent to which it is required only. Further, high cost-efficiency is one of the other benefits linked to it as lesser water utilization and precision in the process allows saving costs and overall expenses. Energy consumption is also reduced significantly through the approach as machines have to run for a lower amount of time and planned intervals take place during the process that lowers the utilization of overall energy.

Irrigation systems and sustainability

Sustainability could be considered as an essential aspect that is related to irrigation systems. To maintain the sustainability within any system, balance between the three pillars of sustainability should be ensured. The three pillars of sustainability are economic, social, and environment.

Agricultural cropping systems irrigation is necessary and considered as one of the main reasons that cause rapid increase in water scarcity in many regions. In order to conserve water, smart irrigation is crucial and plays key role in providing the required water amount to each crop. The process of irrigation may reach the plant late, causing the crops to get dried. An optimal solution for this problem is an automatic controller built based on drip irrigation system. Thus, the integration between the recent technology and irrigation can improve the use of irrigation water in many regions, the developed technology Internet of things (IoT) is proposed in this study. The IoT application can give objective information related to water resources, their use, and management, assisting in the achievement of Sustainable Development Goals (SDG).

Conclusion

The use of these IoT-based systems allows the remote measure and automation of agricultural parameters such as soil moisture, temperature, field humidity, etc., as well as the ability to remotely control field irrigation. It leads to higher yields with less input. An automated irrigation system based on IoT to successfully manage the water requirement of crops. The system measures parameters such as soil moisture and field temperature and automatically supplies water to the field, constantly forwarding field data to the webpage so that the user can gain insight into the field's agricultural data and water supply. The use of this kind of system is expected to reduce the cost of manpower, Directing the busy people into the agriculture sector, and provide quick information of rapid changes in the field. This automatic irrigation system is a low-cost system as well as an easy-to-use system.

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Women Helpline Scheme

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Women's safety is a critical and multifaceted issue that encompasses various aspects of ensuring the safety, wellbeing, and empowerment of women in society. It is essential to address women's safety to create a more inclusive, equal, and just society. Here are some key aspects and considerations related to women's safety.

1. **Physical safety:** Protecting women from physical harm and violence is a primary concern. This includes addressing issues such as domestic violence, sexual assault, harassment, and human trafficking. Legal frameworks and law enforcement agencies play a crucial role in preventing and addressing such crimes.
2. **Public spaces:** Women should feel safe in public spaces, whether it's walking on the streets, using public transportation, or participating in community activities. Improving street lighting, ensuring safe transportation options, and creating gender-sensitive urban planning can help enhance women's safety in public spaces.
3. **Education and Awareness:** Promoting awareness about women's right, consent, and available resources is essential. Education programs can empower women to recognize and report abuse, while also encouraging men and boys to be allies in the fight against gender-based violence.
4. **Economic Empowerment:** Economic independence can increase a women's ability to leave abusive relationships and make choices that prioritize her safety. Programs that support women's economic empowerment, such as access to education and job opportunities, are crucial.
5. **Support Services:** Providing access to support services, such as shelters, counselling, and hotlines, can be lifesaving for women experiencing violence. These services can help women leave dangerous situations and rebuild their lives.
6. **Legal Protections:** Effective legal frameworks and enforcement mechanisms are vital. Laws against gender-based violence and discrimination need to be in place and enforced consistently. Access to justice for women who have experienced violence is critical.
7. **Technology and safety Apps:** The use of technology, such as safety apps and panic buttons, can aid women in distress. These tools can connect them to emergency services and notify trusted contacts in case of danger.
8. **Community Engagement:** Engaging communities and promoting gender equality can have a positive impact on women's safety. Community support and social norms that reject violence against women are essential.
9. **Workplace safety:** Ensuring safe and inclusive workplaces in crucial employers should have policies in place to prevent harassment and discrimination, and employees should be educated about their rights.

Women's safety is not only a women's issue but a societal issue that requires collective efforts from individuals, communities, governments, and organizations to create a safer and more equitable world for all. It involves changing attitudes, policies and behaviours to build a society where women can live free from fear and violence. In this case the government starts a scheme for women's safety, here we discuss about;

The Women Helpline Scheme is another important initiative launched by the Government of India aid and support to women in need. It aims to create a safe and supportive environment for women

by offering them a helpline number they can call in case of emergencies, crisis situations, or to seek information and guidance related to their rights and wellbeing.

Key features of the women helpline scheme:

1. **Helpline Number:** A dedicated helpline number is established that women can call to seek help, support, or information. This helpline is available 24/7 and is often toll free.
2. **Emergency assistance:** The helpline is equipped to provide immediate assistance in case of emergencies such as domestic violence, harassment, assault, trafficking, and other forms of violence against women.
3. **Crisis counselling:** Trained professionals and counsellors are available on the helpline to provide emotional support, guidance and counselling to women facing various challenges.
4. **Referral services:** The helpline can refer women to appropriate government agencies, organizations or services that can provide further assistance, such as legal aid, medical help, shelter, and rehabilitation.
5. **Information Dissemination:** The helpline provides information on women's right, laws, government schemes, and available resources to empower women with knowledge to make informed decisions.
6. **Confidentiality and Privacy:** All calls to the helpline are handled with strict confidentiality and privacy to ensure that women feel safe and comfortable while seeking assistance.

Women Helpline Scheme plays a crucial role in addressing issue of violence and discrimination against women and providing them with a reliable platform to reach out for help. It is an essential component of the broader efforts to promote gender equality and women's empowerment in India. Different states in India may have their own helpline numbers and implementation strategies under the women helpline scheme in coordination with the central government's guidelines.

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Cultivating a Greener Future: The Promise of Sustainable Agriculture

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In today's world, sustainable agriculture is essential because it has the potential to meet our agricultural needs, which conventional agriculture does not. This type of farming employs a unique farming method that maximizes the utilization of the environment's resources without causing harm to them. As a result, the method is safe for the environment and produces healthy agricultural products. Sustainable agriculture is not a particular method but rather a broad idea. It encompasses advancements in technology and agricultural management practices, and there is a growing consensus that conventional agriculture, which emerged following World War II, will not be able to meet the requirements of the expanding population in the twenty-first century. Fundamental processes that are essential to microbial populations drive Agro-ecosystem stability and productivity. Several studies aimed to learn more about the importance, diversity, and dynamics of soil microbial communities, as well as the beneficial and cooperative roles they play in agricultural productivity. However, it is also important to talk about how cyanobacteria and plant growth promoting rhizobacteria (PGPR) help develop safe and sustainable agriculture. Utilizing farmer management practices to influence soil microbial populations and processes in such a way as to achieve beneficial effects on soil productivity is the central paradigm for the biological management of soil fertility. Microbial populations and processes in a variety of ways, each of which lessens the main soil-based productivity constraints, influence soil structure and fertility. In an era marked by environmental concerns and the urgent need to address climate change, sustainable agriculture has emerged as a beacon of hope for our planet's future. As the global population continues to rise, so does the demand for food, putting immense pressure on ecosystems and resources. Sustainable agriculture offers a holistic approach that seeks to balance the needs of food production, environmental preservation, and social well-being. This article delves into the concept of sustainable agriculture, its key principles, benefits, challenges, and the path forward towards a more resilient and harmonious agricultural system.

The Essence of Sustainable Agriculture

Sustainable agriculture is a philosophy that encompasses various practices and techniques aimed at ensuring the long-term viability of agricultural systems while minimizing their negative impact on the environment. It recognizes the intricate relationships between ecosystems, human communities, and agricultural activities. At its core, sustainable agriculture seeks to strike a delicate balance between three fundamental pillars:

- Environmental Health: Sustainable agriculture prioritizes the conservation of soil, water, and biodiversity. By avoiding or minimizing the use of harmful chemicals, embracing organic farming methods, and promoting crop rotation, it maintains the health of ecosystems and prevents soil degradation.
- Economic Viability: A sustainable agricultural system must be economically viable for farmers. It

promotes fair wages, reduces waste, and encourages local markets and distribution networks, thereby ensuring a stable income for agricultural practitioners.

- Social Equity: Sustainable agriculture addresses the well-being of farmers and communities, fostering social equity through ethical labor practices, safe working conditions, and community involvement. It respects cultural diversity and empowers local communities to make informed decisions about their agricultural practices.

Key Principles of Sustainable Agriculture

Several key principles underpin sustainable agriculture:

Crop Diversity

Diverse crop cultivation helps prevent pests and diseases, reduces the need for synthetic pesticides, and ensures food security in the face of changing environmental conditions.

Crop diversity plays a crucial role in achieving sustainable agriculture. Sustainable agriculture aims to meet the needs of the present without compromising the ability of future generations to meet their own needs. Crop diversity contributes to various aspects of sustainability in agriculture:

- Resilience to Climate Change: Diverse crop varieties have varying tolerances to climate stressors, such as drought, heat, and pests. By cultivating a range of crops, farmers can better adapt to changing climatic conditions and reduce the risk of crop failures.
- Pest and Disease Management: Monoculture farming can lead to the rapid spread of pests and diseases, as they find a suitable host across large areas. Crop diversity disrupts pest and disease cycles and reduces the need for chemical inputs, promoting natural pest control.
- Soil Health and Fertility: Different crops have different root structures and nutrient requirements. Crop rotation with diverse crops can improve soil fertility, reduce soil erosion, and minimize the depletion of specific nutrients.
- Biodiversity Conservation: Diverse cropping systems support a broader range of insects, birds, and beneficial organisms, enhancing overall biodiversity on farms. This contributes to a more balanced and resilient ecosystem.
- Nutritional Diversity: Growing a variety of crops promotes a diverse and balanced diet, providing essential nutrients and reducing the risk of malnutrition and diet-related diseases.
- Cultural and Traditional Values: Sustainable agriculture often incorporates traditional and indigenous knowledge of local crop varieties and farming practices, preserving cultural heritage and fostering community resilience.
- Reduced Chemical Inputs: Diverse cropping systems can reduce the reliance on synthetic fertilizers and pesticides. Companion planting and polyculture can lead to natural pest control and improved nutrient cycling.
- Market Opportunities: Crop diversity can open up opportunities for niche markets and value-added products. It allows farmers to respond to changing consumer preferences and market demands.
- To promote crop diversity in sustainable agriculture, several strategies can be implemented:
- Crop Rotation: Alternating the types of crops grown in a field from season to season helps maintain soil fertility and reduces pest and disease buildup.
- Polyculture and Intercropping: Planting multiple crops together in the same field can maximize resource use, improve pest management, and enhance soil health.
- Agroforestry: Integrating trees and shrubs with crops can enhance biodiversity, improve soil quality, and provide additional products like fruits, nuts, and timber.

- Cover Crops: Planting cover crops during fallow periods can protect soil from erosion, enhance soil structure, and contribute to nutrient cycling.
- Conservation Agriculture: Practicing minimal soil disturbance, permanent soil cover, and diversified cropping systems can promote sustainability.
- Promotion of Traditional and Local Varieties: Supporting local farmers who cultivate traditional crop varieties helps preserve agrobiodiversity and local knowledge.
- Seed Banks and Germplasm Collections: Establishing and maintaining seed banks ensures the availability of diverse crop varieties for future generations.
- Education and Training: Providing farmers with knowledge and training on sustainable farming practices and the benefits of crop diversity is essential for adoption.

Incorporating crop diversity into agricultural systems not only enhances sustainability but also contributes to food security, environmental conservation, and resilient livelihoods for farming communities.

Soil Health

Implementing practices such as cover cropping, composting, and reduced tillage enhances soil structure, fertility, and moisture retention.

Maintaining healthy soil is a cornerstone of sustainable agriculture. Healthy soil provides a foundation for productive crops, nutrient cycling, water retention, and biodiversity. Implementing soil health practices can enhance agricultural sustainability by improving soil fertility, reducing erosion, and minimizing the need for synthetic inputs. Here are some key soil health practices for sustainable agriculture:

- Crop Rotation: Alternating different crops in a field from season to season helps break pest and disease cycles, prevents nutrient imbalances, and improves soil structure.
- Cover Cropping: Planting cover crops between main crop cycles helps protect the soil from erosion, adds organic matter, enhances nutrient cycling, and improves soil structure. Leguminous cover crops also fix nitrogen from the air, enriching the soil.
- No-Till or Reduced Tillage: Minimizing soil disturbance through no-till or reduced tillage practices reduces soil erosion, preserves soil structure, and enhances carbon retention. Reduced tillage can also save time and fuel.
- Mulching: Applying organic or synthetic mulch on the soil surface helps retain moisture, suppress weeds, and regulate soil temperature, contributing to healthier soil conditions.
- Composting and Organic Matter Management: Adding compost, manure, or other organic materials to the soil increases soil organic matter content, improving soil structure, water-holding capacity, and nutrient availability.
- Integrated Nutrient Management: Combining organic and mineral fertilizers in balanced ways helps maintain nutrient levels, reduce nutrient runoff, and enhance plant growth without degrading soil quality.
- Green Manure and Nutrient Cycling: Incorporating green manure crops or residues into the soil adds organic matter and nutrients, promoting nutrient cycling and soil health.
- Biofertilizers and Microbial Inoculants: Applying beneficial microorganisms, such as mycorrhizal fungi or nitrogen-fixing bacteria, can improve nutrient uptake and enhance soil microbial diversity.
- Agroforestry and Agroecological Practices: Introducing trees and shrubs into agricultural systems enhances soil health by providing organic matter, improving water infiltration, and contributing to nutrient cycling.
- Rotational Grazing: In livestock systems, implementing rotational grazing allows for rest and recovery of pastures, preventing soil

compaction and promoting healthier soil conditions.

- Soil Erosion Control Measures: Implementing contour farming, terracing, or planting cover crops on slopes helps prevent soil erosion and sediment runoff.
- Water Management: Proper water management, including irrigation practices that avoid overwatering or waterlogging, helps maintain soil structure and prevent salinization.
- Soil Testing and Monitoring: Regular soil testing helps assess nutrient levels and pH, guiding appropriate nutrient management strategies and preventing over-application of fertilizers.
- Crop Diversity: Planting a diverse range of crops improves soil biodiversity, reduces pest and disease pressures, and promotes overall ecosystem health.
- Conservation Agriculture: Adopting a combination of practices such as no-till, cover cropping, and diversified cropping systems under conservation agriculture principles promotes soil health and sustainable land management.
- Educational Outreach: Providing farmers with knowledge and training on soil health practices enhances adoption and encourages sustainable soil management.

Implementing these soil health practices supports long-term agricultural productivity, resilience, and environmental stewardship, contributing to the overall sustainability of farming systems.

Water Management

Efficient water use through techniques like drip irrigation and rainwater harvesting minimizes waste and reduces pressure on local water resources.

Water management is a critical aspect of sustainable agriculture, especially in the face of changing climate patterns and growing water scarcity. Effective water management practices help optimize water use, improve crop yields, and minimize environmental impacts. Here are some key water management practices for sustainable agriculture:

- Drip Irrigation and Micro-Sprinklers: These methods deliver water directly to the plant roots, minimizing water wastage through evaporation and reducing weed growth. They can significantly improve water use efficiency.
- Rainwater Harvesting: Collecting and storing rainwater for irrigation or other agricultural purposes can reduce dependence on groundwater and surface water sources.
- Mulching: Applying organic or synthetic mulch on the soil surface helps retain soil moisture, reduce evaporation, and suppress weed growth.
- Soil Moisture Monitoring: Using sensors or monitoring systems to measure soil moisture levels helps farmers determine the optimal timing and amount of irrigation, preventing overwatering.
- Optimized Irrigation Scheduling: Adopting irrigation schedules based on crop water requirements and growth stages helps ensure that plants receive the right amount of water at the right time.
- Furrow Irrigation Management: Properly designed furrows and controlled water flow can minimize runoff and improve water distribution in row crops.
- Subsurface Drip Irrigation: Placing drip irrigation lines underground reduces water evaporation, minimizes weed growth, and improves water use efficiency.
- Water-Efficient Crop Selection: Choosing crop varieties that are well-suited to the local climate and water availability can reduce water demand while maintaining productivity.
- Crop Rotation and Cover Crops: Rotating crops and using cover crops can improve soil structure and water retention, reducing the need for irrigation.

- Wastewater Reuse and Recycling: Treating and reusing wastewater for irrigation can supplement water resources and reduce pollution.
- Efficient Water Storage: Properly designed ponds, tanks, or reservoirs can store water for irrigation during dry periods.
- Soil Conservation Practices: Implementing erosion control measures like contour farming and terracing helps retain water in the soil and prevent runoff.
- Localized Water Management: Dividing fields into zones based on soil type and water needs allows for targeted irrigation, reducing water use in areas that don't need as much.
- No-Till and Reduced Tillage: Minimizing soil disturbance through these practices helps retain soil structure and moisture, reducing water loss.
- Agroforestry and Windbreaks: Planting trees and shrubs can help reduce wind evaporation, improve water retention, and provide shade to crops.
- Educational Outreach: Providing farmers with training and information about water-efficient practices encourages their adoption and helps improve overall water management.
- Legume Cover Crops: Planting leguminous cover crops can help fix nitrogen in the soil, reducing the need for nitrogen-based fertilizers and minimizing water pollution.
- Efficient Fertilizer Application: Applying fertilizers in a targeted and precise manner prevents nutrient leaching and reduces water pollution.
- Adaptive Management: Continuously monitoring and adjusting water management practices based on changing conditions and new information ensures ongoing sustainability.
- By implementing these water management practices, farmers can enhance water use efficiency, increase crop resilience, and contribute to the long-term sustainability of agricultural systems.

