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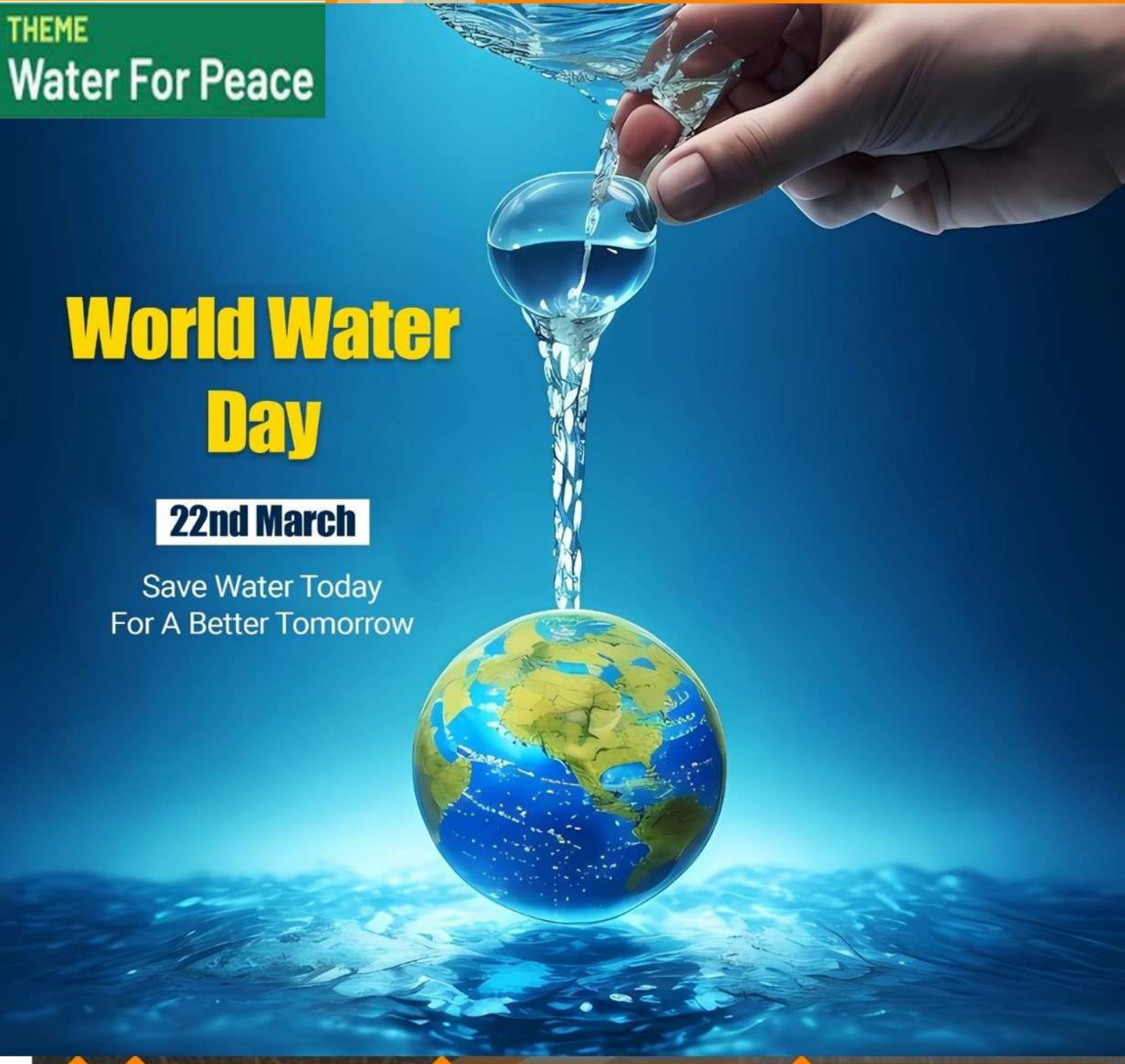


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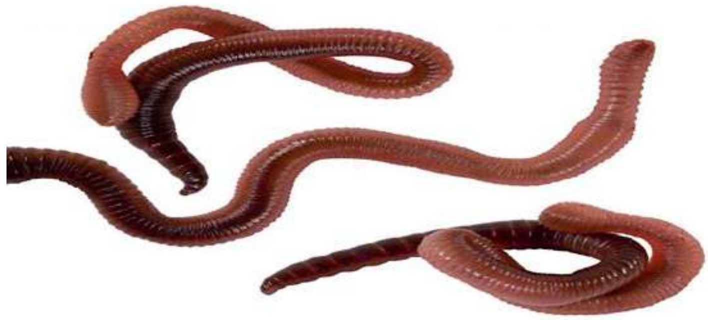

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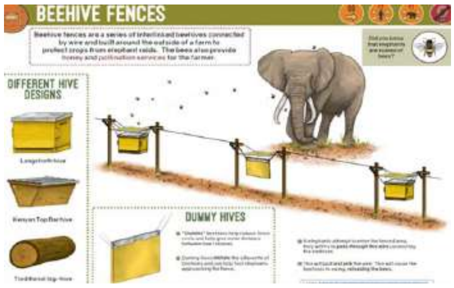

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From the Desk of Editor-in-chief

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I would like to introduce the launch of **“AgriGate - An International Multidisciplinary Monthly e-Magazine Volume 04 Issue No. 03 – March 2024”** with immense pleasure. Ourteam is privileged to dedicate this issue to **Women’s**. Globally celebrated on March 8th annually, **International Women’s Day** honors women’s social, economic, cultural, and political achievements while advocating for gender equality. The symbolic colors, purple, green, and white, represent justice, hope, and purity, respectively, originating from the Women’s Social and Political Union in the UK in 1908.

The main objective of the magazine is to provide a publishing platform to young researchers and scientists as well as an information hub for the enthusiast, progressive farmer and also common readers. We envisage providing an online platform that appreciates illuminating articles on various topics related to agriculture and allied sciences monthly that will appraise and update the students, farming community and the whole society at large on the updates in agriculture.

Last but not the least, I wholeheartedly thank the editorial team, authors as well as anonymous reviewers for contributing to the release of this issue.

Our team welcomes your constructive feedback and suggestions to improve delivering fruitful content to hungry minds.

Dr R Shiv Ramakrishnan
Editor-in-chief
AgriGate Magazine

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 03

DRONE TECHNOLOGY IN AGRICULTURE: BENEFITS AND CHALLENGES FOR RURAL INDIA

Article ID: AG-VO4-I03-01

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Introduction

In recent years, drone technology has become increasingly popular in the agriculture sector. Drones offer farmers a range of benefits, including increased efficiency, improved yields, and reduced costs. However, there are concerns that farmers may be reluctant to adopt drone technology due to fears of job loss or a lack of knowledge and training. We can explore the benefits of drone technology in the agriculture sector and the challenges that may be holding farmers back from adopting this technology.

Benefits of drones Drone Technology

As innovators introduce new technologies, their commercial uses increase day by day. The government has been easing restrictions for drone usage and is supporting startups to come up with novel ideas. As drone surveys become more common, they also become more cost-effective. In agriculture, they have a plethora of advantages. Some are as follows:

Drones can be used for a wide range of tasks in the agriculture sector, including crop mapping, soil analysis, irrigation, and pest management. Here are some of the key benefits of using drones in agriculture:

1. **Improved Efficiency:** Drones can cover large areas of land quickly and efficiently, allowing farmers to gather data and monitor crops more effectively. This can help to identify issues early, leading to faster and more effective interventions.

2. **Enhanced Crop Yields:** Drones can be used to gather data on crop health, allowing farmers to identify areas that require attention. By addressing these issues, farmers can improve their crop yields and increase their profits.
3. **Reduced Costs:** Drones can help to reduce costs by identifying areas of the farm that require attention, reducing the need for manual labour and reducing the use of pesticides and other chemicals.
4. **Improved Accuracy:** Drones can capture high-resolution images and data, providing farmers with a detailed view of their crops. This can help to identify areas that require attention and ensure that interventions are targeted and effective.
5. **Effective and Adaptive Techniques:** Drone usage results in regular updates to farmers about their crops and helps develop strengthened farming techniques. They can adapt to weather conditions and allocate resources without any wastage.
6. **Greater Safety of Farmers:** It is safer and more convenient for farmers to use drones to spray pesticides in terrains challenging to reach, infected areas, taller crops, and power lines. It also helps farmers prevent spraying the crops, which leads to less pollution and chemicals in the soil.
7. **10x Faster Data for Quick Decision-Making:** Drone surveys back farmers with accurate data processing that encourages them to make quick and mindful decisions without second-guessing, allowing farmers to save the time invested in crop scouting. Various sensors of the drone enable capturing and analyzing data from the entire field. The data can focus on problematic areas such as infected crops/unhealthy crops, different colored crops, moisture levels, etc. The drone can be fixed with several sensors for other crops, allowing a more accurate and diverse crop management system.
8. **Less Wastage of Resources:** Agri-drones enable optimum usage of all resources such as fertilizer, water, seeds, and pesticides.
9. **Useful for Insurance Claims:** Farmers use the data captured through drones to claim crop insurance in case of any damages. They even calculate risks/losses associated with the land while being insured.
10. **Evidence for Insurance Companies:** Agricultural insurance sectors use Agri-drones for efficient and trustworthy data. They capture the damages that have occurred for the right estimation of monetary payback to the farmers.

Challenges of Adopting Drone Technology in Agriculture Sector

While agriculture drones offer various simple working processes such as precision spraying, instant monitoring of pests and diseases, and quick mapping, drone agriculture is challenging to address for rural farmers. Unlike large-scale agriculture enterprises, medium and small farmers in rural areas seem very considered when adopting new agriculture technology, including drones. But what makes them less open to modern farming adoption? In this article, we will discuss these challenges of agriculture drone technology in rural areas.

1. **Safety Risks:** Drones can pose a safety risk to people and animals on the ground. For example, drones used for crop spraying can pose a risk to people and animals if they malfunction or are not operated correctly.
2. **Cost:** While agriculture drones offer long-term cost savings, the initial investment can be a barrier for some farmers, particularly those with smaller landholdings. Efforts to make these technologies more affordable through subsidies, financing options, or government support programs can facilitate broader adoption.
3. **Weather Dependence:** Drones are weather-dependent, they cannot fly during heavy rain, snow, wind or fog, and it can limit the use of drones in certain areas and times of the year.
4. **Lack of Expertise and Training:** It's possible that farmers lack the skills or training required to use drones efficiently. Their inability to operate the technology confidently may make it challenging for them to adopt it.
5. **Fear of Job Loss:** Many farmers are concerned that the adoption of drone technology will lead to job loss, as fewer workers will be needed to perform manual labour on the farm.
6. **Regulatory Barriers:** There may be regulatory barriers to the use of drones in agriculture, which could make it difficult for farmers to adopt this technology.

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REVEALING THE FUNCTION OF LIVESTOCK: AN IN-DEPTH ANALYSIS OF PRODUCTION DYNAMICS

Article ID: AG-V04-I03-02

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Abstract

The global livestock industry is quite active. It is changing in nations that are developing in response to the sharply rising demand for animal products. Livestock husbandry is the foundation of the rural economy in India. It is crucial to the rural economy since it creates productive work in the rural sector and enhances household incomes. At present, there are about 220 registered livestock breeds in India (NABARD, 2023-24). Total milk, meat, egg, and wool production of India is 130 MT, 9.77 MK, 138.8 billion, and 33 MK, respectively. Marketing of livestock and their products as milk, meat, egg, and wool has been still traditional and controlled by unorganized sectors like village traders, itinerant traders, producer sellers, and some commission agents. Particularly, peri-urban meat industries adhere to certain formalized processes. Cooperative societies and corporate private enterprises undertake about 20% of dairy trade. The livestock industry contributes significantly to foreign exchange earnings and is doing well in terms of producing, adding value, and exporting dairy, fisheries, wool, poultry, and other goods.

Keywords- Livestock Population, Milk, Meat, Egg and Wool Production, Growth rate.

Introduction

Animal husbandry has been the backbone of national agriculture and a source of employment in rural areas for centuries. The livelihood of two-thirds of rural populations is derived from animals. The livelihood of almost 20.5 million people is derived from animals. Livestock contributed 16% to the income of small farmers. The livestock sector contributes 4.75 % (at current prices) of the total national GDP and 30.47% of the total Agriculture GDP. Farmers can easily maintain their income by working in mixed farming of agriculture and animal husbandry. Farming households with some livestock are better able to withstand distress due to extreme meteorological conditions.

CURRENT STATUS OF LIVESTOCK IN INDIA

Population growth, changing lifestyles, increasing urbanization, and climate change create new challenges in animal husbandry. Increasing the production of non-productive animals is an important problem. Livestock farming is important in India because about 2/3 of the cultivated land is rain-fed, which is controlled by the vagaries of monsoons, making Indian agriculture unstable.

Table 1. Total Livestock, changes, and their contribution to the overall livestock population:

S.NO.	LIVESTOCK CATEGORY	NUMBER (MILLION)	% CHANGE	CONTRIBUTION (%)	POSITION
1.	Cattle	193.46	1.34	35.94	Second
2.	Buffalo	109.85	1.06	20.45	First
3.	Sheep	74.26	14.13	13.87	Third
4.	Goat	148.88	10.14	27.80	Second
5.	Pig	9.06	-12.03	1.69	-
6.	Camel	0.25	-37.05	0.23	-
7.	Horse & Ponies	0.34	-45.22		
8.	Mule	0.08	-57.09		
9.	Donkey	0.12	-61.23		
10.	Yak	0.06	-24.9		
11.	Mithun	0.39	29.52		
	Total livestock	**536.76 million**	**4.82**		

Source: 20th Livestock Census, 2019.

Livestock farming has many impacts on rural economic development, economic development, and nutrition, especially for women, the landless, and small farmers. Rajasthan is the largest state of India. The area of the country is 3.42 square kilometers. The total number of livestock in Rajasthan is 56.76 million, accounting for more than 11.27% of India's total livestock, ranking second in India. (Rajasthan Animal Husbandry Department, 2019). Rajasthan has an 81.37% population of camel, 16.03% goats, 13.95% sheep, 11.94% buffalo, and 6.98% cattle population.

LIVESTOCK AND POULTRY PRODUCTS:

1.Milk Production:

India ranks first in the world with a total milk production of 230.58 million tonnes. Milk production (2022-23) increased by 3.83% compared to the previous year (2021-22). Per person's milk consumption increased by 13 grams/day compared to last year, reaching 459 grams/day.

With an annual milk production of 230.58 million tons, India leads the world and produces around 16% of the milk produced worldwide (BAHS, 2022-23). In India, milk output reached 17 million tonnes in 1950–1951, the year that it continued. The states of Uttar Pradesh, Rajasthan, Madhya Pradesh, Gujarat, and Andhra Pradesh produce the most milk in India. With 9317.11 tons, Tamil Nadu leads the nation in mixed milk production, followed by Karnataka with 8311.93 tonnes. With 9,209.07 tonnes produced, Rajasthan is the top state in terms of domestic/non-descript cattle milk production, followed by Madhya Pradesh. States like Madhya Pradesh (9592.66 tonnes), Andhra Pradesh (9554.79 tonnes), Punjab (8501.19 tonnes), Uttar Pradesh (22988.45 tonnes), and Rajasthan (16072.96 tonnes) are the leaders in buffalo.

India's per capita milk consumption grew from 130 grams in 1950–1951 to 459 grams in 2022–2023; this is a commendable 427 grams per day, marginally more than the ICMR projections. Punjab (1283 g) has the greatest daily per capita milk consumption, followed by Rajasthan (1138 g), Haryana (1098 g), Andhra Pradesh (799 g), and Gujarat (676 g).

Egg Production

The production of eggs significantly increased starting in 1999–2000 and reached 138.83 billion in 2022–2023. Improved fowl and desi fowl account for roughly 88.14% and 10.73%, respectively, of all eggs produced in India; ducks account for the remaining 0.66%. Andhra Pradesh (20.13%), Tamil Nadu (15.58%), Telangana (12.77%), West Bengal (9.93%), and

Karnataka (6.51%) are the top 5 states that produce eggs. Sixty-nine percent of India's total egg output comes from the five states. According to BAHS (2014), West Bengal is the state that produces the most duck eggs overall.

India's per capita egg availability has improved over time, from a meaner 5 eggs annually in 1950–1951 to 101 eggs in 2022–2023, but it is still far below the 365 eggs annually recommended by the ICMR. Andhra Pradesh has the highest per capita egg availability (526 eggs/year), followed by Telangana (466 eggs/year), Tamil Nadu (281 eggs/year), Haryana (281 eggs/year), and Andaman & Nicobar Island (274 eggs/year) (BAHS, 2022-23).

3.Meat Production

In 2022–2023 there will be 9.77 million tonnes of total meat output, which includes poultry meat, up from 1.9 million tonnes in 2021–2022. The output of meat has gone up 5.13 percent over the previous year (2021–2022). Poultry produces 4.99 million tonnes of meat annually, or roughly 51.14% of all meat produced. According to BAHS (2022–23), the contribution of buffalo, goats, sheep, cattle, and pigs to the overall meat output is 17.61%, 14.47%, 10.51%, 3.85%, and 2.43%, respectively.

With a 12.20% share in India's total meat production, Uttar Pradesh leads the country in output, followed by West Bengal (11.93%), Maharashtra (11.5%), Andhra Pradesh (11.20%), and Telangana (11.06%). Uttar Pradesh produces the most meat from pigs and buffalo. West Bengal leads the country in the production of goat meat, while Telangana and Maharashtra produce the most meat from sheep and fowl, respectively. In India, Kerela generates the most meat from cattle. Compared to the ICMR recommendation of 11 g/person/day, the per capita availability of meat in India is only approximately 7.1 g/person/day (BAHS, 2022-23).

4.Wool Production

The amount of wool produced overall ascended to 33.61 million kg (2022–23) from 33 million kg (2021–22), a 2.12% rise from the previous year. The ewe contributes around 72.1% of the total wool output, and the lamb and ram contribute 13.92% and 13.91%, respectively. The Indian state of Rajasthan produces the most wool (47.98%), followed by Gujarat (6.01%), Himachal Pradesh (4.27%), Jammu & Kashmir (22.55%), Maharashtra (4.73%), and Gujarat (6.01%) (BAHS, 2022-23).

CONTRIBUTION OF LIVESTOCK IN RAJASTHAN

Rajasthan accounts for just 11.27% of the nation's total livestock population but produces approximately 14.44% of the nation's milk, 2.46% of its meat, 47.98% of its wool, and 2% of its eggs. The state of Rajasthan leads the world in both milk and wool production. In Rajasthan, every individual has access to 1138 grams of milk each day.

GROWTH RATE OF LIVESTOCK PRODUCTS

The highest growth rate for various livestock products in 2021–2022 and 2022–2023 was 6.77% for eggs, followed by 5.13% for meat, 3.83% for milk, and 2.12% for wool. For the production of milk, eggs, meat, and wool, the states of Karnataka (8.76%), West Bengal (20.10%), Sikkim (63.08%), and Arunachal Pradesh (35.75%) registered the highest yearly growth rates, respectively (BAHS, 2022-23).

FUTURE OF TRADE IN LIVESTOCK PRODUCTS

The primary factor influencing India's potential for exports in the future can be found in the country's need for a variety of livestock-based products and the anticipated growth in their production. If India produces enough of these products to meet its domestic demand and still has excess inventory, it may consider exporting the excess, given that global prices stay high. The output shortfall experienced by several developed and developing countries throughout the world will also have an impact on India's future export growth. India's export growth would be fuelled by the production of other nation's shortfalls.

Conclusion

A large portion of the world's livestock resources come from the Indian livestock business. The livestock sector supports the social and economic growth of the country as well as its overall economy. The livestock industry is prospering in terms of output, enhancement of value, and shipment of dairy, fisheries, wool, poultry, and other products, in addition to having enormous potential and making an exceptional contribution to the agricultural sector in recent years. In addition to their performance, there are other obstacles, such as societal taboos and the disorganized cattle market. These need to be addressed to capitalize on global market prospects.

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GLOBAL MARINE FISHERIES CRISIS AND STEP TOWARDS SOLUTION-A SHORT NOTE

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Introduction

Around the world, the total fisheries and aquaculture production reached an all-time high of 214 million tonnes in 2020, with 178 million tonnes of aquatic production animals and 36 million tonnes of algae, a 3% rise from the previous year's 2019 record of 213 million tonnes. The COVID-19 pandemic in 2020, decreased catches of pelagic species, particularly anchoveta, a decline in Chinese catches, and other factors all contributed to the limited growth, which was principally caused by a 4.4 percent loss in capture fisheries. This decline was offset by continuous aquaculture growth, although at a reduced annual rate in the last two years (FAO, 2022). Likewise, many factors led to the negative impact on the marine ecosystem and leading to the collapse of the marine fisheries which caused the fisheries crisis (Fig. 1). In this popular article, we briefly explain the marine fisheries crisis.