Integrated Pest Management (IPM)

IPM combines biological, cultural, and chemical strategies to manage pests and diseases sustainably, reducing the reliance on harmful chemicals.

"IPM" typically stands for "Integrated Pest Management," which is a holistic and sustainable approach to managing pests and diseases in agriculture. It involves a combination of various strategies to minimize the impact of pests while reducing the use of synthetic pesticides. Integrated Pest Management is an important component of sustainable agriculture because it promotes ecological balance, reduces environmental harm, and supports long-term agricultural productivity. Here's how IPM can be applied in sustainable agriculture:

- Monitoring and Identification: Regularly monitor fields to identify pest populations and their lifecycle stages. This helps determine if and when intervention is needed.
- Preventive Measures: Implement preventive practices to reduce pest pressure, such as selecting pest-resistant crop varieties, practicing proper crop rotation, and optimizing planting density.
- Cultural Control: Use agricultural practices that create unfavorable conditions for pests, such as adjusting planting dates, intercropping, and maintaining proper plant spacing.
- Biological Control: Encourage natural predators, parasites, and beneficial organisms that naturally control pest populations. This includes releasing beneficial insects, birds, or using microbial pesticides.
- Mechanical and Physical Controls: Use physical barriers, traps, or mechanical methods to physically remove or deter pests. Examples include using insect nets, sticky traps, and pheromone traps.
- Biopesticides: Utilize naturally occurring substances, such as neem oil, bacteria, fungi, and botanical extracts, as alternatives to chemical pesticides.

- Responsible Pesticide Use: If pesticides are necessary, choose low-toxicity options, apply them only when needed, and adhere to recommended dosage and timing to minimize environmental impact.
- Crop Residue Management: Properly manage crop residues and plant debris to reduce overwintering sites for pests and diseases.
- Trap Cropping: Plant specific crops that attract pests away from the main crop, reducing pest damage.
- Education and Training: Educate farmers about pest lifecycles, monitoring techniques, and the importance of IPM to encourage adoption.
- Decision Support Systems: Use technology and data-driven tools to predict pest outbreaks and optimize pest management strategies.
- Economic Thresholds: Determine action thresholds based on pest population levels and potential economic damage before deciding on intervention.
- Collaboration and Knowledge Sharing**: Work with local agricultural extension services, research institutions, and fellow farmers to share knowledge and experiences related to IPM.
- Adaptive Management: Continuously assess the effectiveness of IPM strategies and make adjustments based on results and changing pest dynamics.

Integrated Pest Management not only reduces the reliance on chemical pesticides but also promotes a balanced and resilient ecosystem, enhances biodiversity, protects natural enemies, and supports sustainable food production. It aligns with the principles of sustainable agriculture by focusing on long-term solutions that are environmentally sound, economically viable, and socially responsible.

Agroforestry

Integrating trees with crops and livestock systems not only contributes to carbon sequestration but also provides additional income sources and enhances biodiversity.

Agroforestry is a sustainable land management system that combines the cultivation of trees or shrubs with agricultural crops and/or livestock on the same piece of land. This integrated approach offers numerous benefits for both the environment and local communities, making it a valuable practice for achieving sustainable agriculture. Here's how agroforestry contributes to sustainable agriculture:

- Biodiversity Conservation: Agroforestry systems create diverse and complex landscapes that support a wide range of plant and animal species. This enhances biodiversity compared to monoculture systems and helps preserve native species.
- Soil Health Improvement: Trees in agroforestry systems contribute organic matter to the soil through leaf litter and root turnover, enhancing soil fertility, structure, and water retention.
- Nutrient Cycling: Tree roots bring up nutrients from deeper soil layers, making them available to crops. Fallen leaves also provide a natural source of nutrients for the soil.
- Water Management: Trees in agroforestry systems reduce water runoff, increase water infiltration, and help maintain soil moisture, thus enhancing water availability for crops and reducing erosion.
- Climate Change Mitigation: Trees sequester carbon dioxide from the atmosphere, helping mitigate climate change. Agroforestry systems contribute to carbon sequestration while providing additional benefits.
- Microclimate Regulation: Trees provide shade, reducing temperature extremes and creating microclimates that are favourable for crops and livestock.
- Wind and Erosion Control: Trees act as windbreaks, reducing soil erosion and protecting crops from wind damage.

- Livelihood Diversification: Agroforestry diversifies income sources for farmers by providing products such as fruits, nuts, timber, and non-timber forest products.
- Resilience to Climate Variability: Agroforestry systems can be more resilient to climate variability due to their diverse plant composition and better adaptation to changing conditions.
- Reduced Pressure on Natural Forests: By providing alternative sources of timber, fuelwood, and other forest products, agroforestry helps reduce the pressure on natural forests, contributing to forest conservation.
- Wildlife Habitat: Agroforestry landscapes can serve as habitats for wildlife, contributing to the preservation of various species.
- Community Benefits: Agroforestry can improve food security, provide income-generating opportunities, and enhance the overall well-being of local communities.
- Cultural and Traditional Values: Agroforestry often incorporates traditional and indigenous knowledge, preserving cultural practices and fostering community cohesion.
- Erosion Control and Riparian Buffers: Riparian agroforestry systems along water bodies help prevent soil erosion, filter pollutants, and protect water quality.
- Educational and Research Opportunities: Agroforestry provides opportunities for research and education on sustainable land management practices and their benefits.

Challenges and the Way Forward

Despite its evident benefits, the widespread adoption of sustainable agriculture faces certain challenges:

- Knowledge and Education: Farmers need access to training, resources, and information to transition to sustainable practices effectively.
- Market Demand: Consumer awareness and demand for sustainably produced goods must increase to create incentives for farmers to adopt such practices.
- Policy Support: Governments should provide policy frameworks that incentivize sustainable agriculture, including subsidies, research funding, and regulations that favor environmentally friendly practices.
- Scaling Up: While sustainable agriculture has shown success on smaller scales, efforts are needed to adapt these practices to larger commercial operations.

Conclusion

Sustainable agriculture stands as a beacon of hope, offering a path towards a more harmonious coexistence between human activities and the environment. By prioritizing ecological health, economic viability, and social equity, this approach to farming can help us address the pressing challenges of climate change, food security, and environmental degradation. Embracing sustainable agriculture is not just an option; it is a necessity if we are to ensure a greener, more sustainable future for generations to come. Through collaborative efforts between governments, farmers, consumers, and researchers, we can cultivate a world where agriculture nurtures both people and planet alike.

In conclusion, sustainable agriculture represents a fundamental shift in the way we approach food production, emphasizing the harmonious coexistence of ecological, economic, and social factors. It is a holistic approach that aims to meet the nutritional needs of the present while safeguarding the resources and ecosystems for future generations. Through the integration of innovative practices and the preservation of traditional wisdom, sustainable agriculture offers a pathway to address the challenges posed by climate change, environmental degradation, and food security.

At its core, sustainable agriculture recognizes that the health of our planet is intricately intertwined with the health of our agricultural systems. By prioritizing soil health, water management, crop diversity, and integrated pest management, we can foster resilient ecosystems that support diverse and nutritious food production. This, in turn, nurtures both human well-being and the intricate web of life on Earth. Sustainable agriculture empowers local communities, enhances economic viability, and celebrates cultural heritage. It encourages collaboration between scientists, farmers, policymakers, and consumers, fostering a collective commitment to responsible land stewardship. As we look to the future, sustainable agriculture stands as a beacon of hope, guiding us towards a balanced and regenerative relationship with the natural world, ensuring that our actions today lay the foundation for a nourished and thriving planet tomorrow.

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Indian Agriculture Industry and Technology Integration

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Being a South Asian nation, India is the seventh-largest country by area, the second-most populous country as of 2022, India's population stood at 1.417 billion people, and the country is projected to become the most populous democracy by 2030, home to more than 1.5 billion people in the world. India boasts of an immensely rich cultural heritage, including numerous languages, traditions, and people. The country holds its uniqueness in its diversity, and hence has adapted itself to international changes with poise and comfort. While the economy has welcomed international companies to invest in it with open arms since liberalization in the 1990s, Indians have been prudent and proactive in adopting global approaches and skills. Indian villagers have proudly taken up farming, advanced agriculture and unique handicrafts as their profession on one hand, while the modern industries and professional services sectors are coming up in a big way on the other. India is an agrarian economy at its core, with over half of its population engaged in agricultural activities, there are some challenges the agriculture sector has faced for a long time. These include unsustainable practices, lack of tech penetration, limited market access, and, most recently, the threat of insufficient food for the population. Recent years have seen the agriculture industry evolve and grow drastically due to increased digitization, awareness, and above all, agritech platforms and the government's increased focus on the sector's betterment.

Sectoral Advantage for India

Robust Demand of processed foods

Factors contributing to the sharp growth in demand for processed foods include increasing urbanization, increasing disposable incomes, changing spending patterns/ priorities, the emergence of nuclear families, and the growing need for convenience foods in dual-income nuclear families. The demand for organic products in the Indian market is growing and is anticipated to rise with a CAGR of 25.25% between 2022-27.

Attractive Opportunities

Trends indicate a sharp increase in on-the-go eating, snacking in between meals, switching to healthier eating alternatives, pre-cooked ready-to-eat meals, and increasing consumption of organic foods. This has led to a host of new opportunities in the consumer foods market for both domestic and international companies to build a stake in this fast-growing processed food market.

Policy Support for Market Expansion

Online, Competitive, Transparent Bidding System with 1.74 crore farmers and 2.39 lakh traders put in place under the National Agriculture Market (e-NAM) Scheme. A new sub-scheme of PM Matsya Sampada Yojana with a targeted investment of Rs. 6,000 crore (US$ 729 million) to be launched to further enable activities of fishermen, fish vendors, and micro & small enterprises, improve value chain efficiencies and expand the market.

Competitive Advantage in Processing Sector

India has access to several natural resources that provides it a competitive advantage in the food processing sector. Due to its diverse agro-climatic conditions, it has a wide-ranging and large raw material base suitable for food processing industries. India has the second-largest arable land resources in the world. With 15 agro-climatic regions, all the major climates in the world exist in India. The country also has 46 of the 60 soil types in the world. India is the largest producer of spices, pulses, milk, tea, cashew, and jute, and the second largest producer of wheat, rice, fruits and vegetables, sugarcane, cotton, and oilseeds. Further, India is second in the global production of fruits and vegetables and is the largest producer of mango and banana.

According to the Department for Promotion of Industry and Internal Trade (DPIIT), the Indian food

processing industry has cumulatively attracted Foreign Direct Investment (FDI) equity inflow of about US$ 25.47 billion between April 2000-March 2022. India's agricultural and processed food products exports stood at US$ 9,598 million in FY 2022-23 (April-July 2022), up by 30% YoY. Gross Value Added by the agriculture and allied sector is 18.8% in FY 2021-22 (until 31 January, 2022). India has the largest livestock population of around 535.78 million, which translates to around 31% of the world population

Current Scenario of Agriculture Industry

As the backbone of the Indian economy, the agriculture industry contributes to around 16.5% of India's GDP. As of 2022, the Indian agriculture market value stood at USD 435.9 billion and is expected to reach USD 580.82 billion by 2028, growing at a CAGR of around 4.9% between 2023 and 2028. Agritech has been a game-changer to the Indian agriculture industry, which has been relatively slow in terms of technology adoption and digitization compared to other sectors. Today, Agritech has become a promising arena for investors, entrepreneurs, the agricultural community, and all other stakeholders. According to data by NASSCOM, India had around 450 agritech startups in 2022, with the number growing at 25% year-on-year.

Greater Integration of Technology

Like other sectors, AI is a game-changer for the agriculture sector as well and given that technology penetration is lower in agriculture compared to other industries, AI can be incredibly beneficial in building meaningful solutions. For instance, AI can be transformative in helping the farming community optimize water usage and energy consumption and even determine what crops should be grown when depending on the weather conditions and soil quality. The technology is now revolutionizing the Agritech segment in several ways, including through predictive modeling, supply chain management, and automation to improve efficiency and minimize costs.

Similarly, blockchain is another groundbreaking technology in the Agritech ecosystem. Its potential is only now being discovered. By leveraging blockchain, agritech platforms can reinforce the dynamics of Agri trade, which is necessary given the rise in demand for food supply and security and enable transparency in the agriculture ecosystem. In fact, blockchain is one of the only technologies that enable traceability in the food supply chain. With more agritech platforms integrating blockchain into their operations, the technology is likely to uplift the agriculture sector sooner than anticipated.

Apart from Blockchain and AI, technologies like IoT play a crucial role in the agritech segment. In agriculture, IoT is often used to efficiently measure and monitor soil health and data, the chemical and physical composition of the crops, and weather conditions. Further, agricultural robotics and drones are now being tested and deployed in certain areas of farming to minimize manual labor and enable farmers to make more informed decisions. These advanced technologies will become more than just passing trends; they are likely to shape the food ecosystem and drive agribusiness growth.

Sustainable/Green farming practices

While technology is advancing constantly and taking center stage, the alarming levels of global warming and climate change are anything to go by, it's high time to prioritize sustainable agriculture. For instance, concepts like regenerative agriculture, a holistic farming method that ensures the soil is healthy by replenishing resources, are gaining traction. Besides, regenerative agriculture also minimizes the usage of chemical inputs to avoid adverse impacts on the soil, water, and the environment. Farmers are also being educated on the effects of stubble burning and taught more sustainable farming practices.

Agriculture, Food Industry and Exports

The agriculture sector is the largest source of livelihood in India. The country is one of the largest producers of agriculture and food products in the world. In 2022-23, India's agriculture sector growth rate was estimated to be at 3.5% and it was 3.0% in

2021-22. The country produces many crops and food grains such as rice, wheat, pulses, oilseeds, coffee, jute, sugarcane, tea, tobacco, groundnuts, dairy products, fruits, etc. India's exports of agricultural commodities stood at US$ 52.49 in FY23.

During 2021-22, India's tea production stood at 1,344.40 million kg. Coffee production during the same period was 3,420 lakh tonnes, a 2.39% YoY increase. During 2021-22, oilseeds production of India crossed the estimated 37.15 million tonnes while other products such as rice, wheat, maize, pulses, mustard, and sugarcane reached a record high production.

Key Trends Expected

1. Changing demand due to increase in income, globalization and health consciousness is affecting and going to affect more the production in future. Demand for fruits and vegetables, dairy products, fish and meat is going to increase in future.
2. Researches, technology improvements, protected cultivation of high value greens and other vegetables will be more. There will be more demand of processed and affordable quality products.
3. More competition will be there among private companies giving innovative products, better seeds, fertilizers, plant protection chemicals, customized farm machinery and feed for animals etc in cost effective ways at competitive prices giving more returns on investment by farmers. Use of biotechnology and breeding will be very important in developing eco-friendly and disease resistant, climate resilient, more nutritious and tastier crop varieties.
4. Some technologies will be frequently and widely used in future and some will become common in a short time while some will take time to mature. For producing the same products in other way so as to use resources judiciously and using new resources also like hydroponics, use of plastics and bio-plastics in production. There will be more of vertical and urban farming and there will also be efforts in long term to find new areas for production like barren deserts and seawater.
5. Precision farming with soil testing-based decisions, automation using artificial intelligence will be focused for precise application inputs in agriculture. Sensors and drones will be used for precision, quality, environment in cost effective manner.
6. Small and marginal farmers will also be using these technologies with the help of private players, government or Farmer Producer Organizations (FPO). Use of GPS technology, drones, robots etc controlled by smart phones etc. can make life of farmers easy and exciting with good results. These advanced devices will make agriculture be more profitable, easy and environmentally friendly.
7. Use nano-technology for enhancement of food quality and safety, efficient use of inputs will be in near future. Nano-materials in agriculture will reduce the wastage in use of chemicals, minimize nutrient losses in fertilization and will be used to increase yield through pest and nutrient management.
8. India has improved remarkably in its digital connectivity and market access has become very easy. The number of internet users is projected to reach 666.4 million in 2025. Farmers will be behaving more smartly with mobiles in hands and would be able to be more aware and connected with different stake holders. Government will be making wide use of digital technology for generating awareness among farmers, information sharing, government schemes using digital technology for direct transfers of money.
9. There will certainly be more work by government, village communities, agri startups and private players in conserving sharply depleting water resource. Use of

digital technology can make revolution in this direction. There will be use of satellites, IoT, drones for better collection of data regarding soil health, crop area and yield which will make cost for insurers less with better estimations and system will be more exact and effective.

10. There will be more of niche marketers in operations, area, and crop specific small equipment's which will make operations even at small farms easier and efficient. Food wastage will be less and better use of waste materials in agriculture will be more. Number of warehouses in private sector will be more and linkages between government and private warehouses will be increasing. This will help in balancing supply with demand and stabilization of prices of agri-outputs in the market.
11. Retailing in agriculture will largely be digitalized. A study estimates that over 90 per cent of Kirana stores across the country will be digitalized by 2025 with modern traceable logistics and transparent supply chain. Many players have already taken Kirana stores to the door steps of consumers like Amazon and Jio Mart.

Way Forward

Farmers need to be empowered to make informed choices about their crops, markets, inputs, technologies, and organizational forms. They also need to be protected from price volatility, climate shocks, pests and diseases, and other uncertainties. This can be achieved by strengthening the existing institutions and mechanisms such as Minimum Support Price (MSP), crop insurance, extension services, cooperatives, etc., as well as creating new ones such as contract farming, e-NAM, farmer producer organizations, etc.

In the Union Budget 2023, the government has announced that the credit target for the agriculture sector will be increased to Rs 20 lakh crore, with a renewed focus on animal husbandry, dairy, and fisheries. This will benefit the community immensely, seeing as how credit access has always been hard to come by for farmers. Additionally, the government also plans on adopting a cluster-based value chain approach which will facilitate collaboration between farmers, state, and industry inputs and market linkages. Overall, agri-techniques and industry is redefining the status quo of the ecosystem to ensure the betterment of the community and all its stakeholders. The future indeed seems bright for the industry.

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Salicylic Acid: Enhanced Heat Resilience in Plants

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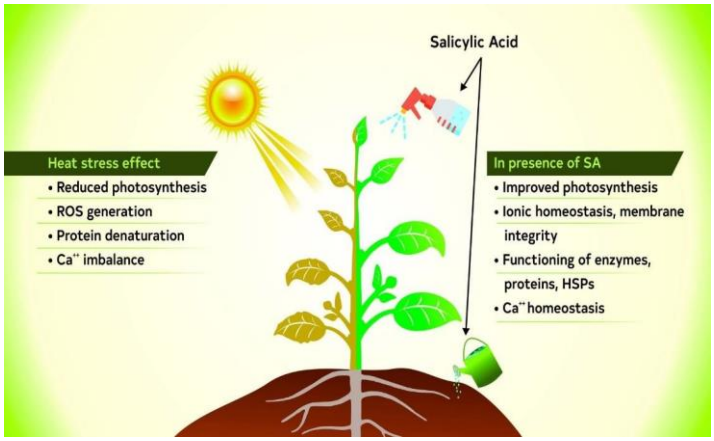
Among the ever-shifting environmental dynamics, the steadily increasing surrounding temperature stands out as one of the most detrimental stressors constantly changing environmental conditions, the gradually rising ambient temperature is one of the most harmful stress. Both scientists and governments are expressing apprehension over this temperatures escalation due to its direct and indirect repercussions on the planet's biodiversity. Heat stress affect plants in a variety of ways including membrane integrity and protein, altering nucleic acid and protein metabolism, destroying membrane structure and lowering photosynthesis. Heat stress causes excessive water loss from plant tissues by accelerating the rate of transpiration. It can cause dehydration, wilting and eventually plant death. When plants are subjected to high-temperature conditions they frequently increase the production of salicylic acid as part of their stress response.

Some of the ways in which Salicylic acid-enhanced heat resilience in plants include:

- Heat shock proteins
- ROS signaling
- Antioxidant defense system
- Photosynthesis efficiency
- Membrane stability and fluidity
- Transcriptional regulation

Salicylic acid (SA) is a crucial component of the signaling pathways for abiotic and biotic defense responses. It is a naturally occurring plant hormone and a key signaling molecule involved in the plant's defense systems against a variety of stresses including heat stress. Salicylic acid-enhanced heat resilience in plants is a phenomenon in which SA plays a crucial role in improving plants' ability to withstand and cope with heat stress. By employing various mechanisms such as the removal of reactive oxygen species (ROS), heightened synthesis of heat shock protein (HSPs), improved photosynthetic efficiency and safeguarding of the reproductive system, topical application confers heat stress resistance upon plants. The effectiveness of SA on plants is influenced by factors like concentration, plants species and maturity, specific treated tissues and the duration of the treatment. protection, it gives heat stress resistance to the plants when applied topically. The concentration used, plant species and age, kind of tissues treated, and length of treatment are all the factors that affect how SA affects plants.



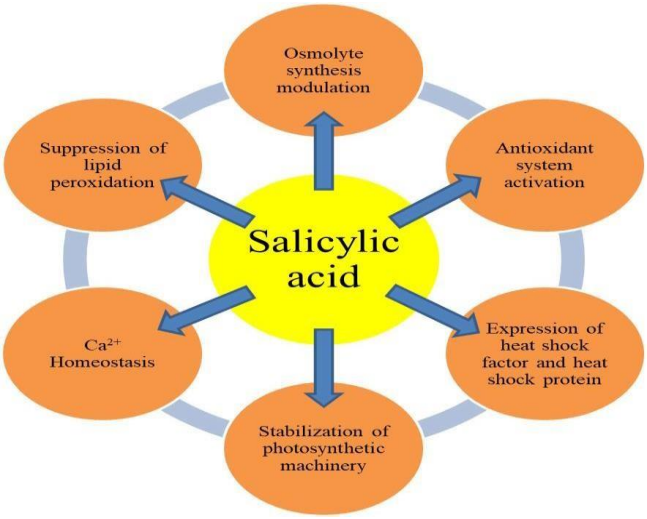
Source (Sangwan *et al.*, 2022)

Heat shock proteins (HSPs)

SA induces the expression of the heat shock proteins also known as molecular chaperones that assist plants in maintaining proper protein folding and protecting them from heat- induced damage. They serve to protect cells from damage and ensure that important cellular functions remain to function properly. HSPs also help in the protection and repair of photosynthetic proteins to maintain photosynthetic efficiency.

ROS scavenging and Antioxidant system

Salicylic acid stimulates antioxidant defense systems, which can neutralize reactive oxygen species (ROS) created under heat stress. ROS are toxic byproducts of cellular metabolism that can cause oxidative damage to plant cells.



Source (Sangwan *et al.*, 2022)

Photosynthesis efficiency: Salicylic acid plays a role in shielding the photosynthetic machinery against heat-triggered harm, thus upholding optimal photosynthetic efficiency and carbon assimilation in elevated temperature conditions.

Ca2+ homeostasis: Salicylic acid (SA) has the capacity to uphold the balance of calcium ions (Ca^{2+}) with in the leaves. The elevation of cytoplasmic Ca^{2+} levels due to prior SA treatment could potentially contribute to the preservation of plasma membrane integrity, thereby bolstering the plant's ability to withstand stress.

Conclusion and future perspectives: The impact of heat stress adversely affects both the vegetative and reproductive aspects of virtually all plant species. To mitigate the detrimental consequences of heat stress, the application of various plant growth regulators is imperative. Among these regulators, salicylic acid (SA) has garnered increasing popularity in the realm of heat stress mitigation techniques. SA's efficacy is popularly notable when administered as a foliar spray. This treatment leads to notable enhancements in key parameters including photosynthetic metrics, relative water content, chlorophyll content, membrane stability index and heat susceptibility index.

> The important role of SA in improving the tolerance against heat in the plants can have significant effects for sustainable agriculture particularly in the face of rising temperatures caused by climate change. Because of its crucial role in the plant defense systems and also stress responses, this is an interesting target for researchers in search of ways to improve crop resilience.

However, the precise mechanisms through which SA operates in the context of heat stress signaling – how it targets are perceived, transuded and coordinated – remain an enigma. To unravel these complexities, an interdisciplinary approach encompassing molecular biology, genetics, computational biology, genomics, bioinformatics, biochemistry and metabolomics holds promise for further elucidating these processes.

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Donkeys Milk – Elixir of Life

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Milk is a valuable commodity which plays vital role in livelihood of humans. Since time immemorial it considered as "amrith" due its importance as source of sustenance and nutrition. Mother's milk is the only source of food for infants in the first months of their life and are exclusively dependent on it, but when the mother's milk is not available it is essential to find a suitable alternative. Cow milk based substitutes are considered as alternative for human milk; however cow milk protein allergy is very common in infants. So people are searching for alternative to cow's milk. On other context, in the present world of modernization people seek towards new tasty foods and want change in food habits and the pandemic has made people more interested in foods that benefit their immunity, metabolism and mental state. So why not use donkey's milk which is known since ancient times for its therapeutic and nutritional properties and also due to its nutritional similarities with human milk it has been reported as alternative for cow's milk to children with cow milk protein allergy.

History

Going back to the history, ancients described donkey milk as elixir of long life. Ancient Greek physician Hippocrates was first to write the medicinal properties of donkey milk. He prescribed it for variety of ailments, including liver problems, infectious diseases, fevers, nose bleeds, poisoning, joint pains, and wounds. Romans also considered donkey milk as common remedy for all ailments. The secret behind the beauty of Egyptian ancient queen, Cleopatra (60 – 39 BC) was that she bathed every day in a steady stream of milk supplied by 700 asses to preserve the youth of her skin.

Properties of Donkeys milk

Nutrients and palatability: Donkey milk has high volume of vitamin B1, vitamin B2, vitamin C, vitamin E, magnesium, calcium, phosphorous, zinc, potassium and sodium. More calories and minerals are present in it. Donkey milk has less allergic properties and is more digestible as its protein that is caseins are similar in nature with that of human's milk. It also contains immune enhancing proteins like lysozyme and lactoferrin. Unlike the sheep and goat milk, which can lead to cross-reactivity between their proteins and cow milk proteins, donkey milk is tolerable and has more digestibility. Due to its high lactose content, donkey milk has good palatability.

Ayurvedic medicine: It is a described as good ayurvedic medicine for new born suffering from asthma, a cure-all for a variety of ailments, and tuberculosis. It's considered to be a hypoallergic milk for infants and cures skin diseases for infants.

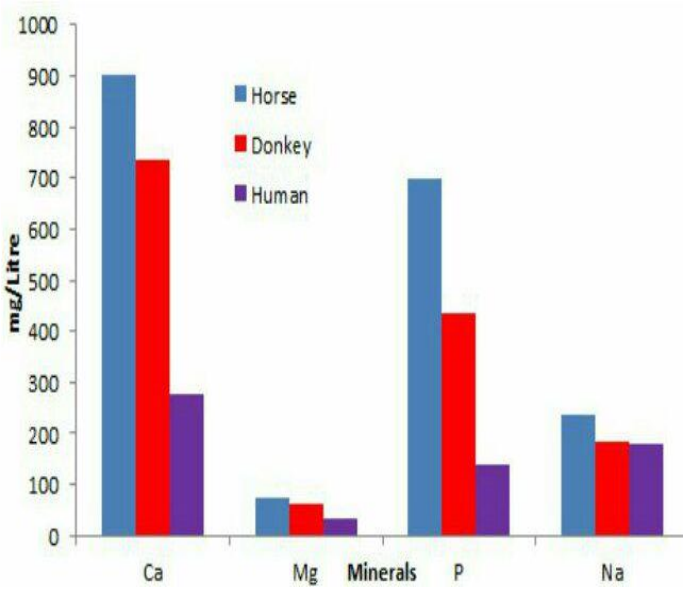
Probiotic: It is rich in calcium and is a good ingredient for probiotic and healing foods and believed to prevent intestinal infections. Studies have reported that donkeys milk lowers cholesterol and triglycerides which are responsible for atherosclerosis.

Anti ageing: Donkey milk is considered as an anti-ageing skin tonic as it is known to erase facial wrinkles, make the skin more delicate, maintain the whiteness and is a powerful tonic capable of rejuvenating the skin. It increases firmness and fights ageing as it is rich in essential fatty acids Omega 3,6 and high level of vitamins and amino peptides. Its property of rich in ceramide and phospholipid intensifies hydration. Optimal ration between lipid and moisture in donkeys milk prevents troubles of oily skin. Lactose richness in Donkeys milk helps in cell revitalization which gives excellent skin brightening quality.

Non allergic: Donkey milk is the closest known milk to human breast milk with high lactose ratios and low-fat content. It is also rich in vitamins, contains anti-bacterial agents, reported to be 200 times more active than in cow's milk, and anti-allergens,

which are believed to be responsible for alleviating psoriasis, eczema, asthma, and bronchitis.

Comparison of Donkeys milk with Human and Mare



Availability

Donkey milk is costly due to its limited availability, as donkeys produce about a litre (500ml/day) of milk per animal per day. They can only be milked for 6 months after producing a foal and has only 2 teats. The Mammary gland of ass has low capacity and they produce milk only when foal is close by. The donkey's milk is called "white gold". Donkey's milk is available in two types of milk; raw donkey milk and donkey milk long pasteurized and lyophilized (freeze dried) to preserve the biological quality.

Products

Cheese: it is called pule and is one of the world's costliest cheeses. This cheese is made from Balkan donkey milk.

Koumiss: it is Mongolians national drink and made from fermented mare's milk. There is saying in ancient tradition that its Kumis cures "40 diseases".

Donkey milk is constituent of some moisturizing creams, organic cosmetics and health drinks.

Conclusion

Donkey milk is referred as "elixir of life due to its medicinal and nutritional properties. Donkey milk can be used to replace human milk as it is close to that of human but the amount should be limited as it can asphyxiation in infants. Donkey milk presents a fascinating option in the field of nutrition and health, with its potential to offer unique benefits to those seeking alternatives to traditional dairy products. As donkeys' milk is becoming thriving business, why not rear donkeys.

Table 1. Composition of nutrients in milk of Donkey, Mare, Human and Cow

Composition	Donkey	Mare	Human	Cow
pH	7.0-7.2	7.18	7.0-7.5	6.6-6.8
Protein g/100g	1.5-1.8	1.5-2.8	0.9-1.7	3.1-3.8
Fat g/100g	0.3-1.8	0.5-2.0	3.5-4.0	3.5-3.9
Lactose g/100g	5.8-7.4	5.8-7.0	6.3-7.0	4.4-4.9
Total solids (TS) g/100g	8.8-11.7	9.3-11.6	11.7-12.9	12.5-13.0
Casein, Nitrogen (CN) g/100g	0.64-1.03	0.94-1.2	0.32-0.42	2.46-2.80
Whey protein g/100g	0.49-0.80	0.74-0.91	0.68-0.83	0.55-0.70
NPN g/100g	0.18-0.41	0.17-0.35	0.26-0.32	0.1-0.19

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Issues and Strategies of Piggery Enterprise in North-Eastern Hilly Region of India

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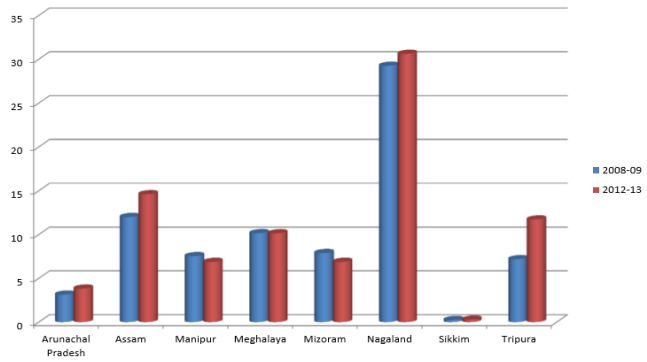
The eight states in North East (NE) India (Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura) are linguistically and culturally very distinct from the other states of India and are amongst the poorest in India with a much higher proportion of the population below the poverty line (35%) than the national average (26%). Agriculture is the prime source of livelihood for the majority (85%) of the rural population in this region. Although cereals dominate the cropping pattern in this region, livestock are an important component of the mixed farming systems and dependence on livestock as an alternative source of income is significant with livestock accounting for 18% of the value of output from the agriculture sector.

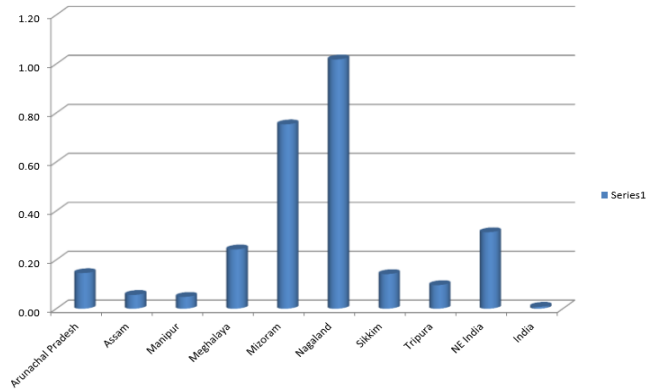
For the majority tribal population in NE India, livestock keeping especially pig keeping is the integral to their way of life, with 3.8 million pigs (over one quarter of the pigs in India) in the NE region of India. Meat consumers are becoming aware of the present scientific nutritive value of pork and so the demand for pork is equally increasing with its production. There is a growing demand for pork due to increasing per capita income, urbanization and changes in lifestyle and food habits. Considering the demand of pork in this region, immense opportunities prevail in improvement of productivity through adopting scientific interventions in routine management and health care services. But much of this demand is met from imports from other states in India and from Myanmar.