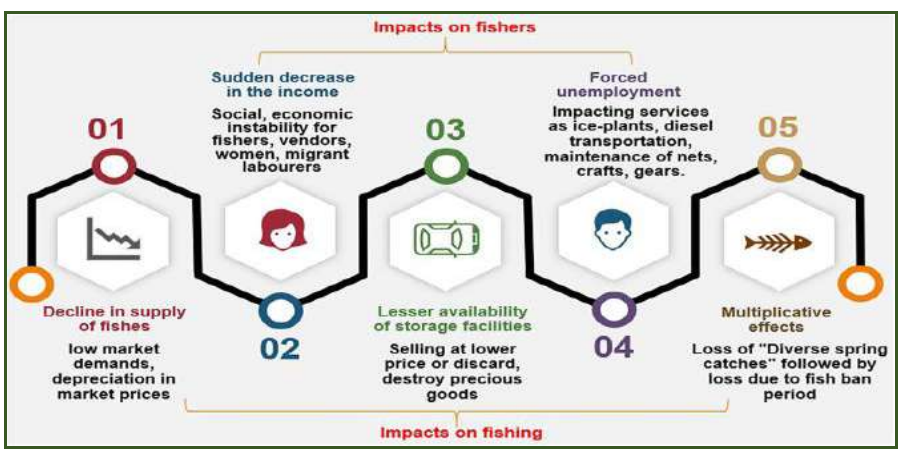

Fig.1: Impacts of crisis in fisheries over the fishers

Following factors are the reasons for Global Crisis in Marine Fisheries

1. Impact of COVID-19

The practice of marine fishing was nearly discontinued as a result of the COVID-19 pandemic and the ensuing lockdown, which had a profound impact on the marine fishery sector. (Mukherjee et al., 2020; Avtar et al., 2021). All along the supply chain, the necessity for additional health and safety procedures and decreased labour mobility have an impact on production capacity and prices (Kundu and Santhanam, 2021).

2. Impact of Climate Change

The marginal people of coastal areas are dependent on the aquatic and marine ecosystem, which is partially or fully influenced by climate change. However, different variables including drought, cyclone, flood, salinity, rainfall, sea level rise, and sea surface temperature have profound antagonistic effects on shrimp and prawn production. Fishery resources are very sensitive to the seashore, river flows and elevation of the lake, and variations related to ocean, coastal, and wildlife productivity (Rahman, 2022). Additionally, it's likely that physiological factors have contributed to changes in growth, reproduction, and death, necessitating adaptation to this new situation (Brander, 2010).

3. Overfishing

The term overfishing refers to situations where fish stocks result in declining phase. The FAO reported that more than 85% of global fish stocks are either overfished or fully exploited, and overfishing or lower biomass limits are responsible for the 40% reduction in Europe's fish stocks. According to the Food and Agriculture Organization of the United Nations, a third of the world's assessed fisheries are currently being exploited to the point where they can no longer support themselves biologically. Over the past fifty years, overfishing has tripled (Pham et al., 2023). Overfishing reduces the adaptability of fish stocks and aquatic resources to climate change. Moreover, overfishing is directly related to a variety of detrimental fishing practices, including illegal, unreported and unregulated (IUU) fishing, bycatching, and harmful subsidies.

4. Oil spills

Oil spills can cause serious damage to fishery and mariculture resources through physical contamination, toxic effects on stock and by disrupting business activities. The nature and extent of the impact on seafood production depends on the characteristics of the spilled oil, the circumstances of the incident and the type of fishing activity or business affected.

5. Micro-Plastics

The presence of microplastics in the marine environment has been a pollution issue for years. Because secondary plastics, which can theoretically be as small as monomers and oligomers, there is a high risk that they could enter the food chain (Malankowska et al., 2021).

6. Ocean-acidification

Large-scale increases in seawater CO_2 and inorganic carbon levels, reductions in pH, and changes in the acid-base chemistry of estuarine, coastal, and surface open-ocean waters are all being caused by rising atmospheric carbon dioxide (CO_2) levels.

7. Heavy metals

Pesticides, heavy metals, paper mill waste, polychlorinated biphenyl, and crude oil are just a few of the potentially dangerous compounds that are frequently dumped into the aquatic environment (Garai et al., 2021).

8. Eutrophication

Eutrophication's impacts on the ocean are quite simple to comprehend. Eutrophication restricts water use for fisheries, recreation, industry, and drinking because of the increased growth of undesirable algae and aquatic weeds and the oxygen shortages caused by their death and decomposition. The excessive enrichment of waters with anthropogenic sources of nutrients especially nitrogen (N) and phosphorus (P) lead to the transformation of oligotrophic water bodies to mesotrophic, eutrophic, and finally hypertrophic (Khan & Mohammad, 2014).

9. Pollution

Environmental and industrial contaminants can affect aquatic ecosystems and aquatic organism behaviour both directly and indirectly. Fish biota can be impacted by pollution by changing their metabolic, respiratory, demographic, developmental, and structural processes. There is strong evidence that confirms the harmful effects on fish fauna due to increased pollution from expanding industrial development (Jan et al., 2022).

Way towards solution

Sustainable fisheries

Sustainable fishing means leaving enough fish in the ocean and protecting habitats and threatened species. By safeguarding the oceans, people who depend on fishing can maintain their livelihoods (FAO, 2018).

(i) Subsidies should only be provided to harvest healthy resources. A healthy resource is a fish population that is at a sustainable fish population size1 and that is being fished at a sustainable rate.

(ii) Subsidies should only be provided to harvest from fisheries with fishing capacity well below the capacity needed to fully sustainably exploit the healthy resource and where the subsidy does not increase fishing capacity to a point where it is close to approaching the capacity needed to fully sustainably exploit the healthy resource.

(iii) Subsidies should only be provided to support harvesting activities within the member country's own exclusive economic zone (EEZ).

Conclusion

Currently inappropriate fishing practices not just depleting fish stocks, they often significantly alter the ecosystems and affects food chain. Fisheries management approaches have focused on managing individual fish stocks. Lack of sufficient data on the real status of fish stocks, their response to fishing pressure, or the impact of fishing pressure on ecosystems and other species, is a significant obstacle limiting the effective management of fisheries.

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STAR GOOSEBERRY: A RELATIVE OF AONLA

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Introduction

Star gooseberry (*Phyllanthus acidus*), a close relative of aonla (*Phyllanthus emblica*) is one of the earliest known fruit being grown in abundance in India. It is also known by the names Otaheite gooseberry, Malay gooseberry, Tahitian gooseberry and West Indian gooseberry. Also known as Arinelli in Malayalam. Star gooseberry belongs to Euphorbiaceae family is native of Indo-Chinese-Indonesian centre of diversity more precisely to India. Though the country has many star gooseberry trees, the fruit is non-commercial and therefore not often sold in markets. Instead, they are house garden plants and seen periodically through the countryside and villages. However, small vendors in the south sometimes offer star gooseberries for sale. In natural forests of Orissa, Kerala and Karnataka, plants with distinct characters have been observed. Also great variation with respect to fruit size, colour, phenol content and bearing potential of trees has reported.

The plant is an intermediary between shrubs and tree, reaching 2 to 9 m high. The tree's dense and bushy crown is composed of thickest, tough main branches, at the ends of which are clusters of deciduous, greenish, 15 to 30 cm long branchlets. The branchlets bear alternate leaves that are ovate or lanceolate in form, with short petioles and pointed ends. The leaves are 2 – 7.5 cm long and thin, they are green and smooth on the upper side and blue-green on the underside.

Suitable Soil

Star gooseberry plant grows on a wide range of soils. However, it prefers soil with good organic matter content and water holding capacity. Soil conditions significantly affect the plant growth in star gooseberry. Soils with slightly above neutral pH (7 – 7.5) and with high calcium content are much suitable. Star gooseberry is a subtropical to slightly tropical plant species which survives under both high and low temperature conditions. Warmer climate with high atmospheric humidity is most ideal for it. At the time of flowering and fruit set which generally takes place during spring, hot and dry weather is detrimental.

Seed

Star gooseberry is usually propagated through seed. Seeds extracted from mature fruits give almost 100 per cent germination. Seeds can be extracted by keeping the fruits for 4 – 5 days in water and then removal of pulp by mashing with water. Seeds were then washed properly with running tap water and sown in sand pots. Seeds germinate in 30 – 35 days and 60 -75 days old seedlings become ready for planting in polythene bags containing soil, farmyard manure and organic matter in equal proportion. June – July is best time for sowing seeds.

Star gooseberry can also be propagated through air layering, budding and grafting. July – August is the best time for air layering whereas, grafting can be attempted either during autumn or spring under polyhouse condition. Semi hard wood cuttings can also be attempted during monsoon season under polyhouse conditions with the use of rooting hormones.

Otaheite gooseberry do not require regular pruning but development of initial frame of the tree is very much essential. Upright growth and inner branches should be removed to facilitate better light and air circulation. Since it bears on old branches, removal of fruit stalks after crop is over is considered to be an essential operation. Diseased and damaged branches and water sprouts should be removed regularly after every cropping season.

Generally no irrigation is practiced in otaheite gooseberry, except that of initial plant establishment. Being a plant of high humidity region, need for supplementary irrigation is very less. Only the conservation of available soil moisture help improves plant growth and performance which can be done by mulching of plant basins.

Fruits

The otaheite gooseberry plants starts flowering and fruiting in 5 – 6 years. The flower panicles are borne on older and mature branches. Numerous male and female flowers are located on the same panicle at different places (monoecious). Flowers are small and pinkish and appear in clusters of 5 to 12.5 cm long panicles. In South India, generally two flowering season is observed in otaheite gooseberry, during April – May (Summer) and August –September (rainy season). In other areas, January - February is the main season of flowering in otaheite gooseberry, however sporadic flowers and fruits can be seen throughout the year. The fruit attains optimum maturity in 90-100 days. A well grown up plant of otaheite gooseberry produces 15-20 kg fruits.

Fruit is pendulous in small clusters from the branches, round or slightly flattened at the poles, with shallow or deep ribs 0.75 inches across. When unripe, gooseberries appear whitish green and are hard to touch. As they ripen on the plant, they turn pale gold. Fruit contain 4 – 5 seeds which are 0.6 – 1.3 cm long, thin, light brown, and enclosed by a gelatinous aril. The seeds maintain viability for 1 – 2 months if properly air dried and stored in a cool dry place.

Star gooseberry, has not yet been exploited properly in spite of its nutritional (Table 1) and medicinal values. In comparison to aonla, it has limited market potential. However, its potential may be realized by developing and promoting its value added products.

Table 1. Nutritional composition of Star gooseberry

Constituents	**Contents (per 100g pulp)**
Moisture	91.9 g
Protein	0.155 g
Fat	0.52 g
Fiber	0.8 g
Ash	0.51 g
Calcium	5.4 mg
Phosphorus	17.9 mg
Iron	3.25 mg
Carotene	0.019 mg
Thiamine	0.025 mg
Riboflavin	0.013 mg
Niacin	0.292 mg
Ascorbic acid	4.6 mg

Yield

Harvesting of star gooseberry is done manually. The whole bunch or individual fruits are picked and kept in containers. The individual fruits are graded according to size and colour and sold in local market. Star gooseberry has very short shelf life due to high moisture content and therefore should be disposed off quickly. Fruits can be kept for 2-3 days at ambient conditions. Fruits are generally used for making some value added products. Fresh consumption of fruit is very limited because of its acidic taste.

Chutney, syrup, pickle and sweetened products can be prepared from star gooseberry.

The sliced raw flesh can be covered with sugar and let stand in the refrigerator for a day. The sugar draws out the juice and modifies the acidity so that the flesh and juice can be used as a sauce. If left longer, the flesh shrivels and the juice can be strained off as clear, pale yellow syrup. In Indonesia, the tart flesh is added to many dishes as a flavouring agent. The juice is used in cold drinks in Philippines.

Medicinal uses

Though star gooseberries do not receive as much attention as aonla, these fruits may still be considered super fruit for their incredible health benefits. Traditionally, star gooseberry fruits were used in India to treat a number of illnesses. According to the book, ‘Biodiversity in India’ these fruits are used as a blood purifier and appetite stimulant. They are also used to remedy bronchitis, biliousness, and treat digestive disorders such as urinary concretions, diarrhoea and piles. Fruits are taken as liver tonic and to enrich the blood. The syrup is prescribed as a stomachic and seeds are cathartic. Because of mucilaginous nature of leaves, they are taken as a demulcent in cases of gonorrhea in India. The roots of star gooseberry are boiled and the steam is inhaled to relieve coughs and headache. The root infusion is taken in very small doses to alleviate asthma. Externally, the root is used to treat psoriasis of the soles of feet.

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TEA PLANTATIONS: NURTURING NATURE WITH INTEGRATED PEST MANAGEMENT

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Abstract

The perennial tea plant, *Camellia sinensis,* is farmed in huge, continuous monocultures. Numerous infamous pests, including weeds, mites, nematodes, insects, and diseases, attack tea plants. The preparation and application of novel botanical and microbial pesticide formulations, the assessment of field bio-efficacy and biological agent conservation, and cultural control strategies are all highlighted in the current trends in environmentally friendly insect pest management practices. In the husbandry of tea, mechanical methods such as manual removal, heat treatments, use of bio-pesticides and bio-control agents, as well as cultural control techniques like plucking, pruning, regulating shade, field sanitation, fertilizer application, manipulation or destruction of alternate hosts, and selection of pest-resistant or tolerant varieties.

Keywords: Rice, Integrated pest management, Insect pests, IPM.

Introduction

Primarily cultivated as a monoculture across vast contaminated regions, *Camellia sinensis* (L.) is a perennial crop. The farming system, being permanent and monoculture, creates a steady microclimate that attracts a variety of insect pests that significantly reduce crop yield. It is critical to look into alternative pest management techniques due to the rising expense of insect pest control and growing worries about the harmful effects of pesticide residues in produced tea. Because the perennial tea plantation system has a high pest diversity, integrated pest management, or IPM, in the tea industry encourages a multidisciplinary approach.

Integrated Pest Management

In tea plantations, integrated pest management (IPM) strategy employs a wide range of techniques, such as cultural practices, chemical pesticides, biological control agents, pest-resistant cultivars, and physical barriers. The immediate protection of tea and various constraints to employ different control methods have led to the incorporation and continued use of all standard control strategies, such as natural control (climatic factors, topographic features, predators, and parasites, etc.) and applied control (cultural control, microbial control, regulatory control, chemical control, mechanical control, biological control, Biological control, Microbial control, Regulatory control, Chemical control, and Integrated control, Breeding of resistant agrotypes, Ionizing radiation, Chaemosterilant, etc.). Since there are many and growing success stories with the implementation of IPM methods, the various components of the practices are listed below with a few specific instances.

1. Cultural control

Certain routine cultural practices, like plucking rounds, adjusting pruning cycles, modifying shade trees, and promptly controlling weeds, can be effectively used as preventive measures of pest control. Cultural control is reportedly the most affordable and widely applicable method of pest management. It involves the intelligent manipulation of all aspects of crop husbandry in tea culture.

1.1. Plucking

One of the frequent occurrences in tea culture is plucking. The elimination or reduction of numerous foliar pests, including scales, aphid jassids, tea mosquito bugs, and leaf folding caterpillars like flushworms and leaf rollers, is greatly impacted by this process. More insect eggs, larvae, and juvenile stages will be removed from the shrub during shorter plucking sessions. Eggs were placed by tea mosquito bugs on the broken ends, or stalks, of harvested plants. During plucking, remove as much of the stalks as possible to minimize the presence of this insect.

1.2. Pruning

An important agronomic technique used in the winter to rejuvenate vegetative growth at the expense of reproduction and boost crop productivity the following year is pruning. Pruning eliminates a significant portion of the pest populations that are on the stems and foliage. During pruning, the majority of foliar pests are eliminated, including tea mosquito bugs, flush worms, aphids, jassids, thrips, red spider mites, scarlet mites, and purple mites.

1.3. Field sanitation

Field sanitation assumes significance in the management of several pests. Weeds offer excellent hiding places and serve as alternate hosts for *Helopeltis* and Red spider mites. *Malastoma malabethricum* and *Urena lobata* weeds act as alternate host of Red spider mite.

2. Physical control

One of the key components of the integrated pest management program is physical control. By employing tools that physically impact pests or change their physical surroundings, these interventions seek to lower pest populations.

2.1. Manual removal

The collection and extermination of Lepidopteran caterpillars is cost-effective and beneficial for both small and large plantations. By manually removing the larvae and pupae, the population of caterpillars that feed on foliage, such as looper caterpillars, faggot worms, flush worms, and leaf rollers, can be greatly reduced.

2.2. Heat treatment and soil solarisation

The growth medium for tea plants is soil. Numerous insects, such as termites, cockchafer grubs, eelworms, and root mealy bugs, can survive or hibernate in areas with appropriate humidity and temperature that are under or close to the soil's surface. The nursery soil can be heated to 60–65°C to destroy the infectious juvenile soil nematode.

3. Mechanical control

Pests can be suppressed manually with mechanical methods and gadgets. There aren't many attempts using this technique to control tea pests. To manage termites, however, not many techniques have been created and implemented in tea plantations.

3.1. Mound digging process

Termitaria, or termite mounds, are dome-shaped, closed-system clay mounds with architectural design that naturally shield against harsh environmental conditions. In order to increase the population, the queen, who resides inside the mound, produces minuscule offspring. Using mechanical control to eliminate termitaria appears to be a workable way to manage termites.

4. Biological control

In order to keep pests below manageable limits, biological techniques of management entail the conservation, maintenance, and introduction of natural enemies such as predators, parasitoids, and diseases. From the tea estates, more than a hundred species of parasitoids, predators, and diseases have been identified.

4.1. Predator

A number of predatory mites, primarily from the families Phytoseiidae, Stigmaeidae, and Tydeidae, feed primarily on phytophagous mites that infest tea..

Hippodamia divergens

Chrysoperla carnea

In tea, Oligota flaviceps is recognized as a predator of red spider mites.*Chrysoperla carnea* has been recognized as a predator of thrips and *Helopeltis*. *Hippodamia divergens*, the lady bird beetle, has the ability to efficiently suppress tea aphid populations. *Verania discolor* has been discovered as the probable predator of the red spider mite

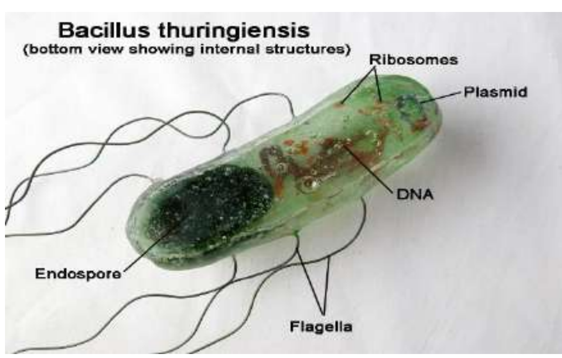
4.2. Parasitoid

The leaf-rolling caterpillar, *Cydia leucostoma,* is parasitized by nine species of braconids, two ichneumonids, one encyrtid, and an Ascogaster pupal parasitoid. *Apanteles aristaeus* is the most prevalent species of larval parasitoids on flushworms. *Erythmelus helopeltidis*, an egg parasitoid, has been successful against *Helopeltis theivora*, a tea mosquito bug.

Apanteles aristaeus

4.3. Pathogens

A recent topic of research for integrated pest management in tea is the use of entomopathogenic fungi. *Bacillus thuringiensis* has proven to be a successful tool in managing many lepidopterous pests, including looper caterpillars, cutworms, and flushworms.



5. Chemical Control

It has long been believed that one of the most important agricultural inputs for raising crop yields is pesticides.

For insect and mite pests of tea to be successfully controlled, the right choice of insecticides, dose, timing, and application technique are crucial.

Conclusion

The most important component of chemical control measures under IPM strategy is the administration of pesticides in a need-based, prudent, and safe manner. It entails learning IPM techniques to protect the environment through appropriate crop health monitoring, ETL observation, and preservation of the potential for natural biocontrol before opting to employ chemical pesticides as a last resort.

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NUTRIENT MANAGEMENT IN ORGANIC FARMING

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Introduction

The organic farming is the production of crops, animals and others without using the chemical fertilizers, genetically modified plants and chemical pesticides. The USDA defines organic agriculture as “a production system that is managed to respond to site-specific conditions by integrating cultural, biological and mechanical practices that foster cycling of resources, promote ecological balance, and conserve biodiversity.” According to the survey of Research Institute of Organic Agriculture (2017), there are 181 countries with 69.8 mha of organic farming lands which is 1.4% of the total agricultural land. Oceania occupies the largest world organic production. The total organic farming land in Asia is 6.1mha from which 1.1 million producers are from India. The green revolution results in use of chemical fertilizers extensively. This leads to pollution which has the adverse effect on climate. Organic farming helps to overcome these hazardous consequences.

Nutrient Management in Organic Farming

Because chemical fertilizers and micronutrients are not utilized in organic farming, managing nutrients can be difficult. Management of the soil's biological health, physical state, and nutritional status are all included in nutrient management.In organic farming, there are many different ways to supply nutrients. They are,

i. Crop rotation
ii. Cover cropping
iii. Addition of compost
iv. Green manures/Green leaf manures
v. Addition of manures
vi. Application of crop residues
vii. Use of biofertilizers

i. Crop rotation

The crop rotation improves soil physical properties (pH, CEC, bulk density), nutrient availability (total nitrogen, available phosphorus, exchangeable potassium) , pest management, nutrient use efficiency and crop yield. Monoculture leads to decrease in the soil nutrients. A legume in the crop rotation helps to replenish the nitrogen in the soil. Growing of legume will make the nitrogen available for succeeding crop. Crop rotation with non host crops helps to break the life cycle of pests or it helps to decrease the rate of population of the pests. Crop rotation with crops having different root architecture helps in use of nutrients in different soil layers.

ii. Cover cropping

The cover crops are grown in between the main crop or grown during the season where the main crops are not grown. They are generally fast growing crops which are not competitive for the main crop. Cover cropping has a role in preventing soil erosion, increase nutrient availability and promote the organic matter of the soil. The cover crops are mostly leguminous plants. These plants act as green manure. They provide additional nitrogen through symbiotic relationship with rhizobial bacteria. The cover crop biomass increases the soil organic matter. So the water holding capacity and soil structure is improved.

iii. Addition of compost:

Composting is the process of decomposition of organic matter by microorganisms under controlled conditions. The product of composting is called compost. The organic materials such as crop wastes, food wastes, animal wastes, municipal wastes, industrial wastes are suitable for composting. It increases the soil physical, chemical and biological properties. Compost provides nutrients in a stable organic form and increases plant rooting depth, plant growth and health. It also improves soil microbial activity and water holding capacity of soil.

iv. Green manures/Green leaf manures

Green Manure

Green undecomposed material used as manure is called green manure. It is obtained in two ways: by growing green manure crops or by collecting green leaf (along with twigs) from plants grown in wastelands, field bunds and forest. Green manuring is growing in the field plants usually belonging to leguminous family and incorporating into the soil after sufficient growth. The plants that are grown for green manure known as green manure crops. The most important green manure crops are sunnhemp, dhaincha, pillipesara,clusterbeans and Sesbania rostrata.