Entrepreneurship development in major sectors like feed formulation and supply, establishing pig breeding unit, artificial insemination facilities, mobile vaccination services, pork processing and use of pork by-product could make the enterprises a profitable one and generate employment opportunities for farmers and youth engaged in this livestock sector.



Source: Basic animal husbandry and fishery statistics, 2014, DAHD, Govt. of India

Fig 1: Pork production in NE India ('000 tonnes)



Source: Household consumption of goods and services in India, 2011-12, NSS, Govt. of India

Fig 2: Monthly per capita consumption of pork (kg).

Issues of piggery in NE India:

1. Lack of superior germplasm

The indigenous pig still occupies majority of pig population in NE region of India, even after implementation of various pig improvement programmes. The problem faced by the pig farmers is the lack of superior germplasm for cross breeding with local breed as they are poor in production and reproduction. The NE region has been importing pigs from the other region to fulfill the demand of this region because of high rate of consumption.

2. Lack of systematic breeding programme

The pig breeding farm established to improve the indigenous pigs through upgrading with exotic breeds like Hampshire, Landrace and Large White Yorkshire. But expected results were not achieved due to lack of systematic breeding plans. This approach has led to mixture of crossbred pigs without a fixed percentage of inheritance.

3. Inadequate artificial insemination service

In all the states of NE India, there is an inadequate artificial insemination service available to the farmers. In NE India, only in Mizoram 90% of pigs are improved genotypes.

4. Lack of compound feed manufacturer

There is no compound feed manufacturer in the whole of the N.E. India. As a result, the utilization of non-conventional feed resources could not be maximized. NE India imports the concentrate feed from the other states of India. Because of high transportation cost, by the time it reaches the different states of NE India the cost of concentrate feed is very high. As we are well aware of the fact that 70-80% of the cost of production of pig goes to the cost of feed alone.

5. Lack of organized slaughter house

Slaughter house is a place or a building, licensed by appropriate authority, where animals are killed under hygienic condition for human consumption. The region lacks organized slaughter house, which raises concerns about public health and food safety. The vast meat-eating community has to depend on those butchers' shops scattered throughout the city whose hygienic condition is below the satisfactory level. The butchers slaughtered the pigs with traditional method without maintaining any hygiene.

6. Lack of organized market

There are no organized markets in all the states of NE India, which involves chains of middlemen who reap the actual benefit depriving the real producers of their rightful share. Pork is generally sold at the roadside or at weekly markets. The whole meat trade in NE India states is handled and controlled by a group of people who have been in the business traditionally and the whole process of production, marketing, fixing of price etc. are done by them.

7. Lack of veterinary health service

In many parts of NE India there is virtually no veterinary service and generally a very low level of awareness among producers of pig diseases and preventative measures. Laboratory diagnoses of the disease are rarely carried out. Unfortunately, most of the farmers neglect diseases and parasite infestation at the early stage which result in serious problems eventually leading to serious losses in the productivity and profitability.

8. Inadequate vaccination

Despite the reported prevalence of swine fever in different states of NE India and the mortalities it caused, there are very few instances of vaccination against swine fever due to apparently inadequate knowledge about the disease, poor availability of the vaccine and lack of proper storage.

9. Poor transport facility due to the topography

The NE region is mostly hilly due to which the transportation of pig from outside state takes a longer time than other places. The pig farmers are located in the interior places so, it is difficult for them to transport regularly to the market. Moreover, during the monsoon seasons there is heavy landslide in these areas, which in turn further aggravates the communication condition.

10. Technical constraints

The majority of the pig farmers are in the rural areas. The education level is low. They follow the traditional practice done over the ages. There is lack of extension activities to introduce scientific way of feeding and management of pig to bring a change in the knowledge, attitude and skill of the farmers. The farmers do not know how to select piglets of high quality.

11. Lack of easy credit facility

Finance has the key role to play for development of piggery. A pig farm should always be equipped with necessary equipments, nutritious food, medicines and chemicals. But most of the pig farmers are small and marginal. So, they do not have sufficient capital investment for establishing infrastructure. Negligence of bank to provide loans in livestock enterprise, applying loan takes lengthy procedure and to get a bank loan, land properties have to be mortgaged. But many farmers are landless and those who have land property are reluctant mortgage land for fear of losing it in case they are unable to repay bank loan. So, most of the farmers in rural areas go to the money lenders, like Mahajan or Dalai and pay higher interest which ultimately minimize their amount of profit.

Strategy of pig rearing in NE region

There is immense potential to augment the productivity of pig farming and bridge the gap in production and demand of pork in NE India.

1. Piggery development policy

There is a need to evolve a comprehensive piggery development policy in NE region of India involving the Agricultural University, Department of Agriculture, Department of Industry and the Department of Veterinary and Animal Husbandry.

2. Breeding policies

The Government should encourage genetic improvement of the indigenous non-descript animals through crossbreeding with superior germplasm. Upgrading of indigenous breeds with exotic breeds should be done in keeping the interest of the farmers. At the same time, measures should be taken to conserve the indigenous pig germplasm i.e. improvement should be done through selective breeding.

3. Adequate AI and pregnancy diagnosis facility

There should be adequate facility for A.I and pregnancy diagnosis at farmer's door to improve the reproductive potential of the pigs.

4. Availability of good quality breeding pigs

There should be availability of good quality breeding pigs to the farmers so as to improve the productivity and reproductive capacity of the indigenous pig.

5. Establishing a compound feed manufacturer

The Government should encourage establishment of compound feed manufactures unit for exploiting non-conventional feed resources, to produce economic ration. The cost of concentrate feed is very high in this region as it is imported from other states of India.

6. Alternative feed resource

The emphasis should be given for use of non-conventional feed resources like cassava leaves, potato leaves, water hyacinth, banana stems and there should be establishment of a compound feed manufacturer for efficient utilization of non-conventional feed resource as a source of pig feed. Presently, much interest in tropical countries in the use of cassava leaves as a replacement for soybean meal and fish meal in pig diets. Fresh cassava leaves can be fed at 41% of the diet, with no apparent signs of toxicity. Water spinach (*Ipomoea aquatica*) does not appear to contain anti-nutritional compounds and has been used successfully for growing pigs as the only source of supplementary protein in a diet based on broken rice.

7. Extension of health care services

NE India with its porous international border possesses huge threat for emergence of exotic diseases like PRRS and frequent occurrence of outbreak of swine fever, FMDs etc. Inefficient health care services and lack of availability of medicines and vaccines aggravate the situation further and often leads to failure of pig production system. Timely prophylactic measures and emergency of services for treatment of pigs should be made available.

8. Modern disease diagnostic laboratory

There should be modern disease diagnostic laboratory to keep strict vigilance on diseases and their prevention. Unfortunately, most of the farmers neglect diseases and parasite infestation at the early stage

which result in serious problems eventually leading to serious losses in the productivity and profitability. It has been proved that adoption of treatment after outbreak of diseases is more expensive.

9. Availability of modern Slaughter House

Slaughter house or abattoir is a place or a building or premise, licensed by appropriate authority, where animals are killed under hygienic condition for human consumption. The slaughter house plays a vital role for supplying quality and wholesome meat to the consumers. So the slaughter house should have adequate facilities of potable water, electricity, drainage and affluent disposal system, cold storage, quality control laboratory, space for antemortem and postmortem inspection, byproduct utilization system etc. The butchers available in the towns should slaughter the required number of live animals only in the slaughter houses and pay a fee to the concerned authority.

10. Establishment of organized market

Establishment of organized networks of market so that the livestock farmers get due share for their products. Organized market involves participation of Government institution or Co-operative federation. The basic motive of the organization is to see that the consumer price doesn't fluctuate violently. This will eliminate the middlemen and the farmers will get the fair price of their products.

11. Technical Guidance and Training

Various training programs should be organized at various places to impart technical knowledge. Besides these regular training programmes, Government should organizes short time training programmes for the extension of the scientific culture. To popularize the scientific culture of pig farming, the veterinary department should organize publicity programmes through different media such as books and pamphlets, TV and Radio broadcasting, exhibition etc.

12. Scheme for pig insurance

There should be provision for insurance to pig farmers in case of sudden death of pig, any epidemic condition, during any natural calamities like flood, etc.

Conclusion

The NE India being an agricultural rural based the scope for piggery production has high potential, because of the food habit of the inhabitants, being mostly non-vegetarian. It also has significance in many spheres of the life of people viz., public functions, social gathering and religious ceremonies. So, the traditional local pig rearing system should be gradually transformed to scientific rearing practices. And suitable measures should be taken to overcome the various constrains faced by the farmers in order to harness the maximum production potential and improve the quality of meat of pig and it's by products by state government and other NGOs, so that it can meet at least the growing demand of pork in the NE states of India. This will also uplift the socio-economic status of the pig rearers and overall development of the NE states of India.

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Current status of piggery in North East India

Table 1: Pig population in different states of India.

State	Population 2012 (million)	Population 2019 (million)	Per cent change
Assam	1.64	2.10	28.30
Jharkhand	0.96	1. 28	32.69
Meghalaya	0.54	0.71	29.99
West Bengal	0.65	0.54	-16.63
Chhattisgarh	0.44	0.53	20.01
Uttar Pradesh	1.33	0.41	-69.37
Nagaland	0.50	0.40	-19.65
Bihar	0.65	0.34	-47.14
Karnataka	0.30	0.32	6.25
Mizoram	0.25	0.29	19.26

Source: 20th Livestock Census 2019.

Table 2: Pig population in North East India of India

State	Population 2012 (thousand)	Population 2019 (thousand)	Per cent change
Arunachal Pradesh	356	271	-23.88
Assam	1639	2099	28.30
Manipur	277	235	-15.16
Meghalaya	543	706	29.99
Mizoram	245	292	19.18
Nagaland	504	405	-19.65
Sikkim	30	27	-10.00
Tripura	363	206	-43.25
Total	3957	4241	8.00

Source: 20th Livestock Census 2019.

Table 3: List of major indigenous and crossbred pigs in India.

Indigenous pig breeds		Crossbred pig breeds	
Name	**Home tract**	**Name**	**Developed by**
Ghoongroo	West Bengal	Rani	ICAR-NRC on Pig, Assam
Niang Megha	Meghalaya	HD-K75	AICRP on Pig, CVSc, Assam
Agonda Goan	Goa	Mannuthy white	AICRP on Pig, CVSc, Kerala
Tenyi Vo	Nagaland	TANUVAS KPM Gold	AICRP on Pig, TANUVAS, Tamil Nadu
Nicobari	Andaman and Nicobar	Asha	ICAR-NRC on Pig, Assam
Doom	Assam	Jharsuk	AICRP on Pig, BAU, Jharkhand
Zovawk	Mizoram	Lumsniang	AICRP on Pig, ICAR-RC for NEH, Meghalaya
Ghurrah	Uttar Pradesh	SVVU-T17	AICRP on Pig, SVVU, Andhra Pradesh
Mali	Tripura	Landlly	AICRP on Pig, ICAR-IVRI, Uttar Pradesh
Manipur Black Pig	Manipur		AICRP on Pig, CAU, Imphal
Purnea	Bihar and Jharkhand		

Source: ICAR-NBAGR website.

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Legumes' Contribution to Increasing Soil Fertility

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Legumes are likely to play a significant role in boosting soil carbon sequestration. Beyond the importance of nitrogen fixation and high protein meals, they may also offer a number of additional significant benefits. These include positive effects on soil quality and biodiversity. Creating the function of legumes and their contribution to both the sustainable intensification of manufacturing and the livelihoods of small holder farmers in many parts of the world requires a lot of attention. In addition to being used as food and animal feed, they play a critical role in preserving soil fertility by fixing atmospheric nitrogen, improving soil structures, and providing organic matter. Additionally, it typically serves as an intercrop, protects plants, and occasionally it is because of its short life cycle, it is grown as emergency vegetation. This crop is relatively profitable from an economic standpoint because it needs little fertilizer and other inputs. By storing carbon and reducing other pollutants, it also enhances environmental quality. Additionally, some kinds of legumes have the ability to remove toxic metals and organic contaminants, making them a viable plant team.

Nitrogen fixation

Protein content is noticeably high in the tissue of legume plants and seeds. This is immediately explained by a legume's ability to meet the majority of its own nitrogen requirements thanks to symbiotic rhizobia microorganisms found in their roots. Legumes that have been exposed to the appropriate strain of rhizobia bacteria can provide up to 90% of their own nitrogen (N). Rhizobia bacteria enter the root via passing through the root hairs soon after a legume seed germinates in the presence of the soil-borne rhizobia bacterium. Infected roots enlarge, forming pale pink nodules as a result of the bacteria multiplying. The microorganisms that eat the carbohydrates produced by the above-ground plant during the process of photosynthesis subsequently use the nitrogen gas already present in the soil and air to fuel. Protein content is noticeably high in the tissue of legume plants and seeds. This is immediately explained by a legume's ability to meet the majority of its own nitrogen requirements thanks to symbiotic rhizobia microorganisms found in their roots. Legumes that have been exposed to the appropriate strain of rhizobia bacteria can provide up to 90% of their own nitrogen (N). Rhizobia bacteria enter the root via passing through the root hairs soon after a legume seed germinates in the presence of the soil-borne rhizobia bacterium. Infected roots enlarge, forming pale pink nodules as a result of the bacteria multiplying. The microorganisms that eat the carbohydrates produced by the above-ground plant during the process of photosynthesis subsequently use the nitrogen gas already present in the soil and air to fuel. The gradual breakdown of the nodules, roots, and above-ground plant leftovers in a legume crop results in the release of nitrogen. When soil microorganisms die, the extremely nitrogen-rich organic material is broken down, releasing the nitrogen into the soil. Typically, two-thirds of the nitrogen fixed by a legume crop comes in handy during the following growing season after a legume in a rotation.

Benefits of legumes for improving soil quality

Legumes have a number of benefits for soil quality, including increasing soil organic matter, enhancing soil porosity, recycling nutrients, enhancing soil structure, lowering pH levels, diversifying microscopic life forms in the soil, and reducing disease and weed problems associated with grass-type crops.

Natural dependencies of the soil

Since legumes contain a lot of protein, they are also nitrogen-rich. The nitrogen provided by legumes enables the decomposition of crop residues in the soil and their conversion to soil-constructing natural matter because most crop residues contain far more carbon than nitrogen and soil microorganisms require both.

Soil permeability

A number of legumes have robust taproots that can penetrate the soil up to 6-8 feet deep and are half an inch in diameter. Earthworms and the tunnels they make are encouraged by nitrogen-rich legume leftovers. The earthworm burrows and root pathways increase soil porosity, allowing for deeper water and air infiltration.

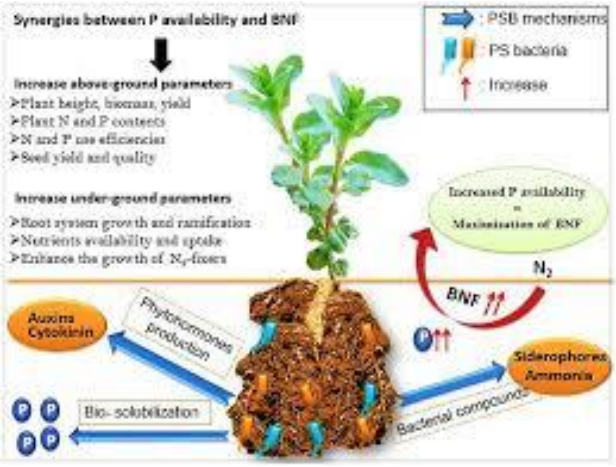
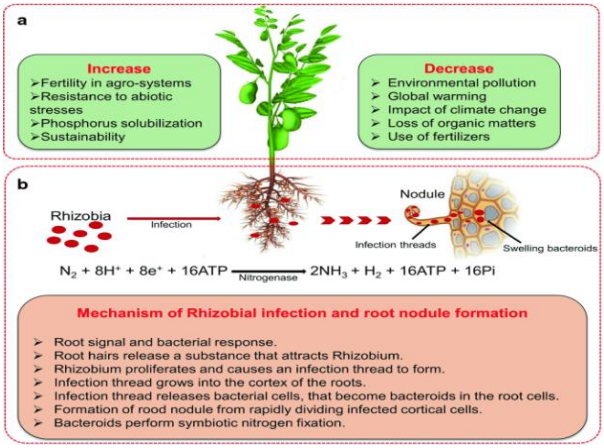


Figure 1 & 2: Biological Nitrogen - fixation

Reuse vitamins



Perennial and biennial legumes have deep roots that enable them to recycle agricultural nutrients that are found deep in the soil profile. This results in a more environmentally friendly use of used fertilizer and avoids nutrients from being wasted owing to leaching under the roots of shallower-rooted crops in the rotation.