Advantages

i. Improves soil structure
ii. Increases water holding capacity and
iii. Decreases soil loss by erosion

GREEN LEAF MANURE

Application of green leaves and twigs of trees, shrubs and herbs collected from elsewhere is known as green leaf manuring. Forest tree leaves are the main sources for green leaf manure. Plants growing in wastelands, field bunds etc., are another source of green leaf manure. The important plant species useful for green leaf manure are neem, mahua, wild indigo, Glyricidia, Karanji *(Pongamia glabra)* calotropis, avise*(Sesbania grandiflora),* subabul and other shrubs.

Advantages

i. Green manuring improves soil structure, increases water holding capacity and decreases soil loss by erosion.
ii. Growing of green manure crops in the off season reduces weed proliferation and weed growth.
iii. Green manuring helps in reclamation of alkaline soils. Root knot nematodes can be controlled by green manuring.

v. Manuring

Manures are the animal or plant wastes which release nutrients slowly by biological decomposition. Manures are grouped into bulky and concentrate organic manure. Bulky organic manures contain small amount of nutrients and should be applied in large quantities which constitute farm yard manure, poultry manure. Concentrate organic manures have large amount of nutrients so it should by applied in small quantities. It includes edible and non edible oil cakes, blood meal, horn meal, hoof meal, bone meal and fish meal.

Bulky organic manure

Organic manure	N(%)	P(%)	K(%)
Cow Manure	0.6	0.4	0.5
Pig Manure	0.8	0.7	0.5
Poultry Manure	1.1	0.8	0.5
Sheep Manure	0.7	0.3	0.9

Average nutrient content of oil cakes

Oil-cakes	**Nutrient content (%)**		
	N	**P2O5**	**K2O**
Non edible oil-cakes			
Castor cake	4.3	1.8	1.3
Cotton seed cake (undecorticated)	3.9	1.8	1.6
Karanj cake	3.9	0.9	1.2
Mahua cake	2.5	0.8	1.2
Safflower cake (undecorticated)	4.9	1.4	1.2
Edible oil-cakes			
Coconut cake	3.0	1.9	1.8
Cotton seed cake (decorticated)	6.4	2.9	2.2
Groundnut cake	7.3	1.5	1.3
Linseed cake	4.9	1.4	1.3
Niger cake	4.7	1.8	1.3
Rape seed cake	5.2	1.8	1.2
Safflower cake (decorticated)	7.9	2.2	1.9
Sesamum cake	6.2	2.0	1.2

Other Concentrated Organic Manures

Blood meal when dried and powdered can be used as manure. The meat of dead animals is dried and converted into meat meal which is a good source of nitrogen. Average nutrient content of animal based concentrated organic manures is given as follows.

Average nutrient content of animal based concentrated organic manures

Organic manures	Nutrient content (%)		
	N	P2O5	K2O
Blood meal	10 - 12	1 - 2	1.0
Meat meal	10.5	2.5	0.5
Fish meal	4 - 10	3 - 9	0.3 - 1.5
Horn and Hoof meal	13	-	-
Raw bone meal	3 - 4	20 - 25	-
Steamed bone meal	1 - 2	25 - 30	-

Crop residues

In India about 141 million tons of crop residues are produced per year, out of which 92 mt is burned each year. The two crops such as rice and wheat are produced large amount of residues in India. These crop residues can be incorporated directly into the field or can be used for composting processes. It plays important role in maintaining the soil carbon content and phosphorus availability .It provides soil organic matter, which improves the quality of the seedbed and increases the water infiltration and water holding capacity of the soil, balances the pH . It also sequester Carbon in the soil.

Use of biofertilizer

A biofertilizer is a substance which contains living micro-organisms which, when applied to seeds, plant surfaces, or soil, colonize the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant. Biofertilizers make the nutrients available to the plants. There are various types of bioferilizers.

i. Nitrogen fixing bioferilizers
ii. Phosphorus solubilizing bioferilizers
iii. Phosphorus mobilizing bioferilizers
iv. Zinc solubilizing bioferilizers
v. Sulphur solubilizing biofertilizers
vi. Plant growth promoting rhizobactria

Liquid Biofertilizers

Biofertilizers are such as *Rhizobium*, *Azospirillum* and Phosphobacteria provide nitrogen and phosphorous nutrients to crop plants through nitrogen fixation and phosphorous solubilization processes. These Biofertilizers could be effectively utilized for rice, pulses, millets, cotton, sugarcane, vegetable and other horticulture crops. Biofertilizers is one of the prime input in organic farming not only enhances the crop growth and yield but also improves the soil health and sustain soil fertility. At present, Biofertilizers are supplied to the farmers as carrier based inoculants. As an alternative, liquid formulation technology has been developed in the Department of Agricultural Microbiology, TNAU, Coimbatore which has more advantages than the carrier inoculants.

Benefits

The advantages of Liquid Bio-fertilizer over conventional carrier based Bio-fertilizers are listed below:

- Longer shelf life -12-24 months.
- No contamination.
- No loss of properties due to storage upto 45º c.
- Greater potentials to fight with native population.
- High populations can be maintained more than 109 cells/ml upto 12 months to 24 months.
- Easy identification by typical fermented smell.
- Cost saving on carrier material, pulverization, neutralization, sterilization, packing and transport.
- Quality control protocols are easy and quick.
- Better survival on seeds and soil.
- No need of running Bio-fertilizer production units through out the year.
- Very much easy to use by the farmer.
- Dosages is 10 time less than carrier based powder Bio-fertilizers.
- High commercial revenues.
- High export potential.
- Very high enzymatic activity since contamination is nil.

Dosage of liquid Bio-fertilizers in different crops

Recommended Liquid Bio-fertilizers and its application method, quantity to be used for different crops are as follows:

Crop	Recommended Bio-fertilizer	Application method	Quantity to be used
Field crops Pulses Chickpea, pea, Groundnut, soybean, beans, Lentil, lucern, Berseem, Green gram, Black gram, Cowpea and pigeon pea	*Rhizobium*	Seed treatment	200ml/acre
Cereals Wheat, oat, barley	*Azotobacter/Azo spirillum*	Seed treatment	200ml/acre
Rice	*Azospirillum*	Seed treatment	200ml/acre
Oil seeds Mustard, seasum, Linseeds, Sunflower, castor	*Azotobacter*	Seed treatment	200ml/acre
Millets Pearl millets, Finger millets, kodo millet	*Azotobacter*	Seed treatment	200ml/acre
Maize and Sorghum	*Azospirillum*	Seed treatment	200ml/acre
Forage crops and Grasses Bermuda grass, Sudan grass, Napier Grass , ParaGrass, StarGrass etc.	*Azotobacter*	Seed treatment	200ml/acre
Other Misc. Plantation Crops Tobacco	*Azotobacter*	Seedling treatment	500ml/acre
Tea, Coffee	*Azotobacter*	Soil treatment	400ml/acre
Rubber, Coconuts	*Azotobacter*	Soil treatment	2-3 ml/plant
Agro-ForestRY/Fruit Plants All fruit/agro-forestry (herb,shrubs, annuals and perennial) plants for fuel wood fodder, fruits,gum,spice,leaves,flowers,nuts and seeds puppose	*Azotobacter*	Soil treatment	2-3 ml/plant at nursery
Leguminous plants/ trees	*Rhizobium*	Soil treatment	1-2 ml/plant

Beneficial effects of Panchagavya on commercial crops

Mango

- Induces dense flowering with more female flowers
- Irregular or alternate bearing habit is not experienced and continues to fruit regularly

- Enhances keeping quality by 12 days in room temperature
- Flavour and aroma are extraordinary

Guava

- Higher TSS
- Shelf life is extended by 5 days

urmeric

- Enhances the yield by 22%
- Extra long fingers
- Ensure low drainage loss
- Narrows the ratio of mother and finger rhizomes
- Helps survival of dragon fly, spider etc which in turn reduce pest and disease load
- Sold for premium price as mother/seed rhizome
- Enriches the curcumin content

Vegetables

- Yield enhancement by 18% and in few cases like Cucumber, the yield is doubled
- Wholesome vegetables with shiny and appealing skin
- Extended shelf life
- Very tasty with strong flavour

Acid lime

- Continuous flowering is ensured round the year
- Fruits are plumpy with strong aroma
- Shelf life is extended by 10 days

Banana

- In addition to adding with irrigation water and spraying, 3% solution (100 ml) was tied up at the naval end of the bunch after the male bud is removed. The bunch size becomes uniform. One month earlier harvest was witnessed. The size of the top and bottom hands was uniformly big.

Jasmine

- Exceptional aroma and fragrance
- No incidence of bud worm
- Continuous flowering throughout the year

Time of application of Panchagavya for different crops is given as follows

Crops	Time schedule
Rice	10,15,30 and 50th days after transpalnting
Sunflower	30,45 and 60 days after sowing
Black gram	Rainfed: 1st flowering and 15 deays after flowering Irrigated: 15, 25 and 40 days after sowing
Green gram	15, 25, 30, 40 and 50 days after sowing
Castor	30 and 45 days after sowing
Groundnut	25 and 30th days after sowing
Bhendi	30, 45, 60 and 75 days after sowing
Moringa	Before flowering and during pod formation
Tomato	Nursery and 40 days after transplanting: seed treatment with 1 % for 12 hrs
Onion	0, 45 and 60 days after transplanting
Rose	At the time of pruning and budding
Jasmine	Bud initiation and setting
Vanilla	Dipping setts before planting

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ADVANCED TECHNIQUES TO INCREASE WATER USE EFFICIENCY

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Introduction

The term water use efficiency originates in the economic concept of productivity. Productivity measures the same amount of any given resource that must be expended to produce one unit of any goods or service. Thus, water productivity might be measured by the volume of water taken into a plant to produce a unit of the output. In general, the lower the resource input requirement per unit, the higher the efficiency.

Water use efficiency includes any measure that reduces the amount of water used per unit of any given activity, consistent with the maintenance or enhancement of water quality. In agricultural terms, the activity is the productivity of the crops in the command area

Water use efficiency is define as yield of marketable crop produced per unit of water used in evapotranspiration.

$$WUE = \frac{Y}{ET} \times 100$$

Where, Y = marketable yield

ET = evapotranspiration

Expressed in term of kg/ ha mm of water.

A. Crop water use efficiency: It is ratio of crop yield to amount of water depleted by the crop in the process of evapotranspiration

$$WUE = \frac{Y}{ET}$$

Where, Y = marketable yield

ET = evapotranspiration

B. Field water use efficiency: is the crop yield to total amount of water used in the field.

$$WUE = \frac{Y}{WR}$$

Where, Y = marketable yield

WR = water requirement

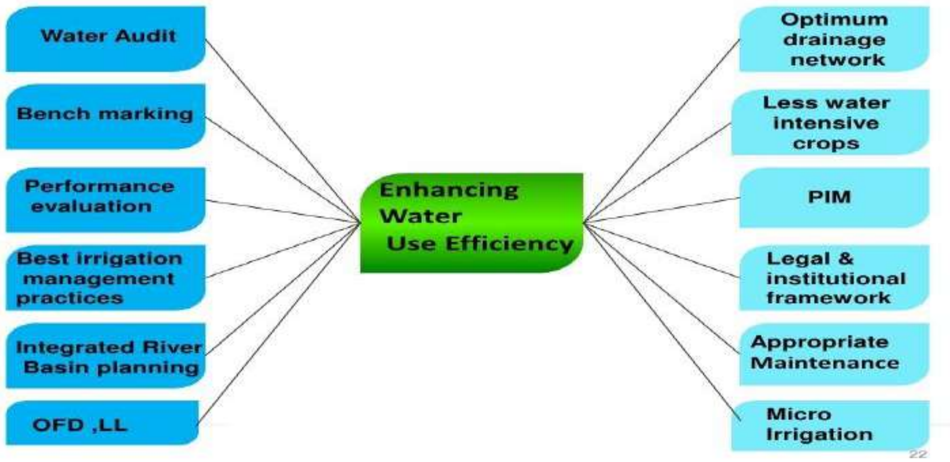
Efficiency is a measure of output, obtained from a given unit of input.

Principal factor influencing WUE.

- Design of the irrigated system,
- Degree of land preparation and
- Skill and care from the irrigator.

Water use efficiency of different crops

Crop	**Water requirement (mm)**	**Grain yield (kg/ha)**	**WUE (kg/ha mm)**
Rice	2,000	6,000	3.0
Sorghum	2,000	6,000	3.0
Pear millet	500	4,000	8.0
Maize	625	5,000	8.0
Groundnut	506	4,680	9.2



B Scenarios

Four scenarios for improving the water-use efficiency of the agricultural sector are evaluated:

1. **Modest crop shifting**

Shifting a small percentage of lower-value, water-intensive crops to higher- alue, water -efficient crops.

2. Smart irrigation scheduling

Using irrigation scheduling information that helps farmers more precisely Irrigate to meet crop water needs and boost production.

3. Advanced irrigation management

Applying advanced management methods that save water, such as regulated deficit irrigation.

4. Efficient irrigation technology

Shifting a fraction of the crops irrigated using flood irrigation to sprinkler and drip Systems.

Irrigation Efficiency

The percentage of applied irrigation water stored in soil and made available for consumption use by the crop .when the water is measured at its entry to a farm, it is called farm irrigation efficiency.

$$\text{Irrigation Efficiency} = \frac{\text{Water stored in the soil for crop growth}}{\text{Water applied as irrigation}} \times 100$$

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SOIL CARBON SEQUESTRATION AND CARBON TRADING

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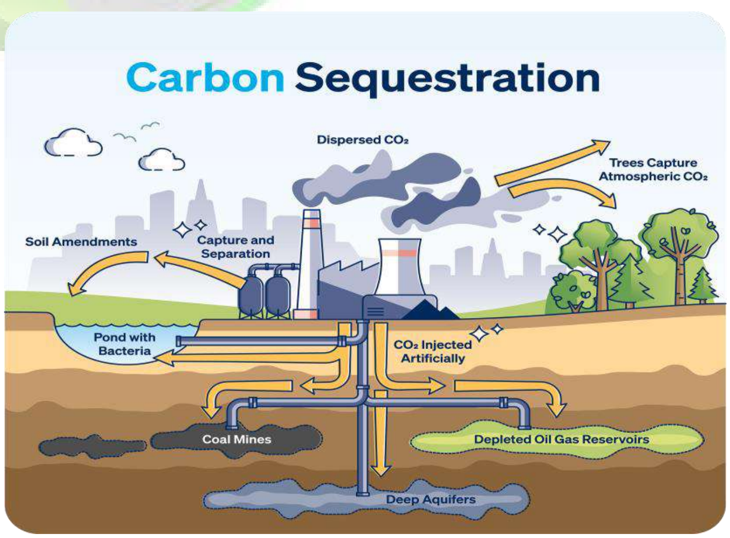
Introduction

Carbon sequestration is the process of capturing and storing of atmospheric carbon dioxide. It is one method of reducing the amount of carbon dioxide in the atmosphere with the goal of reducing global climate change. Carbon sequestration is the process involved in carbon capture and the long-term storage of atmospheric carbon dioxide (CO_2) and may refer specifically to:

"The process of removing carbon from the atmosphere and depositing it in a reservoir." When carried out deliberately, this may also be referred to as carbon dioxide removal, which is a form of geo-engineering. Carbon capture and storage, where carbon dioxide is removed from flue gases (e.g., at power stations) before being stored in underground reservoirs.



Natural biogeochemical cycling of carbon between the atmosphere and reservoirs, such as by chemical weathering of rocks.

Carbon sequestration describes long-term storage of carbon dioxide or other forms of carbon to either mitigate or defer global warming and avoid dangerous climate change. It has been proposed as a way to slow the atmospheric and marine accumulation of greenhouse gases, which are released by burning fossil fuels.

Carbon dioxide is naturally captured from the atmosphere through biological, chemical or physical processes. Some artificial sequestration techniques exploit these natural processes, while some use entirely artificial processes.

Objectives of carbon sequestration

- Developing technologies to reduce rate of concentration of green house gases carbon in air.
- Reducing pollution in air as well as improving natural carbon content in soil
- Improvement of soil structure and restoring degraded soil leading to increase yield in crops.

Carbon dioxide emission in top five countries

China	- 8.1 Billion metric tons per annum
The US	- 5.7 ”
India	- 1.83 ”
Russia	- 1.78 ”
Japan	- 1.26 ”

Sources of carbon dioxide emission

1. **Man made sources**

   Industries

   Transportation

   Land use change

   Soil cultivation

   Biomass burning

2. **Natural sources**

   Volcanoes

   Wild fires

Decomposition

Respiration

Ways of carbon sequestration

1. Geological sequestration – underground
2. Ocean sequestration - deep in ocean
3. Terrestrial sequestration - in plants and soil

1. Geological sequestration

Geologic storage involves capturing anthrophogenic CO_2 before its entries the atmosphere and injecting it into underground formations. Once CO_2 is injected to deep underground (typically more than 800 meters) it is trapped in minute pores or spaces in the rock structure. Impermeable cap rocks above the storage zone act as seals to ensure the safe storage of CO_2.

2. Ocean sequestration

Carbon is naturally stored in the ocean via two pumps, solubility and biological and there are analogous man made method, direct injection and ocean fertilization, respectively.

At the present time approximately one third of human generated emission are estimated to be entering the ocean.

3. Terrestrial sequestration

The process through which CO_2 from the atmosphere is absorbed naturally through photosynthesis and stored as carbon in biomass and soil.

Carbon sources and carbon sink

Carbon sources

A forest is considered to be a carbon source if it releases more carbon than it absorbs. Anthrophogenic activities such as burning the fossil fuels have released carbon from its long-term geologic storage as coal, petroleum and natural gas and have delivered it to the atmosphere as carbon dioxide gas.

Carbon sink

The main natural carbon sinks are plants, the ocean and soil. Plants grab CO_2 from atmosphere to use photosynthesis; some of this carbon is transferred to the soil as plants die and decompose. The ocean are a major carbon storage system for CO_2. Marine animals also take up the gas for photosynthesis; while some CO_2 simply dissolves in the seawater.

The role of trees and forest in reducing the atmospheric carbon

Trees it's the carbon storage expert. One half dry weight of wood is carbon. Trees take in CO_2 from the air in the process called photosynthesis.

The trees effectively breakdown the CO_2 stores, the carbons in all part of the tree and releases the oxygen back into atmosphere. Fast growing trees are, in fact, the most efficient way to sequester atmospheric carbon.

As forests grow, they store carbon in woody tissues and soil organic matter. The net rate of carbon uptake is greatest when forests are young and slows with time. Old forests can sequester carbon for a long time but provide essentially no net uptake.

The main strategies for using forests for carbon sequestration

Active forest management

Avoided deforestation

Forest preservation

Afforestation

Benefits of soil sequestration of carbon

Improved soil structure

Better water use and storage

Less erosion

Increased soil fertility

Improved biodiversity

Healthier ecology

Improved agriculture performance

Challenges in soil carbon sequestration

Deforestation

Burning residues

Conventional tillage

Imbalanced use of fertilizers

Reduced inputs of organic matter

Greenhouse gas concentration in the atmosphere are increasing and the threat of the global climate change requires our attention.

Soil carbon sequestration is an effective tool to sequester atmosphere CO_2 with better practical application than other approaches.

Soil carbon sequestration provide vast opportunity to sequester carbon in the soil.

A diversity of agricultural management practices can be employed to sequester more carbon in plants and soil:

Crop management

Nutrient management

Residue management and conservation tillage

Agro-forestry

Soil carbon sequestration using innovative soil and crop management practices is needed to augment soil carbon sequestration.

Combination of different agricultural management practices can enhance soil carbon sequestration.

Carbon trading

- ❖ It is an administrative approach used to control pollution by providing economic incentives for achieving reductions in the emissions of pollutants.
- ❖ It is the trading of permits to emit carbon dioxide (and other greenhouse gases, calculated in tonnes of carbon dioxide equivalent, tCO_2e). It is one of the ways countries can meet their obligations under the Kyoto Protocol to reduce carbon emissions and thereby mitigate global warming
- ❖ Here sets a limit or *cap* on the amount of a pollutant that can be emitted. Companies or other groups that emit the pollutant are given *credits* or *allowances* which represent the right to emit a specific amount. The total amount of credits cannot exceed the cap, limiting total emissions to that level. Companies that pollute beyond their allowances must buy credits from those who pollute less than their allowances. This transfer is referred to as a trade.

What is Kyoto Protocol ?

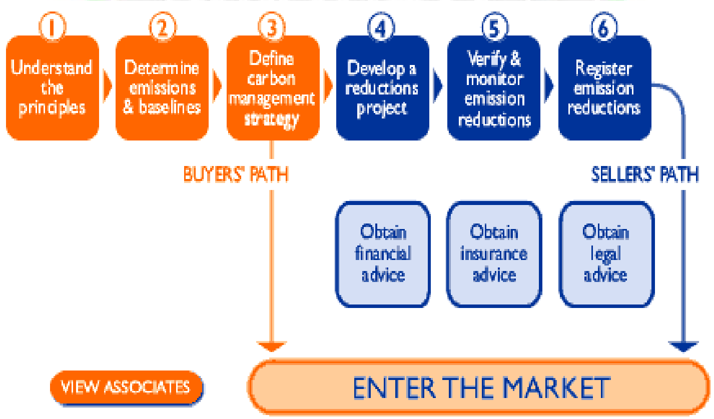
- ❖ From December 1 through 11, 1997, more than 160 nations met in Kyoto, Japan, to negotiate binding limitations on greenhouse gases for the developed nations, pursuant to the objectives of the Framework Convention on Climate Change of 1992. The outcome of the meeting was the Kyoto Protocol, in which the developed nations agreed to limit their greenhouse gas emissions, relative to the levels emitted in 1990.