Enhance the soil's morphology

More stable soil aggregates have been found, which is what is responsible for the benefits. Glomalin, a protein that coexists with other plants in symbiosis along legume and other plant roots, acts as a "glue" to link soil particles into solid aggregates. Since there is more pore space and tilth due to the increased aggregate stability, soil erodibility and crusting are decreased.

Reduced soil pH

The pH of the soil is ultimately lowered by inoculated, nodulated legumes because they obtain their nitrogen (N) as diatomic N from the air rather than from nitrate in the soil. In trials conducted in greenhouses, alfalfa and soybeans reduced the pH of a clay loam soil by a full pH unit. On soils with a pH that is higher than what is ideal for crop growth and development, legumes may help lower the pH and stimulate plant-soil microbial activity.

Improved soil chemistry due to the use of legume crops

The ability of soil to retain or denaturize harmful chemical compounds or other components for the agroecosystem and to give vitamins for crop growth are both related to soil's chemical qualities for sustainability. The main chemical components used to assess soil fertility are soil organic carbon concentration, pH, nutrient levels, and soil cation alternate capacity (CEC). Leguminous crops have been linked to soil chemical features, making it simple to interpret their specifics and allow for a quick improvement through N-fixation and root biomass. The pH of the soil's rhizosphere is altered by legume-based rotation. Legumes' root exudation and the alteration or release of organic acids on the epidermal cells' root surfaces can both increase the availability of P.

Conclusion

Legumes benefit the agroecosystem, agricultural productivity, soil conservation, soil biology, SOC and N stocks, soil chemical and physical properties, biological nitrogen-fixation, nitrous oxide emission, and nitrate leaching by reducing the need for chemical fertilizers.

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Green Farming: Pioneering a New Era of Sustainable Agriculture

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Traditional farming practices have been instrumental in feeding the world's growing population, but they have also taken a toll on the environment, depleting soil fertility, polluting water sources, and contributing to greenhouse gas emissions. In response to these challenges, a new approach to farming known as "Green Farming" is gaining momentum. Green Farming focuses on integrating sustainable practices that prioritize environmental conservation, soil health, and resource efficiency, while still meeting the demand for food production. This article explores the concept of Green Farming and its potential to revolutionize agriculture.

What is Green Farming?

Green Farming often referred to as sustainable or eco-friendly farming is an innovative approach that seeks to balance agricultural productivity with environmental stewardship. Unlike conventional farming, which often relies heavily on synthetic fertilizers, pesticides, and intensive monoculture practices, Green Farming employs a range of strategies aimed at reducing the ecological footprint of agriculture.

Key Principles of Green Farming:

1. **Crop Diversity:** Instead of monoculture practices, Green Farming promotes the cultivation of diverse crops. This helps maintain soil fertility, reduces the risk of pest and disease outbreaks, and supports local ecosystems.
2. **Soil Health:** Green Farming places a strong emphasis on soil health and fertility. Practices such as cover cropping, reduced tillage, and organic matter incorporation improve soil structure, water retention, and nutrient cycling.
3. **Natural Pest Management:** Integrated Pest Management (IPM) is a cornerstone of Green Farming. Beneficial insects, companion planting, and biological controls are utilized to minimize the use of chemical pesticides.
4. **Water Conservation:** Efficient irrigation techniques like drip irrigation and rainwater harvesting are integrated to minimize water usage and prevent soil erosion.
5. **Renewable Energy:** Green Farms often employ renewable energy sources like solar panels and wind turbines to power their operations, reducing reliance on fossil fuels.
6. **Local and Organic Focus:** Green Farming supports local food systems by producing and consuming locally. Organic farming practices, which avoid synthetic chemicals, are often adopted to reduce environmental contamination.

Benefits of Green Farming:

1. **Environmental Preservation:** By minimizing the use of chemicals, reducing soil erosion, and conserving water, Green Farming helps protect biodiversity, reduce pollution, and combat climate change.
2. **Sustainable Resource Use:** This approach aims to ensure that the resources used in agriculture, such as soil and water, are not depleted but rather maintained for future generations.
3. **Enhanced Food Quality:** The focus on natural, organic practices can lead to higher nutrient content and better-tasting produce.
4. **Resilience to Climate Change:** Diverse cropping systems and improved soil health make Green Farms more resilient to extreme

weather events and changing climatic conditions.

5. **Economic Viability:** While transitioning to Green Farming may require initial investment, the reduction in input costs and the potential for premium prices for organic produce can lead to long-term economic viability.

Challenges and Future Outlook:

Transitioning to Green Farming is not without its challenges. Farmers may face a learning curve as they adopt new practices, and there could be yield fluctuations during the transition period. Additionally, scaling up Green Farming to meet global food demand will require policy support, funding, and education.

However, the potential benefits far outweigh the challenges. As consumer awareness about sustainable food production grows, demand for environmentally friendly products is also on the rise. Green Farming could play a crucial role in ensuring food security while safeguarding our planet for future generations.

Conclusion

Green Farming represents a new paradigm in agriculture, emphasizing harmony between food production and environmental conservation. By embracing principles that prioritize biodiversity, soil health, and resource efficiency, Green Farming has the potential to pave the way for a more sustainable and resilient agricultural future. As technology advances, and awareness of the importance of sustainable practices grows, the Green Farming movement is likely to gain even more momentum, offering a promising path forward for farmers, consumers, and the planet alike.

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Bio Dynamic Preparations and Biodynamic Compost

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Biodynamic agriculture, a form of alternative agriculture, developed by Rudolf Steiner in 1924, was the first of the organic agriculture movement. A distinguishing feature of biodynamic farming is the use of nine biodynamic preparations for the purpose of enhancing soil quality besides stimulating plant life and biodynamic compost to recycle organic wastes as well as enhance soil health. Together, the BD preparations and BD compost may be considered the cornerstone of biodynamics.

Bio dynamic preparations

Method of preparation

Horn manure (BD-500)

Fresh cow dung is whipped to prepare a thick smooth paste. The empty lactating cow horn shells are filled with this paste. The filled horns are placed in the pit in upright position with the pointed closed end of horns facing upwards. After that, the pit is filled with good fertile soil and compost mixture (25 : 1). The soil of the pit is to be kept moist for all the time. October-November is the most ideal period for burying the dung filled horns in pits. The horns are kept buried for approximately six months and are taken out during March-April. Compost should be moist and should have a pleasing smell.

Horn silica (BD-501)

Large pieces of Quartz silica is crushed with large mortar covered with cotton cloth. After grinding, the crushed material is sieved to obtain finer quarts silica material and then it is made into paste with water. Quartz silica flour paste is filled in empty cow-horn shells. Opposed to BD- 500, buried vertically during March-April and taken out during October - November.

Yarrow preparation (BD-502)

Dried yarrow (*Achillea millefolium*) blossom is moistened and packed into the dried bladder of deer stag or hart. The bladder is kept into the sun for 3 months and then buried into good soil at the end of September-October. The deer bladders are taken from the ground at the end of March -April. Soil must be removed very carefully from the preparation. As soon as the soil is removed, the bladder can be opened. Finally, the pit can be filled with fertile soil. If the location was convenient, it can be used for the same purpose in the following year.

Chamomile Preparation (BD-503)

Dried chamomile blossoms (*Matricaria chamomilla*) are moistened and stuffed tightly into the cleaned small intestine of a freshly butchered cow. The intestines are hung in a sunny place for at least three months before being buried in the soil. The intestines are buried at the end of September-October. Since the intestines are usually very dry after several months in the air, they must be dipped into a bucket filled with water before burying so that the chamomile inside the intestine is well moistened. The intestines should be lifted very gently from the ground in April. Soil must be removed very carefully from the preparation. If the preparation is too moist, it can be dried in an airy and shady place for a short time.

Stinging nettle preparation (BD-504)

The wilted stinging nettle (*Urtica dioica*) are squeezed in evenly and firmly in pot/ crate and closed the opening. The containers are buried in soil for one full year, enclosed in a mantle of peat moss. After 12 months the finished preparation can be dug up. The remains of the nettle is now very small. Care must be taken to ensure that it is not mixed with soil or peat. The preparation is of a dark black colour. Before the preparation is filled into a container, the remaining stems can be broken up into smaller pieces.

Oak bark preparation (BD-505)

Scrapings of the outer rind of oak bark (*Quercus robur*) are placed in the skull cavity of a domestic animal (sheep/horse/goat) in September-

October and closed the opening with bone. Before filling, the finely crushed bark should be moistened with some water. The bark can be filled into the brain cavity by hand or with the help of a funnel. The skull is placed in the barrel having a closable drain near the bottom. Skull should be surrounded with half rotten plants and soil. Water should regularly flow into and out of the barrel. The skulls can be taken out from the barrel in March-April. The preparation is of a brownish-reddish colour and has adequate humidity. In most areas, animal skulls are widely available, so new skulls can be obtained every year. If this is not possible, well-cleaned skulls can be stored and re-used next year. However, the skull should not be stored in the sun.

Dandelion preparation (BD-506)

Both the dandelion flowers and the animal sheaths (*omentum/mesentery*) can be used when fresh or dried. The fresh or dried and moistened flowers of Dandelion (*Taraxacum officinale*) are pressed into a ball and wrapped in a piece of the *omentum*. The ball is wrapped with a string and tied. Alternatively, the fresh or dried and moistened flowers of Dandelion are wrapped in dried mesentery (membrane holds intestines) of cow. The dandelion preparation is hung in a sunny place for at least three months. It must be dipped into a bucket filled with water before burying, to moist the dandelion. The preparation is buried in soil at the end of September-October, filled with fertile soil and well-marked. It is taken out from ground in March-April and soil adhered to the preparation has to be removed very carefully.

Valerian preparation (BD-507)

The petals of Valerian (*Valeriana officinalis*) are filled into a bottle to about one third and the bottle is filled with rainwater or clean water. The vessel should not be closed tightly to allow gas to escape and the content is mixed well. The vessel is hung up in a tree in partial shade for 10 – 14 days. The liquid is filtered and filled into bottles.

Horse tail Preparation (BD-508)

100 g of dried horsetail (*Equisetum arvense*) or 500 g fresh horsetail is required for one hectare. The plants are crushed into small pieces after drying. The crushed parts are ground into fine powder. 100 g of dried horsetail is soaked in 4 litres of clean water for one day. The content is boiled on low heat in a covered pot for 60 minutes and the tea has to be cooled.

Storage of preparations

BD 500 and BD 502 – 506

These preparations are stored separately in a dark and cool place. Each preparation surrounded by peat or coconut fibre on all sides must be stored separately. Vessels made of ceramic, earthenware, glazed clay pots or glass are suitable and the vessels are stored in wooden boxes. The vessels in the wooden boxes must be surrounded on all sides, including the top and bottom of the box by a layer of peat or dried coconut fibre of 10 cm thickness.

BD 501

The silica preparation can be put into a clean, transparent glass container and stored in a light and dry place. On a windowsill exposed to the morning sun is a good choice; intense and direct midday sun should be avoided. The preparation can also be kept in the horns until use. Filled horns should be stored in a bright and sunny place. It should never be stored in the dark. As long as the preparation is kept in a dry and bright place, it can be used for many years.

BD 507

The freshly prepared valerian preparation is bottled. The bottles should be stored in a dark and cool place. During the first weeks after bottling, fermentation gases can develop and must be able to escape, so bottles should not be tightly closed at first. When gas formation has stopped, bottles can be closed tightly. Stocks should be checked yearly once. During storage, a yeast layer formed on the liquid can easily be removed. If necessary, the preparation can be refiltered with the help of a fine, clean sieve. If well-produced and stored under good conditions, valerian

extract lasts for a very long time and keep its typical valerian scent for years.

Method of application

BD-500

100 g of BD-500 should be mixed in about 25-50 lit of rain or fresh tube-well water/ha by whirling with hand for one hour. It should be applied on soil surface or as foliar spray twice a year, at the beginning and at the end of the season. The best time of application is close to sunset. Best results can be obtained when apply it close to full moon days.

BD-501

4g of BD 501 has to be mixed in 25-30 lit water/ha by whirling with hand for one hour. It should be carefully filtered immediately after stirring and foliar sprayed as fine mist in early morning hours using knapsack sprayer. First dose at 3-4 leaf stage followed by two more times at 30 days interval.

BD 502 – BD 507 (Biodynamic Compost preparation)

2 g per 502 - 506 preparation and 5 ml valerian extract are required for heap of 5 – 10 m x 1.5 – 2 m x 1.5 m. Holes of 50 cm deep should be made into the compost heap by sharpened wooden stick diagonally at regular intervals of 0.5 to 1 m in small compost piles and 1.5 to 2.5 m in long heaps or windrows. The holes can be made either as staggered on the sides of the compost heap or on the top along the compost pile.

BD 508

Before spraying, the horse tail tea can be filtered and diluted with water at 1:9 ratio and stirred for 20 minutes before spraying. For application knapsack/backpack sprayers are suitable; for larger areas spraying is carried out with tractor mounted sprayers. Spraying on three consecutive days is recommended. Furthermore, as a preventive measure Equisetum tea can be sprayed on vulnerable crops in the early stages of growth.

Uses of biodynamic preparations

BD 500 and BD 501 are applied as a foliar spray to stimulate and regulate the plant growth. The next six preparations, BD 502 to 507, are used in making compost. BD 508 is used as foliar spray to suppress fungal diseases in plants.

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The Red-Banded Caterpillar in Mango Orchards: A Threat to Delicious Harvests

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Mango, referred as the king of fruits, holds a vital place in the agricultural landscape of numerous tropical and subtropical regions. It serves as a significant source of income and nutrition for millions of people worldwide. Notably, India stands as the largest producer of mango globally, contributing to 52.63% of the total mango production. Mango cultivation occupies 37.61% of the total fruit cultivation area in the country and contributes 22.21% to the overall fruit production.

However, mango farmers confront several challenges, with pest infestations emerging as a pressing concern. One such threat to mango orchards is the red-banded mango caterpillar (*Autocharis albizonalis*) Hampson. Among the various pests that target mango trees, the red-banded caterpillar is responsible for commercial crop losses ranging from 10% to 52%.

In this article, we delve into the identification and characteristics, symptoms of damage to mango fruit, damage caused by red-banded caterpillars, lifecycle of red-banded caterpillar, management strategies for combating the red-banded caterpillar menace in mango orchards and conclusion. By shedding light on the significance of addressing this pest, we aim to safeguard mango yields and ensure fruit quality.

Identification and Characteristics

- Red banded caterpillars typically have a distinctive red or reddish-brown band or stripe running along their body having a black 'collar' near the head.
- Mango sap stain streaks on mango skin may indicate the presence of an entry or exit hole caused by the red banded mango caterpillar.

Symptoms of damage to mango fruit.

- The main damage is caused by larvae which make holes in the fruit and eat the pulp. As the larvae mature, they further burrow into the kernel and stay in the seed.
- Along with the fruits, these pests also pierce the mango kernels.
- The presence of a liquid exudate from the mouth of a tunnel chewed by the caterpillar through the skin is a usual sign. This liquid trickles down to the tip of the fruit and accumulates. Although almost clear when fresh, the liquid darkens and shows up as a dark streak on the skin leading to a dark spot at the fruit tip.
- Affected fruits drop prematurely. Effects on mango fruit quality, market value, and export potential.
- When an attacked fruit is cut open to expose the inside of the seed, the larvae are likely to be seen tunnelling in the seed, but can also be present in the flesh.

Damage Caused by Red-Banded Caterpillars

- It is a pest of mango fruit in all stages of fruit development, feeding on both the flesh and the seed.
- First and second instar caterpillars fed just beneath the skin surface, tunnelling towards the seed.
- Later instar larvae fed on the inner content of the fruit i.e the seed.

Lifecycle of red-banded caterpillar

The pest has a short life cycle with 3 to 4 generations during the fruiting season. According to (Sahoo and Das, 2004) April-May was the congenial period for the fruit borer infestation when the fruits were medium in size. The life cycle of a red banded caterpillar is as follows:

- Eggs are typically laid on the fruit stalk (peduncle).
- Marble-sized fruit are preferred for egg laying.
- Eggs are usually laid in groups of two though single egg laying and egg masses containing up to 14 eggs (Krull and Basedow, 2006).
- Early-season moths may lay larger numbers of eggs than moths occurring later in the flowering season.
- After 7–12 days the eggs hatch into larvae, which tunnel into the fruit flesh and then into the seed.
- The larvae enter the fruit usually through 1 bore hole.
- Larvae feed for 15–20 days, passing through 5 growth stages (instars) as they grow.
- The first 2 instars feed on mango flesh, the later instars feed on the mango seed.
- The larvae can produce a strand of silk which they can use to move to other fruit or to nearby fruit on other trees when they run out of food, or to drop down onto the tree bark or soil to pupate.
- Pupation occurs under the bark of mango trees or in the soil and usually takes around 20 days. Larvae leave the fruit to pupate. There have been reports of larvae pupating inside the fruit, with the adult moth emerging through an exit hole. Adult moth emergence may be triggered by the onset of flowering.
- Once the adult moth emerges, after mating, the female will commence egg-laying.
- Adult female moths may live for 3–9 days and adult moths emerged from pupae during mango off-season, Krull (2004).
- Adult moth lays egg on fruits.
- The moths are mostly nocturnal, spending their time resting under leaves during the day.

Integrated Pest Management Strategies

- Cut and destroy the fallen fruit that may be infested or harbouring caterpillars.
- Protect the healthy fruits from infestation by covering them with a bag or sleeve.
- Maintenance of field hygiene/sanitation by collection and destruction of all fallen fruits
- Annually prune new mango trees to keep the trees smaller and easy to manage.
- Deposed of any pruned branches or infested plant material away from your orchard.
- Use pheromone traps to monitor and trap adult moths before they lay eggs.

- Spray neem oil at an interval of 15 days for 2 months after the mango fruit is visible.
- Spraying should be done at flushing, flowering and marble stages. This is because chemical control after the larva tunnels into the fruit is not very effective.
- Use of Lambda Cyhalothrin 5 EC @0.5-1 ml/lit water.
- Spray deltamethrin 0.0028 % (deltamethrin 2.8 EC@ 1ml/lit) at marble size and repeat after two weeks
- Two sprays of thiacloprid 21.7 SC 0.04 % (@ 2ml/lit) at 25-30 days interval.
- A single spray is never adequate. Always do repeat sprays for effective control.
- Note: All spray must be done during morning hours.

Conclusion

The red-banded caterpillar poses a significant threat to mango orchards, jeopardizing both crop yields and quality. However, through an understanding of its lifecycle, proper identification, and the implementation of effective integrated pest management strategies, mango farmers can protect their precious harvests and ensure a brighter future for mango cultivation. With ongoing research and cooperation among farmers, scientists, and policymakers, we can work towards sustainable solutions to mitigate the impact of this formidable pest on mango production.

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Anthocyanin Pigments of Banana Flower Bracts as Food and Pharmaceutical Ingredients

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The public and consumers are now-a-days increasingly concerned about the adverse health effects of synthetic dyes used as colorants in foods, drinks and confectioneries as they tend to cause adverse behavioral and neurological effects particularly in children. In such scenario, food manufacturers are searching for new sources of natural pigments particularly of plant origin with high tinctorial power, stability and low cost for use as natural food colorants. One of the useful natural colorants is anthocyanin pigments as substitutes for synthetic chemical for food industries. The interest in anthocyanin pigments has increased significantly because of their different bright attractive colors, ready water solubility coupled with potential health promoting effects on the consumers. The capacity of anthocyanins to exhibit varying colors under different *p*H conditions, the ease for incorporation into aqueous systems due to high water solubility and their greater stability over the higher temperatures is the added advantages of anthocyanins as natural food colorants. For example, anthocyanins provide intense color under acidic conditions, which make them preferable food colorants in moderately acidic foods such as yogurt.

Banana flower bract is a natural abundant source of anthocyanin pigments. Banana flower also called blossom or bell is a male bud of inflorescence after complete opening of female (pistillate) flowers (Fig. 1a & b). Bracts may be of magenta or maroon or purple-red in color depending on the variety (Fig. 2). Male buds are agricultural waste and discarded as residue in abundance in banana culture fields. In India, the florets, after removal of pistil and calyx, are used as main ingredient in preparation of pickle and fritter in Southern part of the country whereas bracts are not used or eaten. However, in The Philippines, Sri Lanka and Zambia and South-East Asian countries like Cambodia, Laos, Thailand and Vietnam, and also in Brazil, the bracts are used as pie filling and in meat based meals. Dried bract flour is also used in the diet because of high content of minerals such as potassium and dietary fiber.

Fig. 1a: Banana flower

Fig. 1b: Banana flower

Fig. 2: Banana flower bracts

The major anthocyanidins present in bracts of *Musa acuminata* are cyanidin, delphinidin, malvidin, peonidin, and petunidin; that of *M. balbisiana, M. velutina* and *M. laterita* are cyanidin and delphinidin; in *M. coccinea* as pelargonidin and cyanidin and as peonidin and malvidin in *M. flaviflora, M. ornata* and *M. violascens*. Most of the commercially cultivated banana varieties in the country belong to *M. acuminata*

and *M. balbisiana* and other *Musa* spp. are grown in Northeastern part of the country.

India leads the world in the production of banana with an annual production of 33.1 million tonnes, which is the 30% of global production. It is a fruit food plant cultivated throughout the year in the country and from economic perspective, bracts may be one of the best potential sources of anthocyanins and commercial viability of anthocyanins production is very much possible from the bracts as the bracts are totally unutilized in the country. Red cabbage, which contains only 25 mg/100 g anthocyanins, is used for commercial production of anthocyanin pigments. In a systematic study, it is found that the yield of anthocyanins from bracts of banana flowers varied between 46 to 95 mg /100 g on fresh weight basis and amount of the pigments present in the banana bracts is higher than red cabbage. The bracts of some of the

Table 1: Total anthocyanins in flower bracts of banana cultivars and genotypes

Cultivar	Contents (mg/100 g fr. wt.)
Red Banana (AAA)	95
Nendran (AAB)	83
Poovan (AAB)	70
Rasthali (AAB)	69
Pachanadan (AAB)	67
Hill Banana (AAB)	66
NeyPoovan (AAB)	66
Udhayam (ABB)	63
Saba (ABB)	55
Karpooravalli (ABB)	49
Grand Naine (AAA)	46
Genotypes	
Monthan II	350
Bhat Manohar	270
Kallumonthan	200
Calcutta 4	150

banana genotypes like Monthan II, Bhat Manohar, Kallumonthan and Calcutta 4 possess more than 150 mg of anthocyanin pigments per 100 g of bracts (Table). In Indian banana cultivation system, a hectare produces 2,400 male flowers and considering a flower yields 0.5 kg of pigment producing bracts, approximately around one kg of anthocyanins would be obtained from a hectare of banana cultivation.

Further on utilization of anthocyanin pigments extracted from flower bracts Red Banana (Fig. 3), several value-added products were produced, characterized and evaluated for their consumer acceptability. Among the value-added products, the squash (Fig. 4) and ice cream infused with anthocyanins were found to be excellent products and the consumer acceptability to these products were very high.

Fig. 3: Anthocyanins extracted from banana flower bracts

Fig. 4: Squash infused with anthocyanins from banana flower bracts

Anthocyanins possess a large gamut of health-promoting effects in animals and human because of their potent antioxidant activities. The foremost health benefit of anthocyanin pigments is that it is a great reliever of oxidative stress. Reactive oxygen species (ROS) like free radicals, singlet oxygen, and peroxides play roles in cell signaling and immune system of the body and if ROS are produced in excess, they cause cellular damage resulting in degenerative problems such as inflammation, aging, cardiovascular, and cancer diseases. The anthocyanins are very effective in quenching the excessive free radicals and terminating the reactions responsible for the oxidative damage. Obesity is a metabolic disorder of excessive accumulation of adipose tissue caused by the

imbalance in energy intake and expenditure. Anthocyanins are found have high anti-obesity effect

by ameliorating the function of adipocyte cells and thus may prevent metabolic syndrome related obesity. Another metabolic disorder is type 2 diabetes, which is a condition that pancreas in the body does not produce normal level of insulin or cells develop resistance to insulin. Long time ingestion of high fat or sugar diets and obesity are possible predisposing factors for type 2 diabetes development. As the anthocyanins have the potential to control obesity and thus, they may consequently prevent type 2 diabetes. Also, the high antioxidant activities of anthocyanins have capacity to protect β-cells from oxidative stress induced by sugars.

Anthocyanins play a significant role in the normal eye vision as normally higher amount of these pigments is found in the eye tissue as compared to brain and liver tissues of the body. Anthocyanins increase the ocular blood flow, prevent the progression of open-angle glaucoma and the impairment of photoreceptor cell function and inflammation of rhodopsin and have protective effect on visual function during retinal inflammation. Importantly, the pigments decrease the dark adaptation threshold of eyes. Anthocyanins also perform various functions beneficial to the brain health. Anthocyanins improve memory performance and delay the onset of decline of neural functions and improve cognitive and motor performance through inhibition of neuro-inflammation. One more important health-promoting character of anthocyanins is their anti-carcinogenic activity, which occurs due to cell cycle arrest and apoptosis in mutated cells.

Considering the multifunctional positive effects of anthocyanin pigments and consumption of them would be beneficial to human health and also considering the banana flower bracts as agricultural wastes containing very high level of anthocyanins, it would be highly economical to fully exploit bracts as raw materials for extraction of natural colorants of foods as well as for alleviating the human ailments.

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Suitable Growing Media for Roof Top Gardening

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Any garden in the roof of the building is termed as rooftop garden. Rooftop gardening is gaining popularity recently since it offers numerous benefits, such as enhanced air quality, energy efficiency, establishment of green spaces in metropolitan areas, hydrological benefits, temperature control, decorative benefit and can also be utilized to grow fresh fruits, vegetables and herbs. For nutrition and optimum health, an adult need about 90g of fruits and 300g of fresh vegetables on daily basis. Due to decreased land availability brought on by rising urbanization, industrialization, warming, and population development in recent years, it has become challenging to supply the daily recommended amount of fruits and vegetables. In order to boost productivity and output during the "green revolution," which was implemented to fulfill the country rising food demand, injudicious use of pesticides and fertilizers resulted in residual pesticide and other chemicals in the finished crops, raising health-related hazards. In metropolitan cities majority of the vegetables and fruits are transported from distant areas, as the horticultural produce are perishable in nature the freshness and the quality of the produce is compromised and the PPE packed fruits and vegetables sold at multi-complexes are even costlier. To overcome these problems urban residents are showing interest to grow several fruits and vegetables in their roof top garden.

The success of roof top gardening largely depends on the selection of the right kind of growing media and several challenges such as confined space, weight constraints and exposure to adverse weather conditions should be overcome to grow a crop successfully. Growing media is a substance or a combination of substances that gives developing plants nutrients, water, air, and physical support as well as serves as a conduit for the root system of the plant. Growing media should have good physical, chemical, biological properties so that it provides all the essential nutrient to the plant during the entire crop growth and development period. The physical properties of a media include water holding capacity, porosity, bulk density and aeration based upon these factors water availability varies. The chemical properties such as media pH, electrical conductivity, fertility and cation exchange capacity determines the mineral nutrients available to the plants. The biological characteristics, like the presence of helpful microbes, determine the rate of mineralization and decomposition of organic matter, which in turn promotes vigorous plant growth. The major considerations for selecting a suitable growing media are listed below:

- **Lightweight and Porous:** As rooftops are designed to support a specific amount of load and exceeding this weight limit can lead to structural damage therefore it is essential to procure lightweight growing medium that doesn't compromise the structural integrity of the building. Porosity is a crucial factor to consider for the luxuriant growth and development of plants as a porous material supplies an ideal air and water balance. The best options are potting mixtures or soilless blends, which often include components like perlite, vermiculite, or coconut coir. These components not only lighten the growing medium's overall weight but also increase its porosity, allowing for efficient water drainage and aeration.
- **Water Retention and Drainage:** Rooftop gardens have unique water management needs. They are constantly exposed to harsh winds and intense light, which may rapidly dry out the soil. On the other side, heavy precipitation could lead to waterlogging. Therefore, finding the ideal balance between water retention and drainage is essential. In order to keep plants moist during dry spells

and to prevent root rot, a good growing medium must be able to drain effectively. Compost or additional organic matter has the potential to retain water better, while perlite or coarse sand increase drainage.

- **Nutrient-Rich and pH balanced media:** Plants obtain nutrients from the growing media for growth and development. Therefore, it is essential to choose a nutrient-rich and balanced pH media. This can be achieved by regularly amending the growing media with organic compost or slow-release fertilizers. Most rooftop garden plants thrive in a slightly acidic to neutral pH range.
- **Container Gardening:** If weight restrictions or structural concerns are significant issues on rooftop, container gardening may be a suitable alternative. Container gardens provides an opportunity to choose specific growing media tailored to the needs of each plant, and it can be easily moved to optimize sun exposure or protect against adverse weather conditions.
- Inert growing media: The growing media should be free from any weed seeds, soil borne diseases causing insects, pests and nematode.

Traditional Growing Media

Despite the fact that soil is widely accessible and primarily utilized as a growing media by most of the growers, placing soil in a container result in growing conditions that are completely different from those of unrestricted field soil. Due to the restricted root growth that occurs when plants are cultivated in containers or pots, the growing media used to raise the crop should have a balanced composition of all nutrients and water. The soil-based growing media is unfavourable for crop growth because it contains weed seeds, pathogens that can cause disease, pests, and when the same soil is used repeatedly, it loses fertility and microbial diversity. When compared to soil-based growing media, soilless growing media are lighter, raise produce of higher quality, yield more food, have less of those nutrients leached out, are free of soil-borne pests, diseases, and weeds, and are more affordable.

Modern day growing media for roof top gardening

With the advancement in research on crop production under various growing systems several types of growing media have emerged to be suitable and highly profitable for growing different crops. As these growing media provides good mechanical support, optimum level of nutrients and water during the entire crop growth and development period. Easily accessible and widely used growing media for roof top gardening are:

- **Cocopeat:** It is a completely organic medium made from shredded coconut husks. It is a hormone-rich and fungus free medium used for speed germination of seeds and rooting. Finely shredded and steam sterilized, coconut coir offers plants an ideal rooting medium that also offers protection against root diseases and fungus. Unlike peat moss, which rapidly depletes from overuse, cocopeat can be reused. It does not have any nutrient so it should be used in combination with several composts and manures.
- **Vermicompost:** is the product of earthworm digestion and aerobic decomposition using the activities of micro- and macro-organisms at room temperature. Vermicompost is rich in nitrogen (2-3%), potassium (1.85-2.25%) and phosphorus (1.55-2.25%), micronutrients, beneficial soil microbes and contain plant growth hormones & enzymes.
- **Compost:** is a mixture of ingredients used as plant fertilizer and to improve soil's physical, chemical, and biological properties. It is commonly prepared by decomposing plant and food waste, recycling organic materials, and manure. The resulting mixture is rich in plant nutrients and beneficial organisms, which helps in mineralization and decomposition of organic matters.

- **Rice husk or hull**: Rice husks are the hard protective coverings of rice grains, which are separated from the grains during milling process. Rice husk is an abundantly available waste material of rice and it contains about 30%–50% of organic carbon. It has good water retention capacity and can be used as growing media in combination with several composts and manures.
- **Sawdust:** Sawdust (or wood dust) is a by-product or waste product of woodworking operations such as sawing, sanding, milling and routing. It is composed of small chippings of wood.
- **Vermiculite:** This compound contains both potassium and magnesium. It holds a lot of water and aids in drainage and aeration of the soil, though it is less durable than some other mediums, such as sand and perlite.
- **Perlite:** The most common types of media used in containerized systems of soilless culture are perlite (Boodley & Sheldrake, 1977). Perlite granules are very light and originate from a silicone mineral that forms in volcanoes. This medium is available from merchants in small to large bags for addition to growing mediums to increase drainage and aeration in the soil.
- **Peat Moss:** Peat moss retains moisture in growing mediums. Many brands of prepackaged potting soil include peat moss for use in container plants that require excess moisture. Tropical plants require extra moisture and warmth to and flourish.
- **Sphagnum Moss:** Its properties allow wide usage in correcting overly moist and overly dry soil alike. Heavy soils such as clay enjoy aeration and drainage with sphagnum moss so that the excess water may drain off and the clay does not absorb as much water. Light sandy soils benefit from sphagnum moss because it will retain moisture and nutrients by not allowing water to run off.
- **Sand:** A sedimentary material consisting of small, often rounded grains or particles of disintegrated rock, smaller than granules and larger than silt. The diameter of the particles ranges from 0.0625 to 2 mm.
- **Gravel:** is a loose aggregation of rock fragments. Gravel occurs naturally on Earth as a result of sedimentary and erosive geological processes; it is also produced in large quantities commercially as crushed stone.

Suitable Growing Media for Hydroponics

Recently hydroponics cultivation is gaining popularity in roof top gardening. Hydroponics is the technique of growing plants using a water-based nutrient solution rather than soil, and can include an aggregate substrate, or growing media, such as vermiculite, coconut coir, or perlite. In comparison to traditional soil-grown crop production hydroponics it provides several benefits such as:

- Up to 90% more efficient use of water.
- Production increases 3 to 10 times in the same amount of space.
- Many crops can be produced twice as fast in a well-managed hydroponic system.
- Decreasing the time between harvest and consumption increases the nutritional value of the end product.
- Indoor farming in a climate-controlled environment means farms can exist in places where weather and soil conditions are not favourable for traditional food production.
- No chemical weed or pest control products are needed when operating a hydroponic system.

Presently a wide variety of alternate porous materials are utilized in hydroponics as growing media, including inorganic mediums like mineral wool, growstone, perlite, and sand, as well as organic media like coconut coir, peat, and pine bark. Apart from these the different types of growing media which acts as a cushion for vegetable cultivation are:

a. **Foam mats (polyurethane):** polyurethane foam is used as cushioning for a variety of consumer and commercial products, including bedding, furniture, automotive interiors, carpet underlay and packaging.