- It Entry into Force on 16 February2005
- India Signed and ratified in August 2002
- Ratified by >130 countries
- Major non-participants: USA and Australia
- Commits industrialised countries to reducing their greenhouse gas emissions by, on average, 5% below 1990 levels in 2008-12
- Individual, quantified emission targets for each industrialized country
- Six greenhouse gases covered: CO_2, CH_4, N_2O, HFC/PFC, SF_6

European Union Emission Trading Scheme

- The scheme, in which all 25 member states of the European Union participate, commenced operation on 1 January 2005
- Under the scheme, each participating country proposes a National Allocation Plan (NAP) including caps on greenhouse gas emissions for power plants and other large point sources.
- In the first phase (2005-2007), the EU ETS includes some 12,000 installations, representing approximately 45% of EU CO_2 emission.
- The second phase (2008-12) is to cover not only CO_2, but all greenhouse gases.

Carbon Trading Cycle



Understand the Principles

- Assist you in identifying and addressing these climate change issues, the direction of policy and their potential impacts on your business.

Determine Emissions & Base Line

- Assist in determining, monitoring and reporting your firm's emissions and baselines and identifying internal abatement opportunities.

Define Carbon Management Strategy

It offers strategic advice on how to achieve an effective carbon management strategy in a manner that best fits your risk profile, regulatory environment, capacity and existing operations

Develop a Reduction Project

❖ It offers a choice of specialist services to assist in developing your emission reduction project through

❖ Joint Implementation

❖ Clean Development Mechanism

Verify & Monitor Emission Reduction

❖ It provides independent greenhouse gas emission verification services involving analytical review of a data acquisition process, assessment and testing of internal controls, and the validation of data.

Register Emission Reduction

❖ Provide independent registry services for emission reductions.

Obtain Financial Advice

❖ The most basic strategic analysis needs to include a review of the Financial Impact of Climate Change, and sellers need CO_2e Project Financing Solutions together with Structured Financial Solutions to liberate hidden value from the instruments themselves.

Obtain Insurance Advice

❖ Insurance services provide enhanced security to your climate change investments and marketability to your reductions. Risk Optimization of Carbon Offset Projects and Trading should enable you to avoid setbacks, reduce unnecessary exposures, provide access to alternative sources of project finance and enhance the competitiveness of your offers to sell emission reductions

Obtain Legal Advice

❖ Sellers need Integrated CO_2e Project Advice, and buyers need to understand the Legal Validity of Project Based Emission Reductions which they may be buying.

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ENHANCING QUALITY AND SHELF LIFE: SUPPLY COOL CHAIN MANAGEMENT FOR FRESH FRUITS AND

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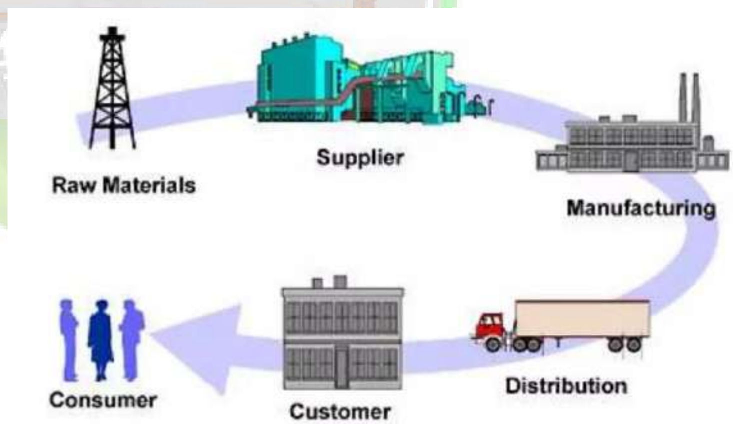
Introduction

The global demand for fresh fruits and vegetables has been steadily increasing due to a growing population, changing consumer preferences towards healthier diets, and increased awareness of the importance of nutrition. However, ensuring the freshness and quality of these perishable goods from farm to table is a complex challenge. Supply Cool Chain Management (SCCM) plays a pivotal role in preserving the quality and extending the shelf life of fresh fruits and vegetables, here we will delve into the intricacies of SCCM, exploring its components, challenges, benefits, and the latest innovations.



Understanding the Supply Cool Chain

The Supply Cool Chain is a series of processes and infrastructure designed to maintain a consistently low temperature throughout the entire journey of fresh produce from the point of harvest to the point of consumption. The primary objective is to minimize temperature fluctuations and prevent exposure to un-favorable conditions that could lead to the deterioration of quality and nutritional value.

Components of Supply Cool Chain Management

1. **Harvesting and Pre-cooling**

The first critical step in SCCM is the proper harvesting of fruits and vegetables. Post-harvest losses can occur if the produce is not handled carefully during this phase. Pre-cooling is the immediate cooling of fresh produce to remove field heat and slow down the ripening process. This step is crucial for preserving quality and preventing decay.

2. **Cold Storage**

Cold storage facilities are integral to SCCM, providing a controlled environment to store fresh produce at optimal temperatures. Different fruits and vegetables have specific temperature requirements, and cold storage facilities must be equipped with the necessary technology to maintain these conditions. Regular monitoring and maintenance of storage units are essential to prevent temperature fluctuations.

3. **Transportation**

Transportation is a critical link in the cool chain. Refrigerated trucks, containers, and specialized vehicles are employed to ensure that the temperature is maintained during transit. Real-time monitoring systems, such as GPS and temperature sensors, allow for tracking and immediate response to deviations from the required conditions.

4. **Distribution Centers**

Distribution centers act as hubs where fresh produce is consolidated, sorted, and redistributed to various retail outlets. These facilities must also have adequate cooling infrastructure to prevent quality degradation during the sorting and packing processes.

5. **Retail Display and Storage**

Once fresh produce reaches retail outlets, maintaining the cool chain becomes the responsibility of the store. Refrigerated display cases, storage units, and proper handling practices are crucial to preserving the quality of fruits and vegetables.

Regular checks and adherence to storage guidelines are essential to minimize losses.

Challenges in Supply Cool Chain Management

1. **Infrastructure Gaps:**

In many regions, especially in developing countries, there is a lack of sufficient infrastructure for effective SCCM. Limited access to reliable cold storage, transportation, and distribution facilities can lead to significant post-harvest losses.

2. **Temperature Fluctuations:**

Maintaining a consistent temperature throughout the supply chain is challenging. Temperature fluctuations, even for short durations, can accelerate the ripening process, leading to a loss of quality and shelf life.

3. **Technological Limitations:**

Some regions may lack access to advanced cooling technologies, making it difficult to implement and monitor an effective cool chain. Investments in research and development are crucial to bringing innovative solutions to diverse agricultural landscapes.

4. **Compliance and Standardization:**

Ensuring that all stakeholders in the supply chain adhere to temperature guidelines and best practices is a significant challenge. Standardization of processes and compliance with international quality standards are essential for a seamless cool chain.

Benefits of Supply Cool Chain Management

1.Extended Shelf Life:	2.Reduced Post-Harvest Losses:	3.Improved Quality and Nutritional Value:	4.Market Expansion:
•The primary benefit of SCCM is the extension of the shelf life of fresh fruits and vegetables. By controlling temperature and minimizing exposure to unfavorable conditions, the rate of deterioration is slowed down, allowing produce to remain fresh for a more extended period.	•Effective SCCM helps in minimizing post-harvest losses, ensuring that a higher percentage of the harvested produce reaches consumers in optimal condition. This not only benefits farmers economically but also contributes to food security.	•Maintaining a cool chain preserves the quality, texture, and nutritional value of fresh produce. Consumers receive fruits and vegetables that are not only visually appealing but also retain their essential vitamins and minerals.	•SCCM enables the transportation of fresh produce over longer distances, facilitating the expansion of markets. Farmers can reach a broader consumer base, including distant urban areas, increasing their potential for sales and revenue.

Innovations in Supply Cool Chain Management

1. **Blockchain Technology:**

Blockchain technology is being increasingly explored to enhance transparency and traceability in the supply chain. By recording every transaction and movement on a decentralized ledger, stakeholders can track the journey of produce from farm to table, ensuring compliance with temperature requirements and quality standards.

2. **Internet of Things (IoT) Sensors:**

IoT sensors play a crucial role in real-time monitoring of temperature, humidity, and other environmental factors during transportation and storage. These sensors transmit data to a centralized system, enabling quick response to deviations and minimizing the risk of quality deterioration.

3. **Advanced Packaging Solutions:**

Innovative packaging materials with insulating properties help in maintaining the desired temperature for a more extended period. Vacuum packaging, modified atmosphere packaging (MAP), and other advanced solutions contribute to the preservation of freshness.

4. **Artificial Intelligence (AI) and Machine Learning (ML):**

AI and ML algorithms analyze data from various sources, including weather forecasts, transportation routes, and historical data, to optimize the cool chain. Predictive analytics help in anticipating potential issues and proactively addressing them, minimizing disruptions in the supply chain.

Conclusion

Supply Cool Chain Management is indispensable for ensuring the availability of high-quality, fresh fruits, and vegetables in the global market. As the demand for these perishable goods continues to rise, it is imperative to address the challenges and leverage technological innovations to enhance the efficiency of the cool chain. By doing so, stakeholders across the supply chain can contribute to reducing post-harvest losses, improving food security, and meeting the growing expectations of consumers for fresh and nutritious produce. Continuous investments in infrastructure, technology, and collaboration among stakeholders are essential to building a robust and sustainable Supply Cool Chain for the future.

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PARAMPARAGAT KRISHI: A SUSTAINABLE AND HOLISTIC WAY OF SOIL HEALTH MANAGEMENT THROUGH ORGANIC AND BIODYNAMIC SOIL INPUTS

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Abstract

Indian agriculture heavily relies on chemical fertilizers for increased crop production, posing environmental concerns such as soil degradation. This article explores diverse farming practices, highlighting organic and biodynamic approaches to ensure sustainability and soil health. Traditional methods like Vedic and Biodynamic farming, coupled with practices such as Rishi Krishi and Agnihotra farming, integrate natural and cosmic influences for holistic soil management. By reducing dependence on chemical fertilizers, encouraging compost integration, and using specific organic formulations, the article emphasizes their positive impact on soil health, including increased organic matter, enhanced nutrient storage, and improved biological parameters. These innovative methods prioritize sustainability, preserving both soil health as well as the environment

Keywords: Agnihotra, Biodynamic Farming, Panchagavya, Rishi Krishi, Soil Health

Introduction

The predominant source of our nation's economy lies in the agricultural sector, accounting for approximately 18.33% of the GDP in the 2022-2023 fiscal year. The excessive utilization of chemical fertilizers has emerged as a significant concern. Since the Green Revolution, there has been a substantial rise in the application of chemical fertilizers in the agricultural section. The immoderate use of chemical fertilizers gradually deteriorates the soil health and its quality in respect of both physical, chemical and biological health of soil. It affects soil pH and nutrient availability, directly impacting soil productivity and causing economic losses for farmers Hence, we will face food crisis for avaoiding the importance of our soil health. To overcome this issue we should need to emphasize on organic amendments along with chemical fertilizers in agriculture to increase farm productivity and farmer's profitability.

Significance of supplementing soils with organic manures is addressed in Rig Veda (8000 BC. Even practice of green manuring is also found in Atharva Veda (Parma and Biswas, 2009). Kautilya Arthashastra (321-296, BC as per Nene, 2012) makes a reference to application of animal wastes and oilseed cakes. Several decades later, Indians innovated a very effective manure made from animal's waste. This is a three-month old liquid ferment called 'Kunepajala' (Surpala, 1000 AD, cited from Nene, 2012). In order to improve soil fertility and maintain crop productivity, apart from India, treatment with organic manures of all shades and introduction of legumes to break cereal- cereal cropping cycle have been practiced since thousands of years in other parts of the world.

Components

In the early stages of agriculture, innovative soil management systems emerged, particularly in India where pro-nature techniques were developed known as Rishi Krishi or Vedic farming. Vedic Farming, including practices like Agnihotra and Biodynamic agriculture, advocates the use of organic manures, specifically decoctions from five cow-based products (Pancha Gavya). These methods highlight the importance of homa in regulating plant growth and recommend organic preparations influenced by celestial body positions. It is believed that the astronomical calendar, aligning with the biorhythm of sunrise and sunset, generates energy from the cosmos, fostering a strong connection between man and nature. In today's context, the use of organic sources undeniably reinforces their constructive role in sustainable soil management.

1. Rishi Krishi:

Derived from the Vedas, farmers in Maharashtra and Madhya Pradesh have adopted the

Rishi Krishi method, a form of natural farming. This technique maximizes on-farm nutrient sources viz. composts, manure, green manure and crop residue for mulching. Soil enrichment is achieved by application of a Rishi Krishi formulation naming "Amritpani". Over one acre, 15 rhizospheric virgin soil collecting from beneath a Banyan tree (*Ficus bengalensis* L.) is broadcasted and then 200 liters of Amritpani is added through over the soil . To prepare Amritpani, 250 g of ghee is mixed with 10 kg of desi cow dung, 500 g of honey and lastly 200 liters of water added to it. This Amritpani preparation is used for seed treatment (Beeja sanskara), soil application & enrichment (Bhumi sanskara) and application also as foliar spray (Padapa sanskara). During soil treatment, this preparation is applied through fertigation. We can imply such a holistic approach for various crops like vegetable crops, cereals, fruits, pulse crops, oilseeds, cotton and sugarcane etc.

2. Panchagavya-Dashagavya Krishi

Panchgavya, a specialized bio-enhancer derived from five cow products (dung, urine, milk, curd, and ghee), has been refined by Dr. Natrajan, a scientist at Tamilnadu Agricultural University, to suit the needs of various crops. The formulation, as detailed earlier, includes Panchgavya and enriched Panchgavya (Dashgavya). The production cost is approximately Rs. 25-35 per litre. Panchgavya contains beneficial microorganisms and micronutrients, acting as a soil tonic to enhance plant vigour and quality production. It provides essential plant nutrients, along with vital plant growth regulators viz. IAA, GA etc. Panchgavya solution (3-4%) is effective for foliar spray, with four to five applications promoting optimal plant growth and production. Two sprays before flowering stage at 15-days intervals, two sprays during the flowering and pod formation stage at 10-days intervals and one spray during pod maturation stageEffectiveness of Panchgavya in various crops such as mango, banana, acid lime, guava, okra, cucumber, spinach, sunflower, green gram etc already get popularized.

3.Natural Farming

Natural farming promotes maximizing on-farm bio- resources. It deals with soil enrichment through the application of a formulation called Jivamrita which can enhance biological health of soil significantly. Bijamrita is used for the treatment of seed and planting materials and Jivamrita is used for soil application as well as foliar application. The package outlined above includes both these components. Jivamrita has been identified as a rich source of diverse beneficial soil microorganisms. As per study carried out by the Bio Centre Bangalore, Jivamrita contains :

Micro Organism	Quantity
Azospirillum	2 x 10^6
Phosphate Solubilizing Microbes (PSM)	2 x 10^6
Pseudomonas	2 x 10^2
Trichoderma	2 x 10^6
Yeasts and moulds	2 x 10^7

One single application over one acre land requires 200 litres of Jivamruta through various surface irrigation (fertigation) methods like drip, sprinkler or by soil drenching.

4. Agnihotra Krishi (Homa Krishi)

Agnihotra Krishi is a holistic approach to agriculture, compatible with various organic farming systems. Agnihotra, the fundamental fire rituals, aligns with the bio-rhythm of sunrise and sunset, drawn from Vedic sciences. Simplified for contemporary use, Agnihotra involves burning cow dung, brown rice and ghee in a pyramid shaped vessel made of copper while chanting a particular mantra. The process is believed to generate purifying and harmonizing energies directed into the atmosphere and preserved in the resulting ash. This highly energized ash serves as effective organic fertilizer in organic farming.

i. Fertilizers - Plants are benefitted from a powerful liquid fertilizer comprising Agnihotra ash, stinging nettles, and water. After fermenting stinging nettles in water for 7 to14 days, varying with weather and nettle quantity, and mixture is diluted in a ratio of 1:9. This implies mixing one-part of stinging nettle solution with nine parts of water, and straining the mixture through a fine screen into a spraying container or watering can to fortify and nourish plants.

ii. Nutrient Solution – Agnihotra plant nutrient solution also prepared by adding about 4 tablespoons of finely grounded Agnihotra ash with dried cow dung in approximately 5 litres of water. Apply this mixture to the plants, and the process can be repeated every 14 days as per requirement.

iii. Gloria Biosol an effective homa biofertilizer - Gloria Biosol, an effective bio-fertilizer, may be easily produced in a Homa environment. The liquid Biosol serves as a beneficial foliar application for plant and soil nourishment, surpassed with vermiwash due to its abundance of beneficial microorganisms and the energy derived from the Homa process. The presence of Agnihotra Ash significantly enhances Biosol, enriching it with macronutrients. The production involves mixing materials in a tank (200, 500, or 1000 liters) with the addition of a copper Shree Yantra disc. After sealing the tank, leave it for couple of days (mainly 20 to 30 days). After digestion is finished, the slurry is extracted. In order to use Biosol, dilute it at the ratio of 1:10 with Agnihotra ash water solution. 200 liters solution is required to cover one hectare of land area.

3. Biodynamic Agriculture

Biodynamic Agriculture, a term derived from 'Bios' meaning life and ‘dynamic’ meaning energy, is a farming method where the farming system is considered as as a living body interacting with the surrounding environment. The goal is to achieve healthy and living soil system and produce nourishing outputs that vitalizes human energy contributing to human development. Collecting from eight lectures by Dr. Rudolf Steiner in 1924, biodynamic agriculture incorporates simple, natural, homeopathic preparations to enhance beneficial cosmic influences on plants and soil. These preparations, including silica, lime, and others, aim to revitalize natural forces, aligning with planetary cosmic rhythms and fostering a living soil. The important elements of biodynamic farming are given below:

i. Incorporation of plant residues, stover, straw etc. into soil.
ii. Avoid chemical fertilizers.
iii. Prevent compaction of soil caused by animals, farm machinery etc.
iv. Promote pasteuring, mulching and avoid excessive tillage.
v. Fallowing the land etc.
vi. Application of formulations BD - 500 and BD - 501.
vii. Preparation of organic compost using formulations BD-502 to BD-507.
viii. Preparation of liquid manure with formulations BD - 502 to BD - 507.
ix. Development of cow dung manure using formulations BD-502 to BD-507.

A total of nine biodynamic preparations have been formulated, designated as formulations 500 to 508. Dr. Steiner provided two preparations (numbered 500 and 501) meant for direct application on soil or plants and six preparations (numbered 502 to 507) intended for use in compost creation. The later-developed formulation 508 serves as prophylactic purpose, and managing fungal diseases.

Prep.	Herb or Material	Relationship to Processes of	Planet	Planet to Organ	Result
BIO-500	Cow horn Manure	Nitrogen (N) Calcium (Ca) Trace Elements	-	-	Compost enrichers and promoters
BIO-501	Cow horn silica	Nitrogen (N) Calcium (Ca) Silicon(Si) Trace Elements	-	-	Compost enrichers and promoters
BIO-502	Yarrow flower *Achillea millifolium*	Sulphur (S) Potassium (K) Trace Elements	Venus	Kidneys	Permits plants to attract trace elements in extremely dilute quantities for best nutrition
BIO-503	Chamomile flower *Matricuria chamomilla*	Calcium (Ca) Sulphur (S)	Mercury	Lung glands	Stabilizes Nitrogen (N) within the compost and increases soil life so as to stimulate plant growth
BIO-504	Stinging Nettle *Urtica parviflora*	Sulphur (S) Potassium (K) Calcium (Ca) Iron (Fe)	Mars	Gall bladder	Stimulates soil health, by providing plants with the individual nutrition components needed, 'enlivens' the earth (soil).
BIO-505	Oak Bark *Quercus glauca*	Calcium (Ca)	Moon	Reproductive	Provides healing forces (or qualities) to combat harmful plant diseases.
BIO-506	Dandelion flower *Taraxicum officinalis*	Silicon (Si) or Silicic acid Potassium (K)	Jupiter	Liver	Stimulates relation between Si and K so that the Si can attract cosmic forces to the soil
BIO-507	Valerian flower *Valeriana officinalis*	Phosphorus (P)	Saturn	Spleen	Stimulates compost so that Phosphorus component is properly used by the soil.

Influence on Soil Health:

In terms of Agriculture, organic and biodynamic practices have set an example of innovation and promise towards farming community. It has a profound impact on Soil Health, Soil Quality with the better quality produce. Soil quality indicates the inherent ability of a soil system working within ecosystem boundaries and sustaining biological production and productivity, preserving environmental quality, encouraging plant growth and maintaining animal health. Numerous physical, chemical and biological characteristics that provide information on the impact of management practices are dependent on soil quality.

The organically managed surface soil has good physical conditions in terms of better soil structure, optimum bulk density, low penetration resistance, higher porosity with maximum water holding capacity that plays an outstanding role in plant growth and development.