Table 1: Different types of growing media for vegetable cultivation

Media composition	Crop	Reference
Cocopeat: vermicompost(1:1) cocopeat: perlite: vermicompost (2:1:1), cocopeat: perlite: vermicompost (1:2:1), cocopeat: perlite: vermicompost (1:1:2),	Bell pepper	Lari *et al.*, 2014
Cocopeat+vermicompost(70 :30), sand+ vermicompost (70:30)	Bell pepper	Nidhi. (2018)
topsoil: rice husk: poultry manure (4:0:1), topsoil:rice husk:poultry manure (3:1:1)	Carrot	K. P. Baiyeri *et al.*, 2019
Composted sawdust + Composted rice hull +Cured pig dung +Top soil, composted rice hull + composted sawdust + cured pig dung + top soil	Carrot	Utobo *et al.*, 2017
Cocopeat + saw dust (1:1 v/v), cocopeat: vermiculite (1:1).	Tomato	Subramani *et al.*, 2020.
Miscanthus shreds	Capsicum and tomato	Krasaka *et al.*, 2018
Husk charcoal growing media	Lettuce	Puraba *et al.*, 2020

b. Oasis (plastic foam): green blocks of sponge-like foam. Oasis is a trademarked name for wet floral foam, the spongy phenolic foam used for real flower arranging. It soaks up water like a sponge and acts both as a preservative to prolong the life of the flowers and a support to hold them in place.

c. Hydrogel: Hydrogel is basically a water absorbing polymer, classified as cross-linked, absorbing aqueous solutions through hydrogen bonding with water molecules. Agricultural hydrogels are referred to as water retention granules because they swell to many times their original size when they come in contact with water.

Conclusion

Rooftop gardening is gaining popularity in urban household as it is rewarding and an environment friendly way to utilize urban space, but success hinges on selecting the right growing media. Many businesses manufacture and deliver various types of growth media to customers' doorsteps in an effort to close the gap between the demand and supply of the appropriate growing media. It is necessary to raise knowledge of the effectiveness of various growing media and their financial engagement. Urban inhabitants can cultivate fresh fruits and vegetables at home scale with excellent understanding of the selection of appropriate growing media to suit the daily nutritional needs of the family.

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The Study on Biodiversity: A Comprehensive Overview and Significance

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Humans depend on variety for more than just the food, air, and water we eat and drink. Plants, animals, the land, water, the weather and people all live on Earth. Biodiversity has a direct effect on people's health, wealth, and safety, and we all have a part to play in the planet's ecosystems because, without it, our lives are in danger.

Biodiversity gives people the medicine they need to stay healthy and the materials they need to build their homes and clothes. However, there is more to it than that. Biodiversity also affects how diseases spread, what the local climate is like, and how well people and land recover after natural disasters.

Everyone is affected by the loss of biodiversity, but the most vulnerable people—those who are already on the outside and living in poverty—are hurt the most. When biodiversity is lost, it is especially dangerous for groups that are already weak. People who live in places that are prone to natural disasters, especially in low-income countries in the Global South, depend on wildlife in many ways. They are also in danger when species is in danger.

Biodiversity, which is short for "biological diversity," is the wide range of life on Earth, from the smallest microorganisms to the largest animals. Moreover, it is not just about rare or threatened species; it is about everything from genes and bacteria to whole ecosystems like forests and coral reefs.

Biodiversity is important for people and our world, and we could not live without it. It gives us food, clean water, and even medicine, which are all things we need to stay alive. Therefore, here is how to look at it. Biodiversity is we. It is like a big web where each species has a role to play.

However, here is the problem: people put too much stress on the world, which has a big effect on biodiversity. We are using up natural resources at a faster rate than ever before, which throws ecosystems out of balance and threatens species. Scientists think that the sixth mass extinction is happening on Earth right now. Scientists have named about 1.75 million different species. This includes 950,000 different kinds of insects, 270,000 different kinds of plants, 19,000 different kinds of fish, 9,000 different kinds of birds, and 4,000 different kinds of animals. This is just a small part of all the species that live on Earth. There are still a lot of species that have not been found or named. (National Geographic)

The three most important things to know about biodiversity

1. Since 1970, the amount of wildlife on Earth has dropped by more than two-thirds.
2. Indigenous peoples protect 80% of the world's biological variety, but they make up 19% of the world's poorest people.
3. Even if we stopped hurting the world in 50 years, it would still take between 5 and 7 million years for biodiversity to get back to how it was before humans.

What is Biodiversity?

To put it simply, biodiversity is all the different things in the natural world that make it possible for us to live. These things include clean water and air, food, and a stable temperature. Nevertheless, we do not have much time left to protect it.

Protecting places like woods and oceans is especially important because they clean and spread water, take in carbon dioxide, and keep us safe from natural disasters.

But we are putting biodiversity in danger: deforestation, farming, too much growth, and pollution are all big problems for this valuable system. Like how the number of fish in the ocean has dropped by half since 1970.

However, there is hope, which is good. In December 2022, government and business leaders signed a landmark agreement to protect biodiversity and stop the rapid decline of nature before it's too late. Part of this agreement was to protect 30% of the land, ocean, and inland waters of the world.

We also need to be smarter about how we use land. When people only think about what they can get right now, they often do harmful things that will hurt our planet for a long time. We need to protect unspoiled areas, fix up land that has been damaged, and take a more global approach that saves biodiversity and puts our shared future first.

What are the main things that cause biodiversity to go down?

Our world is full of species, both known and unknown, but because of what people do, many of them are in danger of going extinct.

Land-use change is the main cause of biodiversity loss. This is when natural landscapes are turned into room for human activities like farming, mining, or expanding cities. When we change how land is used, we destroy native habitats and take away the homes of many species. When ecosystems are broken up, their balance is upset, and there is less room for natural resources and life.

Overfishing, rising and acidifying waters and pollution have all thrown the ocean out of balance in ways that threaten not only sea life but also people. Overfishing is the main reason why fish stocks are going down and marine environments are being destroyed.

Pollution of the air, water, or land by toxic chemicals and other pollutants is also bad for ecosystems and species. Some species go extinct, habitats get worse, and important biological processes are messed up.

Climate change, on the other hand, is the biggest threat to species of all. Because of the climate disaster, habitats are changing, species are moving to different places, reproductive cycles are being messed up, and species are becoming more vulnerable to diseases and pests. When these reasons work together, mass extinctions and the destruction of whole ecosystems happen.

People pay more attention to the climate problem, but biodiversity and climate are both crises that are happening at the same time. Both the loss of biodiversity around the world and climate change are caused by people's exploitative economic systems. They make each other worse, and world leaders need to move quickly to stop them.

10 ways to protect and converse biodiversity

There is no need to sugarcoat it: people have already caused a huge loss of biodiversity on Earth. Back in 2010, 168 countries promised to protect and improve biodiversity by 2020. However, according to a report from the United Nations, not even one of the 20 goals set had been met by 2020.

People are still not aware of how important biodiversity is, development projects rarely include biodiversity, and subsidies for fossil fuels, pesticides, and other harmful substances stay high.

Governments can help change the food system by, for example, making sure that big food companies don't have too much power and instead subsidizing and backing farm efforts that focus on crop diversity, soil rehabilitation, and ecological harmony. Quick Links for 10 Ways to Save Biological Diversity are as follows

1. Laws made by the government
2. Nature preserves
3. Getting rid of invasive species
4. Restoring habitat
5. Breeding in cages and indigenous seed banks
6. Research
7. Slow down climate change effects
8. Buy goods that help the environment
9. Living in a way that is good for the environment
10. Better Education

Rules about how to use water need to be changed to reflect the fact that supplies are running out. Countries need to do more to stop pollution and punish the worst polluters. They also need to control invasive species and limit hunting and capturing of watery species.

Since the ocean is a shared area, countries need to work together more on issues like fishing zones, shipping routes, and pollution.

And while campaigns about plastic pollution often focus on daily items like straws and takeout containers, fishing boats that lose or toss their nets and gear are the main cause of plastic pollution in the ocean. Places with a lot of different kinds of life, like around coral reefs, should be set aside as marine protected areas that limit or stop people from doing things there.

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Entrepreneurship Opportunities in the field of Specialty Agriculture

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The agriculture industry is the largest part of the Indian economy. It has changed significantly during the past 20 years. Commercialization and globalization policies have opened up new opportunities for improving agriculture. As a result, there has been more innovation in this area (Wagh and Dongre, 2016). But as technology has advanced over time, we have observed a divide between science and creativity in a number of sectors. Entrepreneurship is one way to bridge the knowledge gap between science and the market. Many business owners may find it challenging to fill this vacuum and launch new initiatives. Sciascia and Vita (2004) claim that entrepreneurship is a multifaceted and complex phenomenon that involves resource management and acquisition in addition to the creation of new businesses and the implementation of new strategic business initiatives (Carland et al., 1996; Lee et al., 2009) in order to take advantage of these commercial opportunities.

The agriculture sector shall be disregarded when designing and evaluating the core themes of agri-preneurship. This is strange because farmers who use their entrepreneurial skills to engage in market-based activities show their capacities for a disposition toward opportunity recognition, despite the fact that complex market regulatory structures obscure the need for individual business and innovation (Carter et al. (2011).

To establish the foundation for an evergreen revolution, develop agribusiness and help our farmers become entrepreneurs (Sharma and Singh, 2014). Farmers must be prepared to adjust to market whims, varied consumer lifestyles, new requirements, product quality, and portfolio entrepreneurship (Uplaonkar and Biradar, 2015).

More than 52% of the land in India is cultivated. Given the significant changes in the agricultural environment, a second green revolution will need a new strategy and technology. India focused on entrepreneurship, which may be defined as the planned and managed conversion of a person into an entrepreneur through the creation of entrepreneurial knowledge, resources, strategies, and other tools (Anonymous, 2020).

Specialty agriculture is high-yield, environmentally friendly farming that can be lucrative in mountainous and small-scale farming settings. Its diversity makes modeling challenging. According to Section 101 of the Specialty Crops Competitiveness Act of 2004, as amended by Section (10010) of the Farm Bill (floriculture), "fruits and vegetables, tree nuts, dry fruits, horticulture and nursery crops" are considered specialty crops. Plants must be cultivated or maintained for human consumption as food, medicine, or aesthetic enjoyment in order to be considered specialty crops (USDA, 2022).

a) Tree Nuts

b) Nursery Crops

The table 1. presented the name of the topic and name of the journal from where the data has been collected regarding the opportunities and constraints that arises in specialty agriculture.

Scope and Opportunities of Agri-preneurship in Specialty Agriculture

a) Agripreneurship in specialty agriculture focuses on investments made in this sector that would give locals in the area jobs by growing uncommon sorts of crops. In the past, the Indian government adopted a growth and development strategy plan that boosted economic growth and development through

promoting self-employment and entrepreneurship (Uche and Fmilusi, 2018).

b) Seeds, fertilizer, insecticides, and farming technologies are just a few of the many inputs needed for agriculture (Quaim, 2020). Many opportunities are envisioned for producing and creating these inputs. In the industries of bio-pesticides, bio-fertilizers, vermin compost, soil testing, and soil amendment, among others, entrepreneurship is strongly promoted.There is a ton of room for research and advancement when it comes to seed development. To increase agricultural output, new seed kinds will be created even in unusual environmental situations, it is predicted that these types of seeds will function (Kumar,2016).

c) As a result of the realignment of agricultural supply chain management, possibilities in the distribution and logistics sectors are increasing, opening up opportunities for post-harvest processing, output processing, and marketing new business models (Priyadarshi et al., 2020). The cultivation of vegetables, fruits, food grains, pulses, oil seeds, etc., as well as the development of greenhouse concepts, dairy and poultry development, animal husbandry, herbal plantations, packaging of agri products, establishment of food processing units and cold storages, sericulture, and horticulture, present numerous opportunities for the development of agripreneurship (Sharma et al., 2020).

d) The few plant species that have been developed as primary food crops for human use have resulted in agricultural simplification, or the process of favoring some crops over others due to their simple growing requirements, faster processing, and storage (Padulosi et al., 2002). Ecological health depends on biodiversity to enhance human health and wellbeing (Burlingame and Dernini, 2010; Dáz et al., 2006).

Major Constraints of Entrepreneurship Development in specialty crops

The study's conclusion was that the majority of respondents believed that a dearth of market prospects was a major impediment to the growth of specialty crop entrepreneurship. Because of this, the growth of entrepreneurship would be constrained by a lack of market opportunities. One of the obstacles to the entrepreneurship growth of specialized crops, according to 50% of respondents, is a supportive atmosphere. More than half of the respondents believed that a lack of finance prevented them from producing specialized crops. However, every responder claimed that the lack of managerial talent precluded them from making such investments. Grading, packaging, and a shortage of land were also regarded to be major barriers to the growth of specialty crop entrepreneurship. Only a small portion of respondents said they did not invest money on growing specialized crops because of fraud.

Conclusions

The main labour input for growers of specialty crops is seasonal labour. If there is not enough labour to meet the demands of agriculture and animal husbandry, a nation's food supply, especially its fresh fruit and vegetable supply, may be in peril. The study concluded that a lack of funding, managerial incompetence, and a lack of grading and packaging were the main obstacles faced by farmers while producing specialty crops, which restrained the growth of entrepreneurship in the specialty agriculture sector.

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Table 1: List of Reference Books

Name of the Author	Name of the Topic	Name of the Journal	Year
Sharma, K C.and Singh, S.	Socio-Economic Profile of the Cash Crops Growers in Himachal Pradesh	*International journal of creative Research* Thoughts	2020
Hinson, R., Lensink, R., & Mueller, A.	*Transforming agribusiness in developing countries: SDGs and the role of FinTech*	*Current Opinion in Environmental Sustainability*	2019
Carter, Sara & Ljunggren, E. & Welter, Friederike & Alsos, Gry	*Introduction: Researching entrepreneurship in agriculture and rural development*	Handbook of Enterperneurship in Agriculture and Rural Development. Edward Elgar.	2011
Bruce, Analena & Maynard, Elizabeth & Farmer, James	Farmers' Perspectives on Challenges and Opportunities Associated with Using High Tunnels for Specialty Crops	HortTechnology	2019
Rajesha G, H. D. Talang, E. Lireni Kikon, Rakesh Kumar and Bidyut C. Deka	Avenues for Entrepreneurship Development in Agri-Horti Ecosystem for Farmers and Rural Youth	ICAR research Complex for NEH Region, Nagaland Centre, Jharnapani, Medziphema, – 797 106, Nagaland	2016
Burlingame, B. and S. Dernini (eds.)	Sustainable Diets and Biodiversity: Directions and Solutions for Policy, Research and Action. Edited from the presentations made at the International Scientific Symposium: Biodiversity and sustainable diets united against hunger	Food and Agriculture Organization of the United Nations (FAO), Rome, Italy	2010

Padulosi, S., T. Hodgkin, J.T. Williams, and N. Haq	Underutilized crops: Trends challenges and opportunities in the 21st century, p. 323–338	In: J.M.M. Engels, V.R. Rao, A.H.D. Brown, and M.T. Jackson (eds.). Managing plant genetic diversity. CABI International, Wallingford, UK.	2002
Hisrich, R. D., Peters, M. P., & Shepherd, D. A.	*Empreendedorismo-9*	Amgh Editora	2014
Abdelwahed, N.A.A., & Al Doghan, M.A.	Entrepreneurs' perceptions towards the dynamic role of entrepreneurship in overcoming poverty	*International Journal of Entrepreneurship*	2022
Carland, J.A., Carland, J.W., & Stewart, W.H.	Seeing what's not there: The enigma of entrepreneurship	*Journal of Small Business Strategy*	1996
Hall, C	PB1711 Direct Marketing Guide for Producers of Fruits, Vegetables and other Specialty Products,"	The University of Tennessee Agricultural Extension Service, PB1711-5M-8/02 E12-4115-00-003-02	2022
Lee, S.M., Lim, S. & Pathak, R.D	Culture and entrepreneurial orientation: A multi-country study	*International Entrepreneurship and Management Journal*	2009
Fitz-Koch, Sarah & Nordqvist, Mattias & Carter, Sara & Hunter, Erik	Entrepreneurship in the Agricultural Sector: A Literature Review and Future Research Opportunities	Entrepreneurship Theory and Practice. 42. 129-166. 10.1177/1042258717732958	2018
Gupta, A., Sood, S., Agrawal, P. K., & Bhatt, J. C.	Under-utilized food crops of Himalayan region: Utilization and prospective	Newer Approaches to Biotechnology, 101-120.	2013
Boruh, R. Sharma, S.and Das,A	Entrepreneurial Opportunities through Horticulture in assam	Rashtriyakrishi	2015
Padmanand, V., Sood, K., & Reddy, M. C.	Promoting Agri Business Start-ups through Integrated Entrepreneurship Development Approach in Maharashtra:"Mantra" for Start-ups Every Year in Each Indian State.	*SEDME (Small Enterprises Development, Management & Extension Journal*	2016

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Automated Systems for Monitoring in Aquaculture

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It is an aquaculture-based environment monitoring system that is having a network of wireless sensors that records the environmental stimulus and responds accordingly. This system allows a user with a mobile device to monitor the fish farm Environmental Data with Instant mastery and control over the various environmental data. Temperature, dissolved oxygen, PH value and water level sensing modules are incorporated in this monitoring system and can be known with a span of a click on the device.