Soil organic matter content also increases due to long term adoptation of organic farming. Soil organic matter serves as a storage system for essential plant nutrients such as N, P, K, S, Zn, Cu, Fe etc., preventing the leaching of these vital elements crucial for plant growth. This is facilitated by the high cation exchange capacity exceeding 300 cmol (p^{+}) kg^{-1}, enabling nutrient adsorption. The interaction between humic substances and clays results in the formation of clay-humus complexes, enhancing the nutrient exchange capability buffering capacity of soil. Many biological parameters viz. Enzyme activity (urease, dehydrogenase) microbial activity, earth worm population, basal soil respiration also is improved due to application of organic inputs to the soil.

Conclusion

In conclusion, organic agriculture represents a sustainable and environment friendly approach to farming. By prioritizing natural processes and avoiding synthetic inputs, organic farming aims to enhance soil health, promote biodiversity, and produce nutritious crops. The emphasis on organic practices not only benefits the environment but also contributes to the well-being of consumers by minimizing exposure to harmful chemicals. Additionally, the use of organic methods fosters resilience in agriculture, creating systems that are more adaptable to changing environmental conditions. As we face challenges related to climate change and food security, the principles of organic agriculture offer a promising pathway towards a more resilient, ecologically sound, and socially acceptable farming future.

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PLANT DISEASE: PATHOGENS AND CYCLES

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Introduction

A plant disease is defined as "anything that prevents a plant from performing to its maximum potential." This definition is broad and includes abiotic and biotic plant diseases.

Abiotic or non-infectious diseases

These diseases are caused by conditions external to the plant, not living agents. They cannot spread from plant to plant, but are very common and should be considered when assessing the health of any plant. Examples of abiotic diseases include nutritional deficiencies, soil compaction, salt injury, ice, and sun scorch.

Biotic or infectious diseases

These diseases are caused by living organisms. They are called plant pathogens when they infect plants. For the purposes of discussing plant pathology, only plant disease pathogens will be discussed. Pathogens can spread from plant to plant and may infect all types of plant tissue including leaves, shoots, stems, crowns, roots, tubers, fruit, seeds and vascular tissues.

Types of Plant Pathogens

Plant pathogens are very similar to those that cause disease in humans and animals. Fungi, fungal-like organisms, bacteria, phytoplasmas, viruses, viroids, nematodes and parasitic higher plants are all plant pathogens.

Fungi and Fungal-like Organisms (FLOs)

Collectively, fungi and FLOs cause the most plant disease than any other group of plant pathogens. These organisms cannot make their own food, lack chlorophyll, have filamentous growth, and may or may not reproduce by spores. Fungi and FLOs are able to overwinter in soil or on plant debris. However, some fungi and FLOs cannot overwinter in northern climates because of low winter temperatures. These pathogens overwinter in southern climates and then are transported by air currents back to northern climates. Disease movement from southern to northern climates can be monitored during the growing season.

Bacteria

Bacteria are single-celled microscopic organisms with cell walls that reproduce by binary fission (one cell splits into two). Introduction to the plant must occur through natural openings or wounds in the plant. Bacteria overwinter primarily in soil and in or on plant material that does not decompose, but some survive inside insect vectors.

Phytoplasmas

Phytoplasmasare microscopic, bacteria-like organisms that lack cell walls and thus appear filamentous.

Viruses and viroids

Viruses are intracellular (live inside the cell) nucleic acid particles with a protein coat that infect other living organisms and replicate in the hosts they infect. Viroids are virus-like particles but lack a protein coat. Viruses and viroids are primarily transmitted by vectors including insects, nematodes, and fungi, which introduce the virus or viroid during feeding. Viruses and viroids can also be transmitted through seed, vegetative propagation and pruning.

Nematodes

Nematodes are microscopic worm-like animals. The majority of nematodes are soil dwelling animals and move with soil. However, there are some nematodes that are transmitted through insects and infect above ground plant parts.

Parasitic Higher Plants

Parasitic high plants are plants that contain chlorophyll but cannot produce their own food. They parasitize other plants to obtain nutrients and water. Examples include mistletoe and dodder.

Disease Triangle

Three components are absolutely necessary in order for a disease to occur in any plant system. The three components are:

1. a susceptible host plant
2. a virulent pathogen
3. a favorable environment

When these three components are present at the same time, a disease (shaded region) will occur if a susceptible host plant is in intimate association with a virulent plant pathogen under favorable environmental conditions. This concept is represented by the shaded portion of the diagram above. When there is a high degree of overlap (as the shaded area becomes larger), there will be a moderate to high amount of disease.

It is important to remember that within each of the three components –host, pathogen, and environment –there are numerous variables that may affect both the incidence and severity of the disease. These variables include genetic diversity, biology and lifecycle of the host plant and pathogen, and environmental conditions.

Genetic diversity

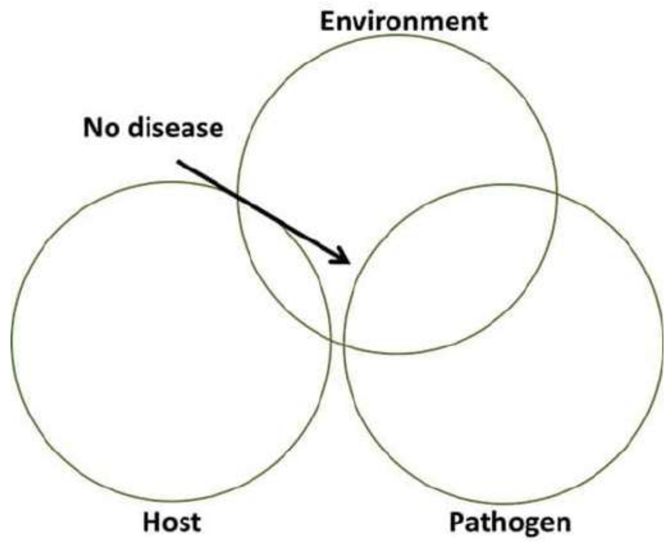
Within one species of host plant there may be an incredible range of genetic diversity that greatly influences susceptibility to any particular species of pathogen. If the host is resistant to a pathogen, even when the pathogen is present under favorable environmental conditions, a disease will not occur. Genetic diversity also plays a role in pathogen virulence or its ability to infect a host and cause disease, which may also influence the amount and severity of a disease.

Biology and lifecycle of the host plant and pathogen:

Host plants may be resistant to pathogens at one stage of development but not at another. In a similar manner, some pathogens must be at a critical life stage in order to cause infection.

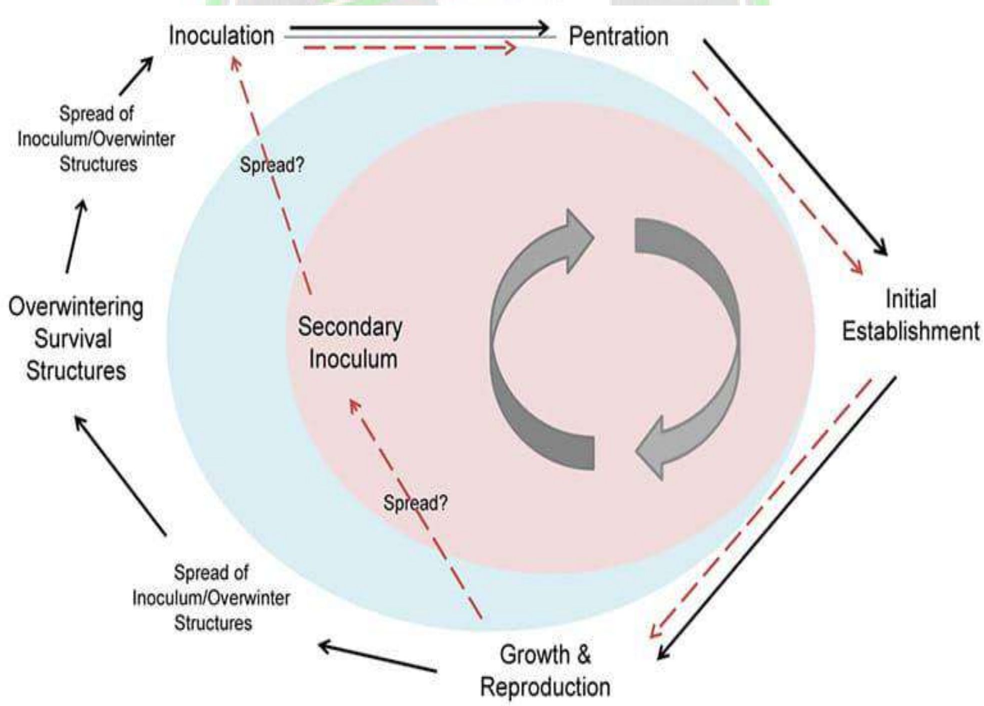
Environmental conditions:

There are numerous variables in the environment that influence disease incidence and severity including temperature, sunlight, moisture, relative humidity, and time of year. Pathogens are typically restricted to an area based on the conditions of the macroclimate. A microclimate is the prevailing climatic conditions in a certain geographical area. Within a macroclimate, small areas may exist in which the climate may be different than the surrounding areas. This is called a microclimate. Each landscape is filled with microclimates that exist because of differences in exposure to sun and wind, soil type and many other factors.



Variables within each component of the disease triangle may affect the presence of disease. This diagram represents a system in which the host is displaying resistance to disease even in intimate association with the pathogen under favorable environmental conditions.

Disease Cycles



In order for a disease to develop, a pathogen must be present and successfully invade plant host tissues and cells. The chain of events involved in disease development includes inoculation, penetration, infection, incubation, reproduction, and survival.

Inoculation

This describes the introduction of the plant pathogen to the host. Different pathogen groups employ different inoculation methods and are equipped with various specialized mechanisms that aid in the inoculation process. For example, some fungal pathogens release spores into the air and the spores are then spread with the aid of air currents.

Penetration

Wound sites and natural plant openings, such as stomata and hydathodes, facilitate the entrance of some plant pathogens; others have evolved unique mechanisms for direct penetration. Fungi and nematodes are able to actively penetrate host tissues and cells if environmental conditions, such as moisture and temperature, are favorable for the penetration process.

Infection

This occurs when the pathogen invades the plant tissue and establishes a parasitic relationship between itself and the plant. Viruses, bacteria, and phytoplasmas are not able to actively penetrate or enter plant host tissues. Therefore they must rely on other methods to infect plant tissues and cells. Associations with insect vectors have been established by these pathogens to aid inoculation and dispersal.

Incubation

Once inside the plant, pathogens may undergo an incubation period and remain latent for a period of time before initiating disease.

Reproduction

Plant pathogens can reproduce sexually and asexually. It is dependent on the pathogen.

Survival

Plant pathogens have evolved so they can survive prolonged periods of unfavorable weather conditions. For example, brown spot is a fungal pathogen that produce spores that are dark in coloration which reduces the amount of UV light penetrating and preventing cell death. In addition, Soybean cyst nematode lay their eggs within a cuticle casing. The cuticle casing is very hard and prevents other microbes and chemicals to penetrate killing the eggs prior to hatching.

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PROPERTIES OF NANOMATERIALS FOR ENVIRONMENTAL APPLICATIONS

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Introduction

Over the past decade, nanomaterials have been the subject of enormous interest. These materials, notable for their extremely small feature size, have the potential for wide-ranging of applications (Buzea *et al.*, 2007). Nanomaterial is a field which takes a materials science-based approach to nanotechnology. It studies materials with morphological features on the nanoscale, and especially those which have special properties stemming from their nanoscale dimensions. Nanomaterials describe, in principle, materials of which a single unit is sized (in at least one dimension) between 1 to 1000 nanometres (10^{-9} meter) but usually is 1 to 100 nm (the usual definition of nanoscale). Nanomaterials research takes a materials science-based approach to nanotechnology, leveraging advances in materials metrology and synthesis which have been developed in support of micro fabrication research. Materials with structure at the nanoscale often have unique optical, electronic, or mechanical properties. Nanomaterials are slowly becoming commercialized and beginning to emerge as commodities

Classification of nanomaterials

Nanomaterials are classified as one dimension, two dimensions and in three dimensions nanoscales (Rao and Murthy, 2007).

- Nanoscales in one dimension are thin films, layers and surface coatings. They are used for decades in the fields such as electronic device manufactures.
- Nanoscales in two dimensions are nanotubes and nanowires have generated considerable interest because of their novel electrical and mechanical properties,

for example, carbon nanotubes.

- Nanoscales in three dimensions (nanoparticles) are less than 100 nm in diameter which can be spherical, tubular, or irregularly shaped and can exist in fused, aggregates or agglomerated forms. Nanoparticles are of interest because of the properties such as chemical and optical behavior that they exhibit compared with larger particles of the same material. For example titanium oxide and zinc oxide become transparent at the nanoscale level, and are able to absorb and reflect the UV light and found to have many industrial applications. Nanoparticles have larger surface area and enhanced activity in potential application such as catalysis.

Manufacturing of nanomaterials

Nanomaterials are not simply another step in the miniaturization of materials. They often require very different production approach. Nanomaterials can be produced through 'top down' and 'bottom up' approaches (Rao and Murthy, 2007) (Figure1).

The bottom-up approach refers to the buildup of a material from the bottom, *i.e.*, atom-by-atom, molecule-by-molecule or cluster-by-cluster. The colloidal dispersion is a good example of bottom-up approach in the synthesis of nanoparticles. Nanolithography and nanomanipulation techniques are also a bottom-up approach. These techniques have been widely used in the formation of structural composite nanomaterials. Top-down approach involves starting with a block bulk material and designing or milling it down to desire shape. This technique is similar to the approach used by the semiconductor industry in forming devices, utilizing pattern formation (such as electron beam lithography). Both approaches play very important roles in modern industry and most likely in nanotechnology as well.

There are advantages and disadvantages in both approaches. The main challenge for top-down approach is the creation of increasingly small structure with sufficient accuracy whereas in bottom-up approach, the main challenge is to make structure large enough and of sufficient quality to be of useful as materials (Fendler, 1998). Bottom-up approach promises a better chance to obtain nanostructures with less defects, more homogeneous chemical composition, and better short- and long-range ordering. This is because the bottom-up approach is driven mainly by the reduction of Gibbs free energy, so that nanostructures and materials such produced are in a state closer to a thermodynamic equilibrium state. On the contrary, top-down approach most likely introduces internal stress, in addition to surface defects.

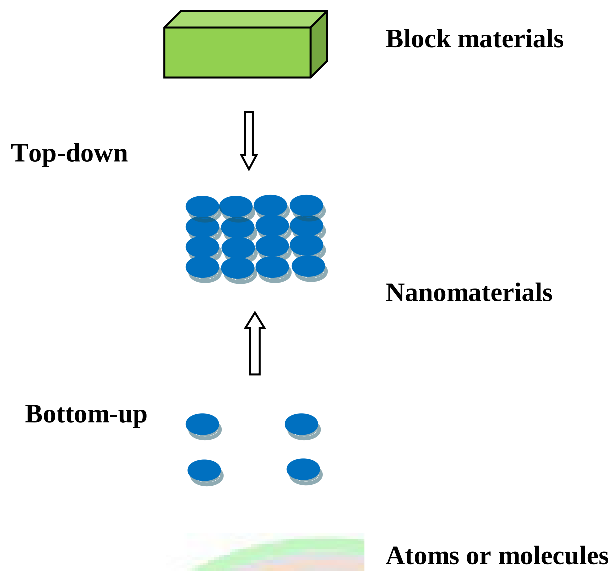

Figure 1. Top-down and Bottom-up methods for production of nanomaterials

Properties of nanomaterials

The properties of material can be different at the nanoscale for two main reasons: increased relative surface area and quantum effects. These two factors can change or enhance properties such as reactivity, strength and electrical characteristics (Rathi, 2009).

Nanomaterials have a relatively large surface area as compared to the same mass of materials produced in a larger form. As the particle size decrease, a greater proportion of atoms are found at the surface compared to those inside. For example, a particle size of 30 nm has 5 per cent of its atoms on its surface, at 10 nm 20 per cent of its atoms and at 3 nm 50 per cent of its atoms. Thus, nanoparticles have a much greater surface area per unit mass compared to larger particles. As growth and catalytic chemical reactions occurs at surface, this means that a given mass of material in nanoparticulate form will be much more reactive than the same mass of material made up of larger particles. In addition, with surface area quantum effects begin to dominate the properties of the matter as size is reduced to the nanoscale. These can affect the optical, thermal, mechanical and magnetic behavior of materials particularly as particle size approach towards the nanoscale. The nanomaterials exploit these effects include quantum dots and quantum well lasers for optoelectronics. The important properties of nanomaterials are listed below.

Optical Property

For last few decades, metallic nanoparticles have fascinated researchers due to their colourful colloidal solutions. Mie was the first to explain the red color of gold nanoparticle in 1908 by solving Maxwell's equation for an electromagnetic light wave interacting with small metallic spheres. The colour exhibited by metallic nanoparticles is due to the coherent excitation of all the "free" electrons within the conduction band, leading to an in-phase oscillation and is known as surface plasmon resonance. Thus, the colour of metallic nanoparticles may change with their size due to surface plasmon resonance.

Unique optical property of nanomaterials may also be due to quantum size effect, which arises primarily because of confinement of electrons within particles of dimension smaller than the bulk electron delocalization length. This effect is more pronounced for semiconductor nanoparticle, where the band gap increases with a decreasing size. The same quantum size effect is also shown by metal nanoparticles, when the particle size is less than 2 nm.

Magnetic Property

Magnetic properties of nanostructured materials are distinctly different from that of bulk materials. Ferromagnetic particles become unstable when the particle size reduces below a certain size as the increase in surface energy provides a sufficient energy for domains to spontaneously switch polarization directions and become paramagnetic. But this transformed paramagnetism behaves differently from the conventional paramagnetism and thus is referred to as superparamagnetism (Frankel and Dorfman, 1990). In other words, ferromagnetism of bulk materials disappears and gets transferred to superparamagnetism in the nanoscale due to the high surface energy.

Mechanical Property

The mechanical properties of nanomaterials increase with the decrease in size. Most of the studies have been focused on the mechanical properties of one dimensional structure such as nanowire. The enhanced mechanical strength of nanowires or nanorods is ascribed to the high internal perfection of the nanowires. Generally, imperfections such as dislocations, micro-twins and impurities in crystals are highly energetic and should be eliminated from the perfect crystal structures. The smaller the cross-section of nanowires, the less is the probability of finding in it any imperfections as nanoscale dimension makes the elimination of such imperfections possible.

Thermal Property

Metal and semiconductor nanoparticles are found to have significantly lower melting point or phase transition temperature as compared to their bulk counterparts. The lowering of the melting points is observed when the particle size is less than 100 nm and is attributed to increase in surface energy with a reduction of size. The decrease in the phase transition temperature can be ascribed to the changes in the ratio of surface energy to volume energy as a function of size.

Types of nanomaterials

Nanomaterials can be divided into natural and anthropogenic particles (Table 1). The particles can be further separated based on their chemical composition into carbon coating and inorganic nanomaterials (Nowack and Bucheli, 2007).

Table 1. Types of nanomaterial based on their origin and compositions

S.No	Origin	Classification	Formation	Particles	Examples
1	Natural	C- containing	Biogenic	Organic colloids	Humic, Fulvic acid
			Geogenic	Soot	Fullerens
			Atmospheric	Aerosols	Organic acids
			Pyrogenic	Soot	CNT, Fullerenes
		Inorganic	Biogenic	Oxides, Metals	Magnetite, Ag, Au
			Geogenic	Oxides, Clay	Fe-oxides, allophane
			Atmospheric	Aerosols	Sea salts
2	Anthropogenic (Engineered)	C- containing	By products	Combustion by-products	CNT, Nanoglobules
			Engineered	Soot	Carbon block, Fullerenes
				Polymeric	Polyethylene glycol
		Inorganic	By products	Combustion by-products	Platinum group metals
			Engineered	Oxides	TiO_2, SiO_2
				Metals	Ag, Fe
				Salts	Metal-phosphates
				Alluminosilicate	Zeolites, Clay

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CULTIVATION OF ORNAMENTAL ANNUALS

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Abstract

Annuals are the most popular type of flowers in ornamental gardening. They are easily raised from seed, grow, bloom, seed and exhaust themselves during a season. They may be grown in beds, herbaceous borders, as an edging, for window boxes, pots etc. There are several things that need to be done for the sustainability of the land and other resources before flower crops are planted in an open field. Preparing the land and performing several cultural operations are among the steps that need to be completed before planting or transferring the plant material from nursery. The main objective of land preparation and cultural operations is to provide the ideal soil conditions and allow plants to withstand biotic and abiotic stress. This will guarantee high-quality produce and help the crop establish successfully.

Keywords: Annuals, season, herbaceous borders, nursery, cultural operations

Introduction

Ornamental annuals are grown in garden for their spectacular beauty when they flower. They are seasonal in habit and grow up to a crop period of four months. Annuals are mostly propagated by seeds which are sown directly in the beds or raised to seedlings in the nursery. These seedlings are transplanted into beds and pots and routine cultural practices like watering, pricking, hoeing, weeding etc. are followed. For raising annual flowering plants, site selection is a must for nursery raising as well as for transplanting of seedlings. The main purpose of these cultural operations is to provide necessary soil/plant conditions to grow and flower profusely and enable the plant to escape biotic and abiotic stress.

Cultivation of annuals

Propagation

Almost all the flowering annuals can be easily propagated by seeds. Seeds of some annuals like Morning Glory, Sweet Pea, Lupin and Nasturtium can be sown directly in the garden at the selected location. many other annuals do best if seedlings are raised and then transplanted.

Soil and bed preparation

Most of the annuals prefer slightly acidic, deep, well-drained soil with moderate humus content. For gardeners with poor soils, two to three inches of compost, well-rotten manure or other organic material should be added to the soil. The beds should be of 2-3m length, 60-80 cm width and 15-50 cm height above the ground level. Depth of bed should be 30 cm, digging should be repeated 2-3 times and pulverize thoroughly. Media consists of 1:1:1 part of soil: sand: vermicompost that is moistened before sowing the seeds

Nursery raising

Before sowing, seeds should be treated with a fungicide to protect the seedlings from fungal diseases. Seeds sown at 3-4 cm apart at a depth of 0.5-0.6 cm. small or minute sized seeds should be sown at high density in the raised beds. After sowing, seeds should be covered with soil mix and sprinkle water immediately. The beds should be covered with dried plant parts or newspapers, which help for better germination. It takes about one month to grow the seedlings and ready for transplanting.

Pricking

It is transferring of young seedlings to another pan or tray. This ensures healthy growth of seedlings.

Pricking

Transplanting

Generally done at one month stage or 3-4 leaf stage. Transplanting is done on cool cloudy days or in the evening which enables the seedlings to establish well.

Irrigation

Most of the annuals need regular irrigation because they do not have deep root system. Some annuals are drought-tolerant, most need plenty of water. So, it is important to irrigate at regular intervals. It's also important to keep the foliage and flowers as dry as possible to prevent disease. Soaker hoses and drip irrigation do this best. If you use sprinklers, run them in the morning so that the plants dry quickly in the sun.

Fertilization

Most annuals need fertile, well-drained soil and nutrients for healthy growth. It's important to incorporate organic matter before preparing beds and granular fertilizers before planting. Slow -release source of nitrogen applied at planting can meet nitrogen needs for the entire season.

Pinching and Staking

Many of the flowering annuals grow tall and lanky with less branches, so to break the apical dominance and encourage axillary branching and thereby improve the flower production. Pinching slightly delays flowering but improves flower production. Pinching 20-25 days after transplanting, has been found to be optimal, e.g.: Carnation, Marigold, Asters, Cosmos etc.

Pinching of apical meristem

Staking

Many tall annual flowering plants must be staked or provided with other support system, especially in windy and exposed areas. Wind, rain or the weight of foliage and blossoms can bend or break the stems of the plant and ruin the display. Dahlias, Hollyhocks and others of the kind can grow to reach 6-7 ft in height and because of the weight of heavy stalks and bloom, they may need support or staking for which split bamboo sticks may be used.

Weeding

Keep annuals free from weeds. A combination of hand weeding and organic mulch application is effective. Weed regularly to prevent weeds from setting seeds and establishing themselves. At least 3-4 manual weedings are required for the full cropping period.

Seed collection

For most families such as *Leguminosae*, *Lilliaceae*, *Cruciferae* and *Papapvaraceae*, seed or pod collection should be started when the ovary wall starts to change from green to yellow colour. With other families such as *Compositae*, *Labiatae* and *Umbelliferae*, each flower head should be harvested individually when the seed is turning brown in colour. The dried flowers should be threshed and winnowed to obtain the seeds. The seeds should be stored in muslin cloth bags or paper bags in a well-ventilated place.

Pests and Diseases

Many pests and diseases attack ornamental annuals. Assessment of symptoms and damage at initial stages is very important. Thus, timely diagnosis of a pest or disease attack and selection of appropriate control measures is critical for initiating suitable interventions to save the crop from damage

PESTS

The annual flowering plants are attacked by a number of insect pests, which damage the plants and their flowers. Among them aphids, thrips, bud worms are of major concern.

Aphids

Aphids are usually found on young leaves and flower buds. They suck the sap of foliage and bud, and cause retarded growth of the plant with poor quality flowers. Two sprays of Endosulfan or Rogor @ 1.0-1.5 ml per litre of water at 15-20 days interval can control aphids.

Caterpillars

The caterpillars are particularly active in summer. They damage the foliage and flower buds. They can be controlled by spray of Malathion @ 1.0-1.5 ml per litre of water.

Thrips

The thrips suck sap from the under-surface of the leaves and also from the flower buds. Thrips thrive in dry hot summer season. Spraying of Rogor or Monocrotophos @ 0.1% controls the thrips.

Mites

Mites infect the annual flowering plants and give them a dusty appearance. These can be controlled by spraying Kelthane (Dicofol) @0.1%.

Leaf hoppers

The hoppers suck sap from the leaves and stem. The infected plants show cupped or rolled leaves and give wilted appearance. Spraying of Rogor (0.2%) controls the hoppers.

DISEASES

The annual flowering plants are affected by a number of fungal diseases, which damage the plants and their flowers. The most destructive diseases are botrytis, root rot and foot rot.

Botrytis

In a botrytis infected plant, brown colour spots are developed and are developed and are visible on the flower petals during the period of high humidity. It can be controlled by spraying Mancozeb @ 2.0 g per litre of water.

Damping off and Root-rot

Root rot is caused by the fungus *Pythium*, which prefers moist conditions. Infected plants lose the root system and suffer heavy loss in flower production. It generally attacks the plants grown in heavy and compact soil.

Root rot can be controlled by sterilization of soil before planting, better air circulation and decreasing the moisture content of the growing media. The disease can be controlled by prophylactic drenching of nursery beds with Captan (0.1%) and Bavistin (0.1%). Seed treatment with Captan (0. 1%) also reduces the incidence of the disease

Leaf spot and Blight

Various pathogens cause leaf spots and blights in annual flowers. The symptoms appear as small brownish spots on the leaves. This leaf spot disease can be controlled by spraying Dithane M-45 @ 0.2%.

Inflorescence blight

Infected inflorescence gives a burnt appearance in severe cases. This disease can be controlled by spacing Dithane M -45 @ 0.2%.

Powdery mildew

Initially, whitish tiny spots appear on the leaves. The entire plant shows white, powdery appearance in severe case. The disease can be controlled by spraying Karathane @ 0.1%

Conclusion

In a garden there are certain operations that are to be followed judiciously for successful cultivation of flowers and ornamental plants, most of these operations, such as pinching, deshooting, disbudding, staking etc, are of vital importance for the growth of the plants. Knowledge about different pests and disease attack, symptoms and timely management helps to develop beautiful annuals

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POST-HARVEST DISEASES AND ITS CONTROL

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Introduction

The diseases which develop on harvested parts of the plants like seeds, fruits and also on vegetables are the post-harvested diseases. The harvested products may get infected on the way to storage or to market or even before their final consumption. The plant parts may get infected in the field, but expression of symptoms may take place later, at any stage before final consumption. The plant products may get infected by microorganisms and cause rotting or decaying — partially or totally. The quantity of plant products becomes reduced due to the above infection. The seeds or grains may get damaged by accumulation of toxic substance, the mycotoxin produced by the infected microorganism.

The fleshy fruits, vegetables etc., like tomato, banana, citrus, strawberries, rhizome of zinger, bulb of onion, tuber of potato etc., may get damaged. This results in reduction of quantity, quality or both of the affected parts or products as a whole. The amount or extent of damage depends mainly on the pathogen(s) involved, on the condition of the products and the condition of storage.The pathogens involved are mainly fungi like Pythium, Phytophthora, Rhizopus, Aspergillus, etc. and some bacteria like Pseudomonas, Erwinia, etc.

Classification of Post-Harvest Diseases

1. Field pathogen
2. Storage pathogen.

1. Field Pathogen

The field pathogens are those, which cause infection during development of plants or their products before harvest.

2. Storage Pathogen

The pathogen which cause infection during storage are the storage pathogen. Symptoms from infection caused by the 'field pathogens' may be very inconspicuous to be noted at the time of harvest. In fleshy and/or juicy fruits and vegetables, infection by field pathogen continues to develop even after harvest.

They may become infected during storage by the same field pathogen(s) or by other pathogen(s). In seeds and grains, the disease caused by field pathogens ceases to develop further soon after harvest. But, they may be infected further by the other pathogens during storage.

Types of Post-Harvest Diseases

1. Diseases of dry, bulk materials, such as seeds and grains, and
2. Diseases of fleshy storage organs, such as vegetables (tubers, rhizomes, bulbs etc.) and fruits.

Observations of many investigators indicate that the real cause of the spoilage of vegetables and fleshy fruits in transit and also in storage are due to high moisture, high temperature, and injuries caused during marketing. Due to high moisture content and nutrient in harvested vegetables and fruits, they are vulnerable to attack by the pathogenic organisms.

Injuries of fruits and vegetables may be caused during harvesting, packing and transposition they help the pathogen to enter the host and cause damage. But the seeds and grains can be stored for long time due to low moisture content (about 12-14%), where most of the pathogens cannot grow favourably.

I. Diseases of stored seeds and foodgrains

Field fungi, like Alternaria, Fusarium, Cladosporium, Verticillium, Helminthosporium, Colletotrichum etc., attack seeds and grains on growing crops, but are unable to grow in storage due to low relative humidity i.e., below 90%. During storage or transit the seeds and grains are damaged by the different species of Aspergillus and PeniciHum, which can grow well at a relative humidity ranges from 70-90%. The commonly available Aspergillus species are A. repens, A. ruber, A. flavus, A. candidus, etc.

Aspergillus and a number of other storage fungi invade the embryo of the seeds and grains and they discolour the embryo or seeds as a whole, thereby the germination percentage reduces markedly. In some cases, spoilage of stored grains and seeds results in drastic increase of temperature up to 70°C or more, which encourage the growth of different thermophilic and thermotolerant fungi such as Aspergillus fumigatus, Absidia spp., Mucor pusillus, etc.

In addition to storage fungi, other microorganisms may grow in/or on seeds and accelerate the deterioration process. During breeding period of insects, the moisture content and temperature of seeds increase, thereby rapid growth of the pathogen takes place producing enormous amount of spores. During storage, the fungi produce mycotoxins that cause great damage to both domestic animals and human beings. The important fungi in this respect are Aspergillus and Penicillium, which produce aflatoxin and other toxins.

Most Important Toxins are

1. Yellow Rice Toxins

Produced in grains of rice, barley etc., by species of Penicillium.

2. Tremorgenic Toxins

Produced on prepared food during storage in refrigeration or in other places and also on food produced from infected grains and/or seeds.

3. Penicillic Acid

It is a carcinogenic substance produced by the different species of both Aspergillus and Penicillium in molded cereal grains.

Control

The above-mentioned loss or damage by decay and spoilage of seeds and/or grains by storage fungi can be controlled by the following procedures:

1. Low Moisture

The moisture content of the rooms for storage should be kept below 70%.

2. Low Temperature

Temperature in store house should be maintained below 30°C, because most of the storage fungi can grow well at temperatures between 30°C and 55°C.

3. Ventilation

Proper ventilation should be maintained during storage and also during holding period before sending to market.

4. Sanitation

Proper sanitation should be maintained to keep storage products clean.

5. Use of Insecticide

Insecticides like methyl bromide and some other fumigants are used to treat the harvested seeds, thereby they regulate the storage fungi and reduce economic loss.

6. Clean

Clean, uninjured and properly ripened seed should be selected for storage, then only they are able to resist the action of the storage pathogen(s).

II. Diseases of Vegetables and Fruits

Different members of Ascomycotina and Deuteromycotina cause the major post-harvest diseases of fruits and vegetables.

These are Alternaria, Botrytis, Fusarium, Penicillium, Sclerotinia etc.

1. Alternaria

Different species of Alternaria cause rot of many fresh fruits and vegetables, e.g., black rot of orange, tuber rot of potato, rot of sweet potato, purple blotch of onion, Alternaria rot of onion, Alternaria rot of cabbage, etc.

2. Botrytis

It causes “grey mold rots” of fruits like pear, apple, citrus etc., and vegetables like onion, tomato etc. Every year it causes great economic loss.

3. Fusarium

It causes different diseases, commonly called “pink or yellow molds”. Different species of Fusarium cause damage to tubers, bulbs, storage roots etc. and frequently on cucurbits, tomato etc. It also cause brown rot of fruits like lemon, orange etc.

4. Penicillium

Species of Penicillium are commonly called “blue or green molds”, these cause rots of different fruits like onion, sweet potato etc. They also cause spots on different fruits. Under storage, the spotted fruits bear tufts of spores. Though most of the Penicillium species prefer relatively high temperature for their growth in storage, they still remain active near freezing temperature — at a slow rate.

A few species produce ethylene which increases respiration of fruits, thereby it reduces the storage life of the fruits. It also produces patulin — a mycotoxin — which directly contaminates the sauces and fruit juices prepared from infected partly rotten fruits.

5. Sclerotinia

It infects different fruits and vegetables. Most common diseases are cottony rot of lemon, watery soft rot of bean pods, cucurbits etc. Storage diseases like bacterial soft rot of vegetables such as onion, carrot, potato etc. are mainly carried out by different species of Erwinia, such as E. carotovora, E. chrysanthemi etc.

Control of Post-Harvest Diseases

The diseases can be controlled or reduced following the preventive procedures are

1. The fruits and vegetables should be harvested and handled carefully to avoid any injury which may facilitate the pathogen to cause infection.
2. The infected region on the vegetables should be cut off to avoid further infection during transportation and storage.
3. Storage container, warehouses etc., should be properly cleaned with $CuSO_4$, formaldehyde etc. to avoid contamination.
4. The crop should be stored or transported at a temperature low enough to slow down the development of disease.
5. Proper ventilation in storage reduces the spread of further development of disease.
6. The crops should be free from Insects and other pests, thus creation of new wounds and disease can be avoided.
7. Hot water and hot air treatment help to reduce further spread of the disease.
8. Chemical control. Post-harvest diseases may be controlled by the application of thiabendazole, dichloran, dosa-ash, etc. These chemicals help to prevent infection and suppress the development of pathogen on the host surface.

Some other chemicals, such as vapours of acetaldehyde, biphenyle/nitrogen chloride forming chemicals etc., are used as supplementary measures to control the post-harvest diseases during storage and transportation.

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PROMOTION OF HYBRID MAIZE THROUGH FRONT LINE DEMONSTRATIONS (FLDs) IN BUNDELKHAND REGION: CASE STUDY

Article ID: AG-VO4-I03-15

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Introduction

The Front Line Demonstrations (FLDs) under SCSP were conducted on 40 hectares (ha) area involving 80 farmers during *kharif* season in three districts/two states of Bundelkhand region i.e., Uttar Pradesh (Jhansi-District) & Madhya Pradesh (Datia & Tikamgarh). The Front Line Demonstrations (FLDs) focused on demonstration of released two single cross hybrids i.e., DHM-117 & DHM-121 in Bundelkhand region during *kharif*-2020. The average yield in FLDs was 35 quintals per hectare (q/ha), which was three times higher than that obtained in farmers practices (12 q/ha) during *kharif*-2020.

table:-1. input details of front line demonstrations (flds) on maize during *kharif*-2020.

Sl. No.	Details	Quantity to be used
1.	Total number of FLDs conducted	40 FLDs
2.	Total area covered (1 hectare for 1 FLDs)	40 hectare/100acre
3.	Total quantity of seeds used to distribute to the farmers to conduct FLDs on Maize	800 kg/8 Quintal
4.	Quantity of seed distributed for 1 acre area	8 kg/acre
5.	Quantity of fertilizers (18:18:18 super phosphate) used to distribute to the farmers	3 kg/acre
6.	Hybrids used to conduct FLDs on Maize	DHM-117 = 48 kg DHM-121 = 752 kg Total = 800 kg

The yield gains over the farmers practices in different states/districts in *kharif* season ranged from 35-40 %. Input details of FLDs are given in the **table-1**.

1. **SELECTION OF THE FARMERS FOR CONDUCTED FLDS ON MAIZE DURING *KHARIF*-2020:** 80 Schedule Caste (SC) farmers were selected for conducted FLDs on maize during kharif-2020 under SCSP which were covered three districts of Bundelkhand region (Uttar Pradesh & Madhya Pradesh) i.e, Jhansi (Village-Pipra), Datia (Village-Sanora) & Tikamgarh (Villages-Dargaon Kala, Punchampura & Kunwarpura) **(Table-2).**
2. **SEEDS INPUT DISTRIBUTION UNDER SCSP:** Total 800 quintal seeds of two single cross maize hybrids i.e., DHM-117 & DHM-121 were distributed to the 80 farmers. The farmers were selected under SCSP for conducted FLDs on maize during *kharif*-2020 in three different districts (Jhansi, Datia & Tikamgarh) of Bundelkhand region and covered the five different village of Uttar Pradesh & Madhya Pradesh. 8 kg seeds / acre were distributed to the farmers for conducted FLDs on maize during *kharif*-2020. The details of the seeds distribution are given below in **table-3**:
3. **SOWING OF FLDS ON FARMERS FIELD:** The sowing of FLDs at farmers field were completed during 15/07/20 to 21/07/20. Sowing of FLDs were done following the FLDs technology i.e, “Hybrid vs. traditional cultivars” at the farmers field in the villages/districts; Pipra-Jhansi, Sanora-Datia, Dargaon Kala, Punchampura, Kunwarpura-Tikamgarh of Bundelkhand region during kharif-2020 under SCSP. The details are given in **table-4**.
4. **FERTILIZERS (UREA) DISTRIBUTION UNDER SCSP:** 6 kg/acre fertilizers (18:18:18 super phosphate) were distributed to the farmers for conducted FLDs on maize under SCSP during *kharif*-2020 at five villages namey; Pipra (Jhansi), Sanora (Datia), Dargaon Kala, Punchampura & Kunwarpura (Tikamgarh) Bundelkhand region which were covered the 80 farmers.
5. **FARMERS TRAINING UNDER FRONT LINE DEMONSTRATIONS (FLDs) ON MAIZE DURING *KHARIF*-2020:** Farmers training on Maize Production Technology had been conducted during 22nd & 25th March, 2021 in Tikamgarh, Datia, Jhansi & Lalitpur Districts of Bundelkhand region. Total ten Farmers were trainings organized under SCSP programme funded by ICAR-IIMR, Ludhiana. Total ten villages were selected for conducted farmers trainings namely; Kunwarpura & Punchampura of Tikamgarh District, Sanora, Dikauli, Parbai, Lakara & Ronija of Jhansi District & Dhovalkheri, Pachoni & Varkhiriya of

Lalitpur District. Total 150 farmers were benefited by training in each villages. Scientists with different streams delivered a lecture on maize production technology in Bundelkhand region.

TABLE-2: RESULTS OF THE DEMONSTRATIONS DURING *KHARIF*-2020.

Hybrids	No. of demos.	Average yield (q/ha)	Local check yield (q/ha)	Yield gain (%)	Net returns	B:C ratio
DHM-117	**10**	**32**	**12**	**20**	**55100**	**1.13**
DHM-121	**40**	**35**	**12**	**23**	**60500**	**1.39**

TABLE-3: PERCENT FALLL ARMY WORM INFESTATION ON MAIZE FIELD IN DIFFERENT VILLAGES OF BUNDELKHAND REGION DURING *KHARIF*-2020.

Sl. No.	Name of Village	No. of field	Percent infestation
1	Pipra Jhansi	**5**	**46**
2	Sanora-Datia	**5**	**64**
3	Daryan Kala-Tikamgarh	**5**	**56**
4	Kuwarpura-Tikamgarh	**12**	**48**
5	Punchampura-Tikamgarh	**25**	**40.55**

TABLE-4: A TOTAL 52 SOIL SAMPLES WERE COLLECTED FROM DIFFERENT VILLAGES ANALYZE IN LABORATORY:

Sl. No	Name of Villages	No. of Soil Samples
1	Pipra- Jhansi	05
2	Sanora- Datia	05
3	Daryan Kala- Tikamgarh	05
4	Kunwarpura- Tikamgarh	12
5	Punchampura- Tikamgarh	25

Conclusion:

The Farmers with or without resources keep their land fallow in *Kharif* and cultivate wheat, gram, linseed and lentil in *Rabi*. Here we found *Kharif* Maize a promise crop to increase Cropping intensity in Bundelkhand region. With majority of Scheduled Castes population living in villages under studied area were economically isolated. Those were below poverty line and their livelihood dependent solely on agriculture and livestock rearing the SCSP Plan seems to be boon for uplifting their status.

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INDIAN AGRICULTURE'S JOURNEY TOWARDS GDP DOMINANCE SINCE INDEPENDENCE

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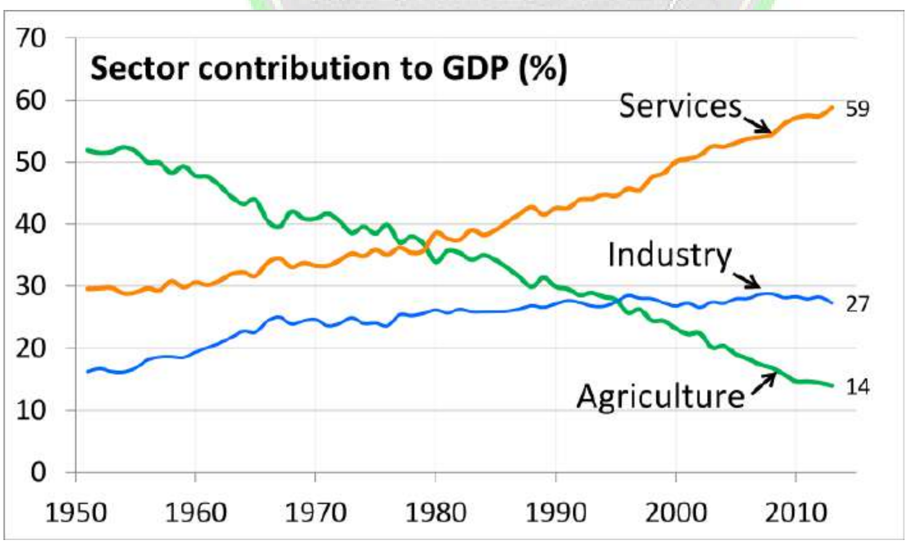
Introduction

India, the land of diverse cultures and traditions, has always been deeply rooted in agriculture. At the time of independence in 1947, the agricultural sector stood as the backbone of the economy, providing livelihoods to millions and contributing significantly to the Gross Domestic Product (GDP). Over the decades, Indian agriculture has witnessed a remarkable journey, marked by transformations, challenges, and strategic initiatives.