As the need for the food is increasing day by day in order to meet the alarming rates of hunger and malnutrition the food sector is also increasing at a rapid pace. Aquaculture is playing a key role in meeting the demands of the on growing malnutrition .As the intensity is increasing day by day there is a need for automated monitoring systems to keep a quick check and alter the system and its parameters automatically.

Benefits of automated farming system

- ✓ Precise adjustments can be made in the environment
- ✓ Improved environmental control
- ✓ Reduced losses caused by major disasters
- ✓ Reduced human interference
- ✓ Quick actions can be taken
- ✓ Improved aquatic product quality.

These following are the components of an automated monitoring system.

Hardware architecture

Hardware architecture is having an integration of sensors which acts as an input device like that of computer and also has controlled devices just like that of the output devices of a computer. These controlled devices work on the commands given by the central processing system after processing the data that is received from the sensors viz., temperature, sensor, dissolved oxygen, PH sensor and water level sensor. This automated system works on low power supply which can be assisted with the help of batteries, solar panels etc.

Temperature sensing module

Temperature sensing module uses the PT100 sensor. This device is composed of coiled platinum wire, wound onto an insulating cylinder that is a temperature resistancesensor. These sensors receives the change in the temperature and sends the signals to the processor.

Temperature sensing module

(Source: Jui-Ho Chen (2015))

Water level sensing module

The water level sensing module uses an ultrasonic transmitter to transfer acoustic waves that is later received by the receiver. The sound wave reflection time is converted into the water level. The intensity of the transmitted acoustic wave is affected by distance it travels

- ✓ It acts as the echo sounder which is present at the bottom of the vessel
- ✓ If the sound wave reflection time is more then the water level will also be more and vice versa.
- ✓ If the water level is more then the intensity of the waves received by the receiver will also be more.

Water level Sensing Module

(Source: Jui-Ho Chen (2015))

pH and the amount of dissolved oxygen sensing module

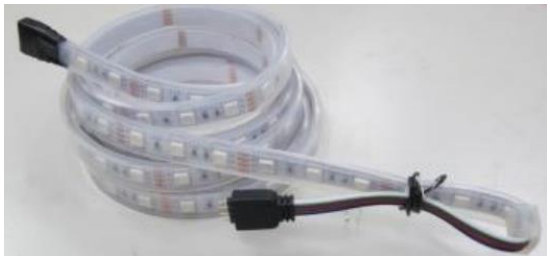
After the PH instrument and dissolved oxygen instrument receives the signal from the environment then the signal is sent to the central processing. After processing the value is displayed

PH meter and DO meter

(Source: Jui-Ho Chen (2015))

RBG light modulating system

The system adjusts the colour of the lights (red blue and green) and adjusts the intensity that is required. Delicate multicolor light is varied to adjust the light color fish need. Generally, this type of lights is used by the smart aquaponics system where suitable light is provided for plants and fishes.



RBG modulating system (Source: Jui-Ho Chen (2015))

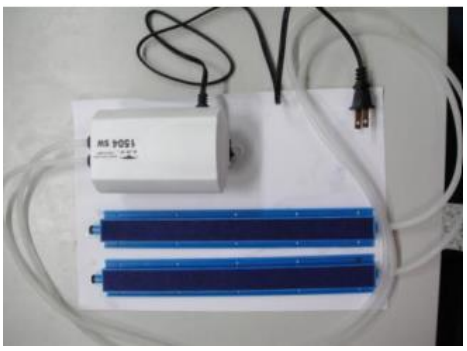
Heaters

When the temperature is below the range set by the user, the central processing system will automatically send signals to turn on the devise to increase the water temperature by increasing the heating rod load.

Heating rod (Source: Jui-Ho Chen (2015))

Do inflators

When the dissolved oxygen value falls below the range set by the user the central processing system will automatically send a signal to start the load to improve the amount of dissolved oxygen in the water.



Do inflators (Source: Jui-Ho Chen (2015))

Automated fish feeder

The fish feeder can be set through terminal device once the commands given by the mobile the feeder starts releasing the feed. Type of feed depends on the species which we are growing and duration of the feed is adjusted accordingly.

Fish feeder (Source: Jui-Ho Chen (2015))

Software design

The terminal (mobile devices) uses the Android operating system to do the monitoring. The software provides a Windows program design with a graphical user interface tool and program development tools.

The software can be installed in mobile phones and made use with the help of an app

Power supply

This system is designed for low-power sensors. The power supply can be battery-powered or the user can switch to electricity or solar power. The power supply will be used as a stable electricity supply mode with uninterruptible power systems for the auxiliary battery. This greatly reduces the instability caused by power outage or drained batteries increasing the reliability of the entire system

Smart aquaponics system

Aquaponics is the hybrid of aquaculture and Hydroponics where the nutrients from the culturing are utilized by the plants and then the water is pumped back into the system after mechanical, chemical, and biological filteration. Aquaponics is defined as the process of growing aquatic organisms and plants symbiotically (Yep and Zheng, 2019).

The smart aquaponics system was developed by integrating seven modules:

1. Data acquisition unit,
2. Alarm unit,
3. System rectification unit,
4. Central processing unit,
5. Web application,
6. Mobile application, and
7. Cloud server

Data acquisition unit:

The data acquisition unit continuously collects data using five sensors.

- ✓ Water temperature sensor gathers water temperature of the fish tank.
- ✓ Water flow rate sensor measures water flow rate from the fish tank to plant grow beds.
- ✓ Digital light sensor quantifies light intensity of the environment.
- ✓ pH level sensor detects water pH level in the fish tank.
- ✓ Ultrasonic ranger measures the plant height

Alarm unit

The alarm unit consists of a green LED light, a red LED light, and a buzzer. This unit displays green light when the system is healthy, but displays red light with buzzing sound to alert the user when the system is unhealthy.

System rectification unit

The system rectification unit automatically intervenes and rectifies the system abnormality by activating respective devises. Decision to activate or deactivate the devices is determined by the central processing unit based on the collected data and user preset values. This unit comprises four devices i.e., water heater, water pump, led light, fish feeder.

Central processing unit

It is having the processor which process the data received by the sensors and gives the commands to the system rectification unit. This is having the connection with the terminal devices and can be operated via android platform or through web.

Web application

It also allows the user to timely monitor the aquaponics facilities and remotely controls the devices.

Mobile application

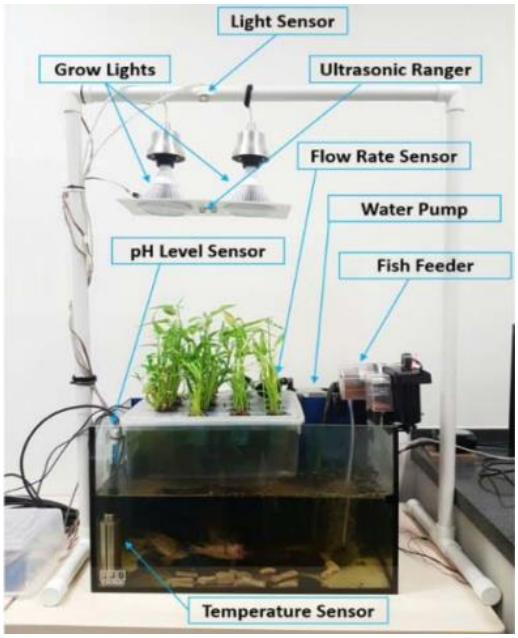
The mobile application was created on Android platform.

Cloud server

The cloud server is used to establish communication between the central processing unit and mobile application.

System implementation

All hardware components were integrated according to the final design diagram. Each component was carefully inspected and tested before the integration. The implemented system was evaluated by simulating different possible scenarios. For example, when the water temperature falls into an unhealthy range, the system should trigger the alarm unit to alert the user, and activate the system rectification unit to rectify the problem by turning on the water heater.



Smart aquaponics system

(Source: Jui-Ho Chen (2015)

Conclusion

Monitoring system is a smart way of monitoring and managing things in the aquaculture production systems. This way of managing the aquatic environment saves time and reduces the man power and increases the efficiency of the system.

Reference

Jui-HO Chen, Wen-Tsai Sung and Guo-Yan Lin (2015). Automated Monitoring Systems for the Fish Farm Aquaculture Environment, 2015 IEEE International Conference on Systems, Man and Cybernetics.

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New Concept of Biofloc Technology (BFT)

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Globally, the aquaculture sector is the fastest-growing food-producing sector, as the demand for low-cost animal protein is increasing due to the shortage of protein food supply in many countries to feed the ever-growing population. Presently, the total world fishery production is about 178 MT, of which aquaculture production is 87.5 MT, which contributes about 62.2% of the total Production (Sofia 2022).The enormous increase in aquaculture production is due to the introduction of high-density intensive culture practices.

Apart from these benefits, intensive culture systems are also associated with some environmental and economic problems because, it requires more than 50% of the total production cost is driven to feed only. However, only 20- 30% of feed is utilised by the culture species; the remaining 70-80% will be accumulated as organic waste (uneaten feed and excretory products) in pond water, leading to water quality deterioration, affect culture species in terms of growth, survival and ultimately causes disease outbreaks. Moreover, aquaculture also has some limitations like less availability of land, water, feed ingredients and bio security measures.

To overcome these above problems application of an environmentally friendly culture system known as "Biofloc Technology" is more advantageous, it is a green culture system in which nutrients are reused and recycled continuously with minimum or zero water exchange. It is mainly based on the growth of microorganisms (bio-floc), which helps to improve the water quality by the uptake of nitrogen and to produce a microbial protein; in addition, FCR can be reduced, which ultimately reduces the feed cost.

Biofloc

Biofloc is the heterogeneous macro aggregations of algae, diatoms, protozoa, microbial grazers, filamentous and floc forming bacteria with uneaten feed, faeces, and sludge, which were grouped into floc biomass by a biological adhesive such as poly-

Sr. No.	Component	Percentage
1	Protein	24.3 - 53.85 %
2	lipid	0.5 -5.4 %
3	Fibre	0.7 - 16.65 %
4	carbohydrate	21.1 -81.5 %
5	Ash	6.31 – 31.9 %
6	Nitrogen free extract	18- 29.24 %
7	Energy	12 – 19 Kj/g

hydroxyalkanoates (PHA) released by the microorganisms within the water column. Bio-flocs are very light, highly porous, delicate and irregular in shape and vary from 50-200 microns (reach up to 1000microns) in size.

Proximate composition of biofloc

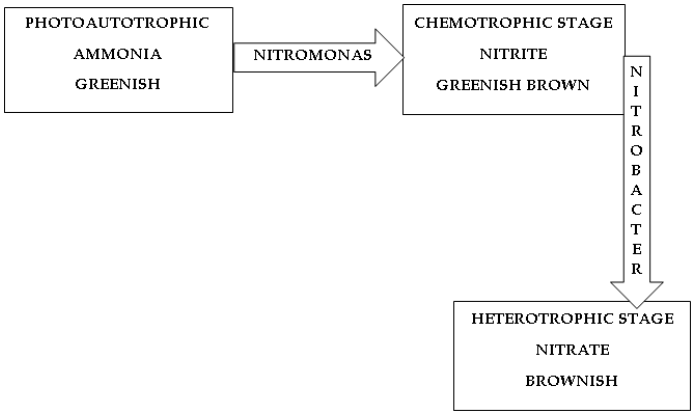
The nutritional values in the bio-floc mainly depend on what type of carbon source is used

Principle Of Biofloc: "Nitrogenous wastes present in the uneaten feed and animal excreta are converted into a consumable 'bacterial floc', with the addition of carbon sources at high oxygen levels with limited (less than 10%) or zero exchange of water "(Schneider et al. 2005, Avnimelech 1999; Crab et al. 2009) due to continuous aeration, and carbon supply, usually highest densities of biofloc are observed in this system only. In this system, algae won't grow sufficiently or not at all grow and this biofloc system is solely based on bacteria, hence it is called as "True/brown biofloc system". This system is alone recommended for shrimp/ fish culture.

C:N ratio: C/N ratio plays a vital role in the formation of bacterial biomass from the organic waste

accumulated in the water. Carbon enhances the growth of heterotrophic bacteria.

C:N ratio of 10:1 holds good for the biofloc technology but, in some cases the ratio may exceed depending on the need of the heterotrophic bacteria15:1 to 20:1. Therefore a well-balanced carbon source is added in the form of jaggery, molasses, glycerol etc.



Formation of biofloc: Continuous aeration in the pond water promotes the biofloc development by oxidising the ammonia in three stages that can be identified based on water colour as following.

1. Photo autotrophic stage: This is the very initial stage of the biofloc system, the water appears in green colour due to the growth of filamentous microalgae such as chlorella, spirogyra, algae, anabaena and Oscillatoria are mostly dominated.

2. Chemotrophic stage: It is the later nitrifying stage, in this system nitrifying bacteria such as Nitrosomonas, Nitrobacter and pseudomonas are mostly dominated as they convert the toxic ammonia to less toxic nitrite and water appears in the form of greenish brown in colour.

3. Heterotrophic stage: water appears brown in colour due to the domination of heterotrophic bacteria and these bacteria take the nitrogen and produce a singlecelled microbial protein. in this stage nitrite gets converted into nitrate.

Preparation of floc

Wash the tank or pond and then allow it to dry, now fill the water up to 35-50% of the tank capacity and start aeration and let it continue for 24 hrs. Initially TDS will be in the range of 800-1000ppm, in biofloc TDS should be high in order to increase Add 1kg of salt/10,000lit. of water to maintain the total dissolved solids (TDS) range between 1400 to 1600(Do not use iodised salt, use only raw salt).

The Ph of the unit should be in the range of 7.5-8.5 and Ph corrections should be done by adding lime or gypsum depending on the situation.

After proper aeration and when the system is having optimal Ph and TDS now add urea @1g/1000litres or Triple Super Phosphate @ 0.14g/1000 liters as nitrogen source.

After addition of nitrogen source only carbon source is added@7gms/1000litres, if using jaggery add 2gms/1000litre of water.

After one day add probiotic powder @ 20g/1000lit. to enhance the performance of the immune system. And continue the process of aeration and within 7-10 days floc is formed in the system.

After required floc volume is obtained then stock the system and culture until the days of culture are over.

Shell fishes are stocked @ 250-500pl/m²and for finfishes it is stocked @150-200 fingerlings/m2.2000kg /6months is produced in a 1acre area.

NOTE: From 1gm of ammonia, about 15.85gm of algae biomass; 0.2gm of nitrifying bacteria; 0.87gm of heterotrophic bacteria can be produced.

Daily add 600gm of carbon for every 1kg of feed (maintenance phase@ 0.6:1) added until the floc reaches10- 15ml/L to maintain a C/N ratio of 10:1.

Ideal density of floc is 10-15ml/L for shrimp and 25 - 35ml/L for fish.

Preferrable species for biofloc technology

Fish / shrimp species that can tolerate high stocking density, high total suspended solids concentrations, intermediate levels of DO, TAN and filter-feeding / omnivorous habit are best suitable.

1. Non air breathing fishes: *Labeo rohita*, Common Carp, Grass Carp, Silver carp,Tilapia (*Oreochromis aureus, O. niloticus, O. mossambicus*).

2. Air breathing fishes: Magur (*Clarius batrachus*), Murrels, *Anabas*, Channel catfish, and *Clarias gariepinus.*

3. Shell fishes: *Litopenaeus vannamei* (Indian white leg shrimp) and *Penaeus monodon* (Tiger shrimp).

Among all the cultural species *Litopenaeus vannamei* and Tilapia are highly recommended to culture in bio-floc technology as they are filter feeders with omnivorous/ detritivorous habit and can also withstand poor water quality conditions.

Advantages

- ✓ It is a green approach to reducing the environmental impact and increases the biosecurity.
- ✓ High productivity compared to conventional fish farming.
- ✓ Increased growth and survival rate of cultured species
- ✓ Lower the feed conversion ratio (FCR) as biofloc acts as alternative feed thereby reduces the feeding cost.
- ✓ High stocking density in less space
- ✓ Consuming the floc biomass enhances the immune system of culture species
- ✓ Improves the water quality by recycling the nutrients
- ✓ Zero water exchange or a minimum of 10% is exchanged.

Disadvantages

- ✓ Maintaining a constant C/N ratio is problematic during culture as it is maintained all the days of culture.
- ✓ As it requires continuous aeration it consumes more power on a whole.
- ✓ A continuous supervision is required to Monitoring floc volume, oxygen saturation, and ammonia levels requires highly skilled persons and a fully equipped laboratory at the farm only.
- ✓ High turbulence may also lead to floc breakage as they held together by a loose matrix.

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