The Green Revolution

In the 1960s and 1970s, India underwent a revolutionary transformation known as the Green Revolution. This agricultural marvel was characterized by the adoption of high-yielding varieties of seeds, advanced irrigation techniques, and the use of fertilizers and pesticides. The result a surge in food grain production, making India not only self-sufficient but also a global player in agricultural productivity.

The Green Revolution had a profound impact on Indian GDP by significantly boosting agricultural productivity and ensuring food security. The term "Green Revolution" refers to a set of research, development, and technology transfer initiatives that took place in the 1960s and 1970s. This period marked a transformation in Indian agriculture, primarily focused on increasing the production of staple crops like wheat and rice.

Key factors and contributions of the Green Revolution to the Indian GDP include:

1. **Increased Agricultural Productivity**
   - The introduction of high-yielding varieties of seeds, modern irrigation techniques, and the use of fertilizers and pesticides led to a substantial increase in crop yields.
   - The productivity gains were particularly notable in the cultivation of wheat and rice, the main staple foods in India.
2. **Food Security and Self-Sufficiency**
   - The Green Revolution played a crucial role in making India self-sufficient in food production. Prior to the Green Revolution, the country had faced periodic famines and relied on food imports to meet domestic demand.
   - With increased crop yields, India was able to feed its growing population, reducing dependence on foreign food aid and imports.
3. **Contribution to GDP Growth**
   - The surge in agricultural productivity had a direct positive impact on the overall economy. As the agricultural sector flourished, it contributed significantly to the Gross Domestic Product (GDP).
   - The increased income and purchasing power of farmers stimulated demand for goods and services in other sectors of the economy, fostering overall economic growth.
4. **Rural Development and Employment**
   - The Green Revolution brought about rural development by enhancing agricultural practices and infrastructure.

This development contributed to improved living standards in rural areas.

- The increased agricultural productivity also generated employment opportunities in rural communities, reducing poverty and promoting economic stability.

5. **Technology Transfer and Research:**
   - The Green Revolution was characterized by the effective transfer of technology and agricultural practices from research institutions to farmers.
   - Scientific research and development played a critical role in developing and disseminating new farming techniques, which contributed to sustained agricultural growth.

While the Green Revolution brought about significant positive changes, it is essential to note that it also faced criticism for certain negative consequences, including environmental degradation, overuse of water resources, and social inequalities. However, in terms of its impact on the Indian GDP and ensuring food security, the Green Revolution remains a landmark period in the country's agricultural history. It laid the foundation for subsequent developments and discussions around agricultural policies and practices in India.

Land Reforms and Redistribution

Post-independence, several states embarked on ambitious land reforms aimed at addressing issues of land ownership and tenancy. The objective was to reduce the stark disparities in land distribution, ensuring that the benefits of cultivation reached the small and marginal farmers. While the success of these reforms varied across states, the initiative marked a significant step towards equitable growth in the agricultural sector.

Shift in Crop Patterns

Over the years, there has been a notable shift in crop patterns, reflecting changing market demands and economic aspirations. Indian farmers, once predominantly engaged in traditional crops, have diversified towards cash crops and high-value produce. This shift has not only contributed to increased income for many farmers but has also presented challenges related to sustainability, water usage, and environmental concerns.

Technological Advancements

The 21st century has witnessed a technological revolution in Indian agriculture. The integration of precision farming, biotechnology, and information technology has become more prevalent, promising to elevate productivity, reduce losses, and enhance overall efficiency. From soil health cards to mobile apps providing real-time market information, technology is empowering farmers across the country.

Challenges and Solutions

Despite these positive developments, Indian agriculture faces a spectrum of challenges. Small and marginal farmers struggle with issues such as access to credit, technology, and fair market prices. Water scarcity and climate change pose threats to agricultural sustainability, and market access remains a persistent concern. In response, the government has launched initiatives like PMKSY, PMFBY, and e-NAM to address these challenges and promote inclusive growth.

Current Scenario

As of my last knowledge update in January 2022, the Indian government continued to focus on agricultural reforms, with ongoing dialogues between policymakers and farmers regarding new agricultural laws. The commitment to finding solutions that balance the needs of both farmers and the economy reflects a nuanced understanding of the challenges faced by the agricultural sector.

Conclusion

Indian agriculture's journey since independence is a testament to resilience, adaptation, and progress. From the Green Revolution to embracing technological innovations, the sector has evolved to meet the changing needs of a growing nation. As we look ahead, the challenges persist, but with strategic reforms, sustainable practices, and inclusive policies, Indian agriculture is poised to continue its crucial role in shaping the nation's economic landscape. Cultivating growth isn't just about crops; it's about nurturing the very foundation of our nation's prosperity.

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BENEFITS OF ARTIFICIAL INTELLIGENCE IN AGRICULTURE

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Abstract

Artificial intelligence technology is being used by several agricultural businesses to boost productivity and efficiency. Artificial Intelligence solutions are assisting in removing traditional barriers in all industries. AI in agriculture is helping farmers reduce their impact on the environment and increase crop output. Crop productivity has improved using artificial intelligence, as has real-time tracking, harvesting, processing, and sales. Many cutting-edge computer-based technologies aim to detect a multitude of important elements, such as crop quality, yield detection, weed identification, and many more. Artificial intelligence (AI) has been widely adopted by the agriculture industry in an effort to enhance overall performance. The current study presents a perspective of how artificial intelligence can be used to drive the various sectors of agriculture.

Key words: Artificial intelligence, Crop Productivity, Real time tracking

Introduction

Artificial intelligence is predicated on the notion that human intelligence can be adequately characterized to enable a computer to replicate it and carry out even the most challenging tasks. Perception, thinking, and learning are the three tasks that artificial intelligence seeks to perform. Technologies based on artificial intelligence (AI) have the potential to greatly boost production in many different economic areas, including agriculture. Soil content sensors, irrigation, crop yield, crop monitoring, weeding, and crop establishment are a few examples of agriculture sectors. Agricultural robots are meant to offer high-value AI (artificial intelligence) solutions in various industries. The growing world population is causing problems for the agriculture industry, but artificial intelligence (AI) holds the promise of offering much-needed answers. Artificial intelligence (AI)-based technical solutions have helped farmers attain higher yields with less input while also enhancing the quality of their produce by ensuring a speedier time to market for harvested crops. (Shilpa *et al*., 2022)

Applications of AI in agriculture

In the food supply chain, artificial intelligence technologies help grow healthier crops, control pests, monitor soil and growth conditions, organize data for farmers, reduce labor costs, and improve a range of agriculture-related tasks. Compared to human laborers, robots are meant to complete basic agricultural jobs like harvesting crops significantly more swiftly and efficiently. The following are two examples of robot applications: (a) See and Spray (a weed control robot) and (b) CROO harvesting (a robot that harvests crops). The major AI applications are provided by agricultural robots, specifically milking robots (Albellan *et al*., 2010).

Crop management:

The process of managing crops begins with planting and continues with growth monitoring, harvesting, storage, and distribution. PROLOG assesses the operational behaviour of a farm system by using meteorological data, machinery capacity, labour availability, and details on authorised and prioritised operators, tractors, and tools. Additionally, it calculates crop yield, total farm revenue, and net profit for each field. (Lal *et al*.,1992).

Crop prediction methodology uses sensors to measure soil properties such as PH, nitrogen, phosphate, potassium, organic carbon, calcium, magnesium, sulphur, manganese, copper, iron, depth, temperature, rainfall, and humidity to decide on the ideal crop. (Snehal and Sandeep, 2014) With two cameras for recording and a GPS sensor for navigation, Demeter is a computer-controlled speed-rowing device. It can plan harvesting procedures for an entire field and then carry out those activities by repositioning itself in the field, slicing crop rows and discovering unanticipated impediments. (Pilarski *et al*., 2002)

Table 1: Different AI tools in crop management

AI techniques		Function
CALEX		An integrated expert decision support system for crop management
PROLOG	PROgramming in LOGic	To assess the operational behaviour of a farm system, it makes use of meteorological data, machinery capacity, labour availability, and details on authorised and prioritised operators and implements.
ANN	Artificial Neural Network	Can predict the response of crops to soil moisture and salinity. Widely used for predicting rice yield

Soil and crop health monitoring system

Soil health deteriorates over time, forcing farmers to shift to other fields despite the fact that good soil produces an abundance of healthy produce. Climate and geographic variables influence the condition of the soil. Because they break down more easily under irrigation in arid regions, soil nutrients are more likely to produce salinity—that is, chemicals that retain water—if they are not managed properly. The chemical state of rich and healthy soils can be tracked with IoT sensors. The amount of fertilizer required can be estimated by analyzing data readings from certain sensors (such as moisture sensors), which are then transmitted to the data control and interpretation layer for analysis (Cadavid *et al*., 2018)

Weed management

For site-specific weed management, a map-based approach requires developing trustworthy processes for collecting, evaluating, and drawing management zones for later use. Weeds within a crop can be identified and their spatial distribution mapped using remote sensing, which makes use of satellite and satellite pictures. Another technique for detection is proximal sensing, which describes in-field machine-mounted sensors (such those on tractors, robots, and harvesters) (Srinivasan, 2006). In contrast, a weed management system that can simultaneously detect and manage weeds is used in real-time monitoring and spraying. This tactic calls for constant forward motion of the vehicle while decision-making, processing technique monitoring, and spraying are carried out. Therefore, for map-based SSWM, remote sensing is advantageous, whereas proximal sensing is advantageous for both (LoPez-granados , 2011).

Some of the Artificial intelligence techniques employed in weed management are

- Optimization using invasive weed optimization (IVO)
- Support Vector Machine (SVM),
- Digital Image Analysis (DIA),
- Learning Vector Quantization (LVQ)

Soil and crop health monitoring system:

AI-based applications are able to identify illnesses and pests that impact plants as well as nutritional deficits in the soil. Farmers can use the generated data to determine when to apply fertilizer to enhance the quality of their yield. This uses computer-assisted and deep learning algorithms to analyze data from plant sensors and soil health, i.e., the PEAT pest and soil problems, based on a thorough investigation with Plantix diagnostics. a deficiency in soil nutrition. Trace Genomics is a more example to add to the list. This machine learning service aids farmers in diagnosing deterioration and doing soil analyses. This uses mechanical learning to give farmers an awareness of both the potential for healthy crop production and the means of preventing low yields.

Plant Monitoring and Disease Diagnosis:

Monitoring plant health is typically done in a time-consuming and labor- intensive manner. Monitoring and identifying possible issues with plant health or deficits in nutrients in the soil can be done efficiently with AI. Applications to analyse crop health trends in agriculture are developed with the aid of thorough research. Applications with artificial intelligence (AI) features might assist with soil health, plant diseases, pests, and improved understanding.

A serious threat to the economy, the environment, and food security is plant disease. For plant diseases to be effectively controlled, early detection is crucial. The use of mobile devices like smartphones for field-based diagnostics may be made possible by the high accuracy with which AI-based imagery recognition algorithms can identify some plant diseases. (Peter *et al.*,2021). "Enhancing agricultural research with artificial intelligence" generated AI-powered devices that assist land owners and farmers in making environmental decisions by utilising big data and location-based science. The aforementioned tools direct the choice of sustainable crop management techniques and offer early warning of pest and disease outbreaks. A disease management technique includes Computer vision system (CVS), genetic algorithm (GA), Fuzzy Logic (FL), Web-Based Intelligent Disease Diagnosis System (WIDDS) and Expert system using rule-base in disease detection. (Ngozi Clara Eli-Chukwu., 2019)

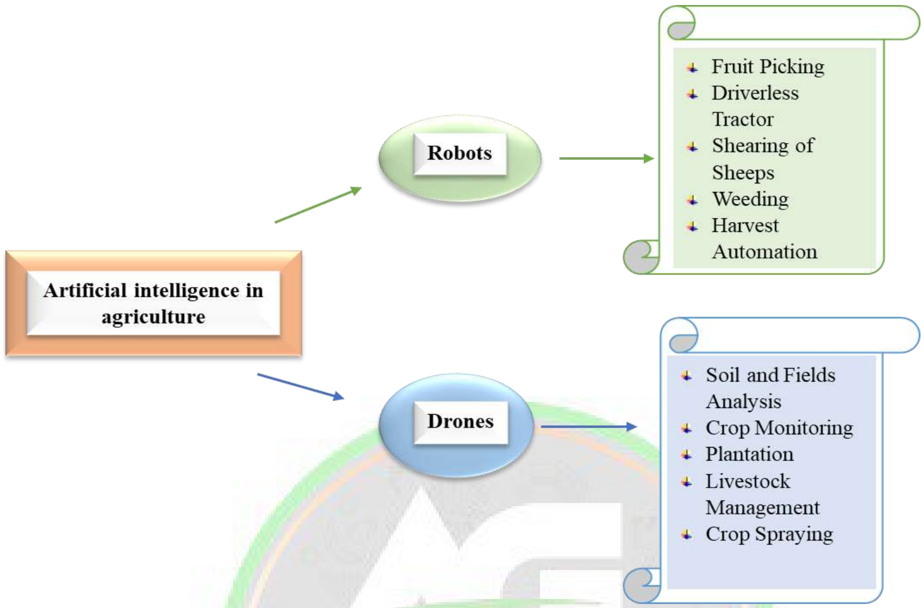

Fig 1: Uses of artificial intelligence in agriculture

Challenges

Among the numerous major obstacles that agriculture faces are temperature fluctuations, groundwater density, paucity of food, and a lack of irrigation infrastructure. The future of cultivation is mostly determined by the cognitive approaches that are received. Even if the industry is still terribly undeserved, there is still a lot of unfinished research being done and certain applications are already available. Agriculture is still in its infancy when it comes to facing and conquering the obstacles that farmers face in the real world through experience and insight. To fully explore AI's enormous promise in agriculture, applications need to be more dependable.

Future scope

In agriculture, artificial intelligence not only helps farmers automate their operations, but also helps them achieve more precise cultivation, which yields higher-quality and higher-yield crops with less resource consumption. Future technological advancements will enable businesses that are enhancing machine learning- or artificial intelligence-based goods and services—such as drones, automated machinery, and training data for agriculture—to offer more beneficial applications to this industry, assisting the global community in addressing the challenges associated with food production for an expanding population.

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SUCCESS STORY ON DIVERSIFIED AQUACULTURE: PABDA CATFISH CULTURE WITH MONOSEX TILAPIA

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Introduction

Mr. Ansarul Hoque, a teacher in primary school at lalgola Murshidabad, West Bengal, has 1 acre area. He is mainly interested in duck farming in his farm area, excavating 0.13 ha pond for duck rearing. Established duck shade house for 2000 ducklings. After communication with KVK fisheries SMS decide to start fish culture in that pond, suggested them to stock monosex with catfish like pabda (*Ompok bimaculatus*) introduced as a diversified high value fish species through KVK FLD demonstration programme in 2023. After 20 days of stocking 10000 monosex tilapia fry (3-5cm size), released 2000 pabda fingerling in 0.13ha pond. After one month of culture facing algal bloom problem then suggested to stock advanced fingerling of silver carp and catla, 100 nos. each. Maintained good water quality with continuous support of KVK supervision. Regular health checks up for pabda and monosex tilapia and recorded. With in 150 to 180 days of culture harvest monosex tilapia and pabda, sell it local market.

Name	**Ansarul Hoque**
Address	**Subarnamrigi, Murshidabad**
Age	**38 yrs.**
Education	**B.A.**
Contact no.	**9563809173**
Email Id	**-**
Size of land holding (acre)	**1 acre**

Profit

The farmer gets annual income (per cycle) of Rs. 116980.0 from culture of monosex tilapia with pabda and IMC in a duck cum fish farming system. Now, he can generate an income of Rs.9748.0/- per month.

Farmer's field:

KVK contribution:

With KVK interventions like, giving need-based training, proper farm management practices like IFS based, guided in every step through grow out culture system, advised to apply organic juice or bio-juice for reducing feed cost and produce huge amount of zooplankton which serve as primary live food during culture.

Impact on other farmers/ youth:

1. He is confident enough to culture such types of species in duck cum fish farming system.
2. Serving as a master trainer and source of motivation for other fish farmers.

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BUTTER FLY PEA- AN UNTAPPED FORAGE LEGUME CROP

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Introduction

Butterfly pea or Sangupoo (in Tamil), botanically called *Clitoria ternatea* (2n: 16), belonging to plant family Fabaceae and sub family Papilionoideae is a tropical forage legume. Butterfly Pea Flower is also known as as Asian pigeon wings, blue bell vine, blue pea, cordofan pea and Darwin pea. It is a tropical legume that climbs over a trellis or a fence and produces vivid blue, purple, mauve and white flowers. It is also grown as ornamental flower plant in houses and also used for adorning God by the hindus. It is a high quality protein rich legume and also called tropical alfalfa. Livestock tend to prefer it to other legumes and grasses and therefore much valued as a pasture legume.

Botanical Description of Clitoria

Habitat: Adapted to wide range of soils and drought tolerant, but cannot tolerate water logging and flooding. It can tolerate light shade and hence grown as cover crop in rubber and plantations.

Habit: Vigorous trailing, scrambling or climbing, strongly persistant herbaceous perennial legume

Roots: Deep penetrating tap root with root nodules.

Stem: Fine stemed twining sparsely pubscent, sub-erect and woody at base and may grow up to 5 m long.

Leaves: Leaves pinnate with 5-7 leaflets; petiole 1.5-3 cm long, stipules persistent, narrowly triangular, 1-6 mm long, subulate, prominantly three nerved; stiples filiform to 2 mm long, leaflets elliptic, ovate or nearly orbicular, tip acute or rounded often notched, base rounded or cuneate; both surface sparsely appressed pubscent.

Inflorescence: Axillary racemes with single or paired flowers.

Flowers: Colour ranges from white, mauve, light blue to dark blue; Pedicle 4-9, twisted to 180 degree so that standard inverted, bracteoles persistant, broadly ovate or rounded.

Calyx: Gamosepalous; 5 lobed, 1.7-2.2 cm long with few fine hairs, companulate, 0.8 to 1.2 cm long, lobes triangular or oblong.

Corolla: Standard obovate, funnel shaped, 2-5.5 cm long, 2-4 cm wide, notched or rounded at apex with a pale yellow base or entirely white, a few fine hairs at apex

Androecium: Diadelphous (9+1).

Gynoecium: Ovary superior, ovules few in marginal placentation.

ruit: Pods linear to oblong, flattened with persistent style, with 8-11 seeds

Seed: Oblong somewhat flattened, dehiscent when dry, seeds olive brown to almost black, shiny, often mottled, minutely pitted.

Pollination: Predominantly self-pollinated

Center of origin: Tropical Africa

Related Species: *Clitoria laurifolia*

Cultural Method

Clitoria ternatea is easy to grow from seed. It is easy to grow with minimum care. They require less water and is tolerant to drought. But if irrigated it performs well and produce best results. It should not be watered heavily and cannot withstand heavy waterlogging for a too long time. The soil can be fertile to moderate level and can be moist. It is adapted to many types of soil from sandy to heavy clays. It can grow very well in full sun as well as in partial shade. In spring, prepare the seeds by lightly scratching the surface with a nail file and soak them overnight in water. The next day, sow them either direct or raise as seedlings by planting 2cm deep. Rooted cuttings may also be transplanted. Pinching can be done to keep the vine leggier and bunchy. Once in a fortnight it should be fed with liquid fertilizers and once in a month with solid fertilizer. The plant is usually free of pest and diseases, but monitoring should be done to avoid catter pillars and grasshoppers as they will damage the leaves as well as the plants. Once it's established, it becomes drought tolerant. As a legume, its nitrogen fixing capabilities means it needs little fertiliser. If you've prepared the soil beforehand, as is my preference, it doesn't need additional fertiliser. Furthermore, the vine seems to be fairly resistant to garden pests.

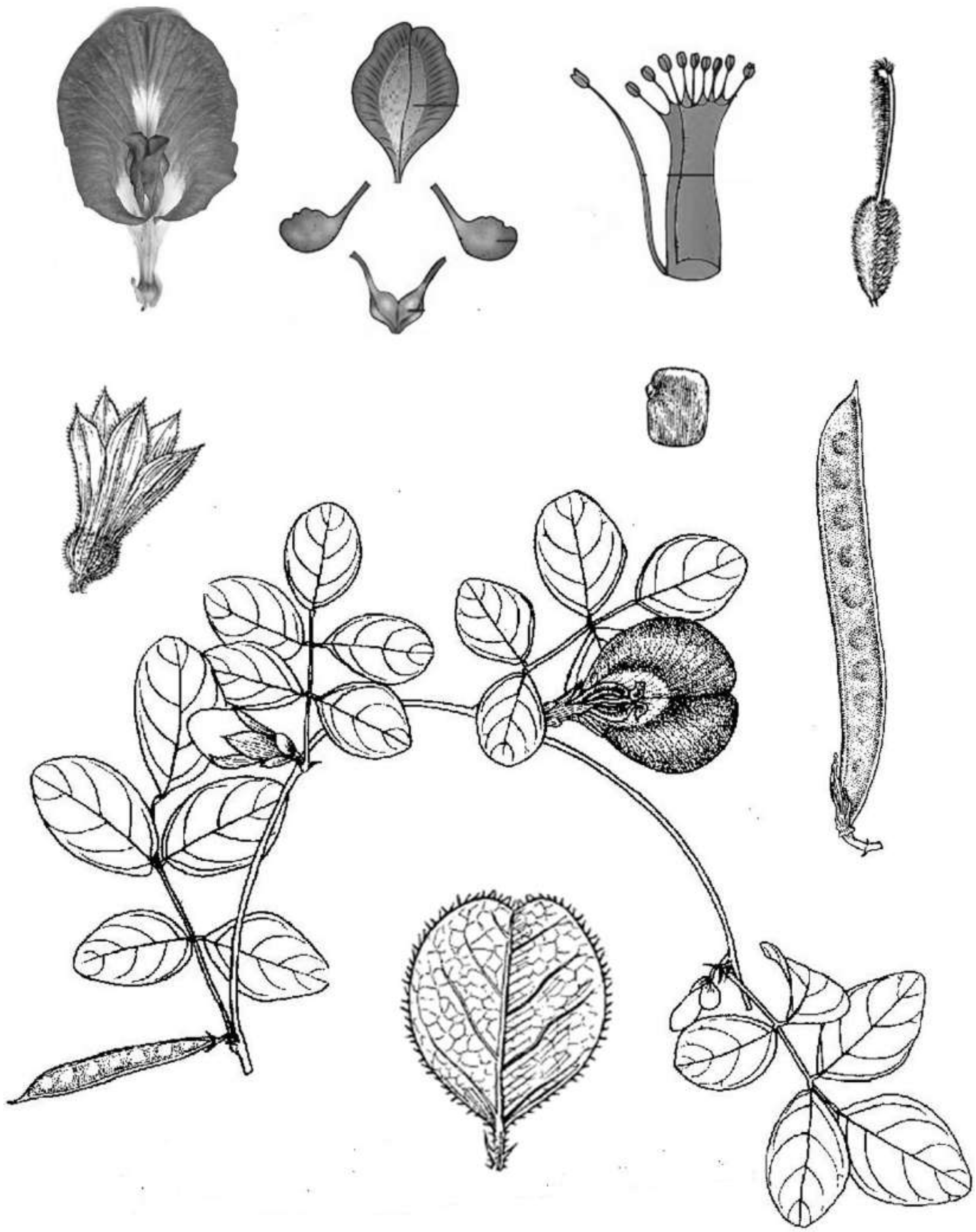

Fig. 1. Butterfly pea-Clitoria ternatea- Botanical illustration

USES OF CLITORIA

1. Used as short and medium term pastures
2. Used as green manure crop
3. Used as cover crop to prevent soil erosion
4. Also used as cut and carry fodder crop
5. Used as hay after drying
6. Widely planted as an ornamental and as fence rows
7. Have some medicinal value in some ethnic medicines
8. The flowers are used to adorne gods by the hindus.
9. Dried leaves are used as feed diluent for broilers.
10. It is grow on trellises as an ornamental species for its showy flowers.
11. Its petals are used for extraction of dye.
12. It is grown as a cover crop in rubber and coconut plantations.
13. It contains peptide Cliotides that have potential antimicrobial property against *Echericheria coli* that is found in mamalian duct.
14. It fixes admospheric nitrogen in the soil and enriches the soil.
15. It is useful in revegetaion of coal mining sites.

FODDER VALUE OF CLITORIA

Green fodder: Excellent nutritive value with high protein and digestibility upto 80 per cent. It is mostly suited to ruminants and monogastric animals. its forage quality persist even when mature, without affecting digestibility or feed intake. Green fodder is suited to sheep, goat, cattle, pigs and even rabbits. The green fodder yield ranges from 6 to 12 tonnes of Dry Matter/ha/year depending upon the growing conditions. Under irrigated condition even up to 30 t DM/ha/year is possible. This species is best suited for cut and carry system. For this it should not be cut too low or too often.

Nutritive value: Protein: 10 per cent, Fiber: 30 per cent, and Ash: 8 per cent . It is rich in calcium, Potassium, manganese and zinc.

Palatability: Very palatable for almost all types of farm animals. It is highly palatable for sheep, goat and cattle since it has high fiber content. Livestock tend to prefer it over other legumes and grasses and it is therefore much valued as a pasture legume.

Toxicity: No toxicity has been observed. But seed contain condensed tannins and trypsin inhibitors which act as a purgative and impair digestion to some extent.

Pasture: Clitoria is mostly used as pasture legume and allowed to graze at low to moderate levels. It is sensitive to tampering and should not be allowed to graze until establishment. Once established, it can be allowed to graze 2-3 hours per day on rotational basis.

Hay and Silage: Hay is a supplementary feed to dairy cows at different stages of lactation. The dry mater digestibility ranges from 72 to 74 per cent, which reflects the high fiber content of the forage. Dried leaves are used as feed diluent for broilers.

ADVANTAGES OF CLITORIA

1. It is an high quality, protein rich pasture legume fodder.
2. It is drought tolerant and can withstand 5-6 months drought in drier tropics.
3. It can grow in sodic soil with pH range of 5.6 to 8.9.
4. Can be grown in association with forage grasses and cereal fodder crops.
5. It has a low establishment cost and can quickly cover the soil.
6. Fodder quality is maintained even when mature without affecting digestibility or feed value.
7. Can grow in light shaded condition in rubber and coconut plantations.

LIMITATIONS OF CLITORIA

1. Clitoria has low tolerance to flooding.
2. It should not be cut too low or too often
3. It is sensitive to trampling and may hamper regrowth

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NATURAL FARMING: A DIVERSIFIED FARMING SYSTEM

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Introduction

Natural farming, also known as zero budget natural farming, is an innovative farming approach. It is low input based, climate resilient, and low cost farming system because all the inputs (insect repellents, fungicides, and pesticides) are made up of natural herbs and locally available inputs, thereby reducing the use of artificial fertilizers and industrial pesticides. It is becoming increasingly popular among the smallholder farmers. Natural farming is a special form of agriculture that does not requires any financial expenditure to purchase the essential inputs such as seeds, fertilizers, and plant protection chemicals from the market. Natural farming, though in its preliminary stages, is showing increased positive results and is being adopted by farmers in good faith. It is even cited by farmers that labor and production costs have drastically reduced 14–45% (*Chandel et al., 2021*).

It can be defined as a “chemical- free farming and livestock based ”. Soundly grounded in agro-ecology, it is a diversified farming system that integrates crops, trees and livestock, allowing the optimum use of functional biodiversity. It holds the promise of enhancing farmers’ income while delivering many other benefits, such as restoration of soil fertility and environmental health, and mitigating and/or reducing greenhouse gas emissions. Natural farming also referred to the Fukuoka Method” “the natural way of farming” or “do –nothing farming” is an ecological farming approach. This farming approach was introduced by Masanobu Fukuoka, a Japanese farmer and philosopher, in his 1975 book The One-Straw Revolution. It builds on natural or ecological processes that exist in or around farms. Internationally, Natural Farming is considered a form of regenerative agriculture—a prominent strategy to save the planet. It has the potential to manage land practices and sequester carbon from the atmosphere in soils and plants, where it is actually useful instead of being detrimental. There are many working models of natural farming all over the world, the Zero Budget Natural Farming (ZBNF) is the most popular model in India. This comprehensive, natural, and spiritual farming system was developed by Padma Shri Subhash Palekar.

.**Principles of Zero Budget Natural Farming**

- Zero external inputs
- Crops to cover the soil for 365 days (Living Root)
- Soil disturbance at a minimum
- Biostimulants as essential catalysts
- Utilize native seed for mixed farming
- Mixed cropping
- The incorporation of trees onto the farm
- Conservation of moisture and water
- Bring animals into farming
- More organic debris in the soil
- Using plant extracts to control pests
- No artificial pesticides, herbicides, or fertilisers

Concept

Natural Farming is a chemical-free farming system rooted in Indian tradition enriched with modern understanding of ecology, resource recycling and on-farm resource optimization. It is considered as agroecology based diversified farming system which integrates crops, trees and livestock with functional biodiversity. It is largely based on on-farm biomass recycling with major stress on biomassmulching, use of on-farm cow dung-urine formulations; maintaining soil aeration and exclusion of all synthetic chemical inputs. Natural farming is expected to reduce dependency on purchased inputs. It is considered as a cost- effective farming practice with scope for increasing employment and rural development.

Components of Natural Farming

There are four primary components and models:

1. Bijamrita

Bijamrita is utilised to treat seeds.Bijamrita is a natural seed treatment solution for crops, prepared by soaking seeds in a mixture of cow dung, water, lime and cow urine. the seeds are treated with formulations made using their dung and urine. After soaking, the seeds are dried and then sown. This traditional practice is believed to enhance seed germination, protect against diseases, and promote healthy plant growth in an organic and sustainable manner. While neem leaves and pulp, tobacco, as well as green chilli extracts are used to manage insects and pests.

Benefits:

Fungal and other seed- and soil-borne infections may impact the seeds sowed in the field. The seeds are shielded against illnesses by the "Bijamrita" seed treatment (*Devakumar et al. 2014*).

2.Jeevamrit

Jeevamrit acts as a biostimulant made by re-establishing and promoting the activity of existing farmers' friendly soil microbes. Cow dung, cow urine, jaggery, pulse flour and water are used to make Jiwamrita by fermentation process . A gramme of cow dung may contain 300–500 billion helpful microorganisms. These bacteria help decompose the soil's biomass and transform it into readily usable nutrients for crops. . When applied to soil, this fermented microbial culture enriches the soil with nutrients and acts as a catalyst to encourage the activity of earthworms and microorganisms. For each hectare of land, 500 litres of jeevamrutha should be applied twice a month; following three years, the system might become self-sustaining. This nutrient-rich liquid fertilizer enhances soil fertility, stimulates microbial activity, and aids plant nutrient absorption, contributing to sustainable agriculture by reducing the need for synthetic inputs (*Ganesan*, *P. 2013*).

Benefits: By promoting soil microbial activity, this culture improves the availability of nutrients to plants, shields crops from soil diseases, and raises the carbon content of the soil.

3.Acchadana/Mulching:

Mulching is the process of covering the topsoil with plant material such as leaves,grass, twigs, crop residues and straw etc. In natural farming, the term mulching refers to the use of organic and biodegradable plant materials. However, m ulching may also include covering the soil surface using live crops with fast growth and short life spans. Mulching has multiple benefits such as decomposition of mulch material helps in increasing the organic matter content of the soil, conserves moisture in the soil through lowering of soil temperature, prevents soil erosion and also weed growth (*Saldanha LF,2018*).

Types of mulching:

- **Crop Residue Mulch**: This comprises any dried vegetation, farm stubble, such as dried biomass waste etc. It is used to cover the soil against severe sunlight, cold, rain etc. Residue mulching also saves seedsfrom birds, insects, and animals.
- **Live Mulch:** Live mulching is practiced by developing multi-cropping/inter cropping patterns of short durational crops in the rows of a main crop. It is suggested that the pattern should be of monocotyledons and dicotyledons in the same field, in order to provide all the essential nutrients. Monocots, like wheat and rice, supply nutrients such as potash, phosphate and sulphur, while dicots are capable of nitrogen-fixation in fields. Such practices reduces the demand fo some essential plant nutrients required for their optimal growth.

Benefits

Decomposing the materials used for mulching results in humus, which not only improves soil nutritional status but also conserves topsoil, boosts soil water retention, reduces evaporation loss, and promotes soil fauna. It also inhibits weed growth.

4. Waaphasa/Moisture (Soil Aeration)

Whapasa means the mixture of 50% air and 50% water vapour in the empty space between two soil particles.It is the soil’s microclimate on which soil organisms and roots depend for most of their moisture and some of their nutrients. It increases water availability, enhances water-use efficiency and helps crop growth in drought conditions. The basic principle for Whapasa formation is irrigation should be done six inches outside the shadow circumference of any plant/tree formed at 12 noon during the day time.

Benefits

Applying Jiwamrita and mulching promotes soil aeration, humus content, availability of water, water retention capacity, and soil structure, all of which are essential for crop growth, particularly during dry spells.

Plant protection measures of natural farming

- **Neemastra:** Neemastra is a bioinsecticide and pest deterrent for natural farming that is incredibly simple to manufacture. it is used to prevent or cure diseases, and kill insects or larvae that eat plant foliage and suck plant sap. This also helps in controlling the reproduction of harmful insects. Neemastra is very easy to prepare and is an effective pest repellant andbioinsecticide for Natural Farming.
- **Agniastra:** it is a natural insecticide prepared by the combination of neem leaf pulp, tobacco powder, greenchilli, garlic paste and turmeric powder. It is used to mange all sucking pests and caterpillars like leaf roller, stem borer, fruit borer, pod borer.
- **Brahmastra:** This is a natural insecticide prepared from leaves of neem, karanj, custard appleanddatura which have specific alkaloids to repel pests. It is used to manage all sucking pests and hidden caterpillars that are present in pods and fruits.
- **Dashaparni ark:** turmeric powder, ginger paste, Asafoetida, tobacco powder, chilly pulp, garlic paste, ginger paste, any 10 leaves are used to prepare dashparni ark. It is used to mange all types of pests and used depending on the level of infestation.
- **Fungicide:** cow milk and curd are used to prepare fungicides that are found to be very much effective to mange the fungul disease.

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BIOREMEDIATION STRATEGIES FOR CONTAMINATED ENVIRONMENTS

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Abstract

Strategies for bioremediation provide economical and environmentally friendly ways to reduce pollutants in the environment. The many bioremediation strategies for polluted habitats are examined in this abstract. Microorganisms are used in microbial bioremediation to break down contaminants into less hazardous forms. Using plants to absorb, detoxify, or accumulate pollutants from soil, water, or the air is known as phytoremediation. Bioaugmentation, which involves introducing particular microorganisms to speed up degradation, and biostimulation, which entails supplying nutrients or other growth-promoting agents to increase microbial activity, are two further ways to improve both approaches. Many toxins, such as pesticides, heavy metals, and petroleum hydrocarbons, have been successfully treated via bioremediation. But before it can be widely used, issues including extensive maintenance times and site-specific requirements must be overcome. For contaminated areas, bioremediation procedures must be optimized by continued study and technical improvements.

Keywords: Bacteria, microbes, plants, pollutants, soil and water

Introduction

The area of bioremediation has attracted a lot of attention because of its potential to solve problems with environmental contamination. With an emphasis on current developments and their applications, this thorough analysis seeks to investigate several bioremediation techniques for contaminated areas. Microorganisms plays key role bioremediation technique to break down or change pollutants into less harmful forms. The utilization of bacterial strains for the biodegradation of polycyclic aromatic hydrocarbons (PAHs) in polluted soil were done and it was found that PAHs were efficiently broken down by the bacterial consortium, underscoring the potential of microbial bioremediation in polluted environments. Similarly, bacterial strains were used to degrade diesel-contaminated soil, leading to a substantial decrease in diesel hydrocarbon levels. Bioremediation is the utilization of living organisms to eliminate or counteract pollutants from the environment, proving to be a sustainable and economical method for environmental cleanup. It provides a hopeful remedy for the increasing issue of environmental contamination resulting from diverse industrial operations such as mining, agriculture, and manufacturing. This strategy harnesses the metabolic capabilities of bacteria, plants, or enzymes to break down or convert pollutants into less hazardous forms, ultimately rejuvenating the health and equilibrium of ecosystems. Recent study has greatly enhanced our comprehension of bioremediation mechanisms and their utilization in polluted environments.

Bioremediation Strategies

Various subcategories of bioremediation use various techniques and species to remove toxins from damaged environments. Using plants to remove, break down, or stabilize contaminants in soil, water, or the air is known as phytoremediation. Phytoextraction is the process by which pollutants are stored in the tissues of plants; phytodegradation is the process by which toxins are broken down by biochemical processes in plants. It has been demonstrated that phytoremediation works well in eliminating pesticides, hydrocarbons, and heavy metals from contaminated areas. Microbial bioremediation, a different category, uses bacteria, fungi, and algae among other microorganisms to break down contaminants. Through metabolic processes, microorganisms can decompose complex organic pollutants into simpler, less dangerous compounds. To increase degradation efficiency and increase the range of contaminants that can be treated, consortia of different microorganisms are commonly used. Another important subclass that uses enzymes to remove contaminants is enzymatic bioremediation. Certain pollutants, including hydrocarbons or pesticides, can be catalysed to break down into less dangerous molecules by the enzymes that are produced by bacteria or plants. Enzymatic bioremediation provides a targeted and effective approach to decontaminate environments.

Bioaugmentation and Bioventing

Two distinct bioremediation methods that have gained notoriety for their efficacy in clearing contaminated areas are bioaugmentation and bioventing. The addition of specific microorganisms to contaminated areas in order to enhance the degradation of pollutants is known as bioaugmentation. These microorganisms may be local natives or may have undergone genetic modification to enhance their degradation potential. Research has indicated that bioaugmentation can significantly accelerate the breakdown of contaminants such pesticides, chlorinated solvents, and petroleum hydrocarbons. Conversely, bioventing is a method that uses oxygen delivery to boost microbial activity and hasten the natural biodegradation of contaminants in soil. This method works especially well for treating soil that has been contaminated by volatile organic compounds (VOCs) or petroleum hydrocarbons. Bioventing promotes the growth of aerobic bacteria, which can break down contaminants more effectively, by increasing the amount of oxygen available.

Phytoremediation

Using plants to heal damaged surroundings is a promising and environmentally responsible approach known as phytoremediation. Utilizing plants to extract, break down, or render contaminants in the soil, water, or air is this tactic. Phytoextraction is the process by which contaminants are absorbed by plants through their roots and then deposited in their tissues. Moreover, they are capable of breaking down contaminants through a process called phytodegradation, which occurs during internal metabolic processes. Furthermore, through mechanisms including Phyto immobilization and rhizosphere degradation, plants can stabilize contaminants in the soil. Phytoremediation is a flexible and long-lasting method of repairing the environment since it has been effectively applied to remove a wide range of contaminants, such as radionuclides, organic pollutants, and heavy metals.

Mycoremediation

Fungus is used in mycoremediation, a kind of bioremediation, to break down or sequester environmental toxins. Because of their special enzymatic properties, fungi can degrade a variety of contaminants, such as heavy metals, pesticides, and hydrocarbons. The ability of fungi to survive in a variety of environmental conditions and colonize areas where other remediation techniques might not be feasible is one of the main benefits of mycoremediation. Recent studies have highlighted the applicability of mycoremediation in many environmental settings. By using biosorption, the fungus *Aspergillus niger* has the ability to effectively remove heavy metals from contaminated water, offering a viable substitute for heavy metal remediation.The breakdown of textile dyes in wastewater by fungal strains highlights the potential of fungi in the treatment of industrial effluents .Furthermore, mycoremediation has been studied for oil spill cleanup; fungi having the ability to break down petroleum hydrocarbons include Trametes versicolor .

Factors Influencing Bioremediation Efficiency

Numerous variables affect bioremediation efficacy, all of which are essential for a successful cleaning of the environment. The kind of contamination is an important consideration since various microorganisms and enzymes are needed to break down different contaminants. Both the amount and distribution of contaminants are important because high concentrations can suppress microbial activity and uneven distribution can reduce the amount of time that pollutants and microorganisms come into contact. The effectiveness of bioremediation can be changed by environmental factors that impact microbial activity and enzyme performance, including temperature, pH, and moisture content. Furthermore, co-contaminants and environmental stressors such as heavy metals can affect the development and metabolism of microorganisms, reducing the effectiveness of bioremediation. Low nutrient levels can reduce the effectiveness of bioremediation. Microbial growth and metabolism depend heavily on the availability of nutrients, especially carbon and nitrogen sources.

Furthermore, co-contaminants and environmental stressors such as heavy metals can affect the growth and metabolism of microorganisms, reducing the effectiveness of bioremediation. Low nutrient levels can reduce the effectiveness of bioremediation. Microbial growth and metabolism depend heavily on the availability of nutrients, especially carbon and nitrogen sources. The success of bioremediation can also be influenced by the richness and makeup of the microbial community at the contaminated site, since some microbial species may be better at breaking down contaminants than others.

Enhancing the solubility and bioavailability of contaminants through the use of natural or synthetic surfactants can improve the effectiveness of bioremediation. The efficiency of bioremediation can be greatly impacted by the design and application of bioremediation procedures, including the selection of technology (such as bioaugmentation or biostimulation) and the use of suitable inoculum or amendments.

Another important factor influencing the effectiveness of bioremediation is oxygen availability, since many aerobic biodegradation processes need for adequate oxygen levels. The efficacy of bioremediation can be increased, and oxygen limits can be addressed with the use of techniques like bioventing, which entails infusing air or oxygen into polluted soils. Pollutants must be bioavailable in order for degradation to take place, as toxins need to be in a form that microbes can reach. The effectiveness of bioremediation can be hampered by elements such as pollutant sorption to soil particles or organic materials, which can reduce their bioavailability.

The efficacy of bioremediation is also significantly influenced by the metabolic flexibility of bacteria. Widely varying metabolic capabilities improve the likelihood that different contaminants will be broken down by microorganisms, increasing the efficacy of bioremediation. The efficiency of bioremediation can be increased by using genetic engineering techniques to increase the metabolic capacity of microorganisms for particular contaminants. Efficiency can also be impacted by how long bioremediation treatments are given; for complex contaminants or in regions with low microbial activity, longer treatment durations may be required. The best possible efficiency and efficacy in cleaning up contaminated places can be ensured by tracking and refining bioremediation procedures over time.

Conclusion

With its wide range of techniques, bioremediation has proven successful in eliminating a variety of pollutants, such as pesticides, heavy metals, and oil spills. These techniques not only lessen pollution in the environment but also have a positive economic impact because they are affordable and require little outside assistance. In addition, compared to mechanical or chemical techniques, bioremediation frequently causes less ecological disruption. In order to handle new and emerging pollutants, bioremediation methods show potential for further study and development. All things considered, bioremediation is a flexible and sustainable method of environmental remediation that has the potential to be extremely important in guaranteeing a better and more sustainable future for our world.

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IMPACTS OF SOIL SICKNESS AND ITS CONTROL

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Abstract

Soil sickness, a phenomenon characterized by declining soil fertility and increased susceptibility to diseases, poses a significant challenge to sustainable agriculture. This abstract explores the causes of soil sickness, including monocropping and chemical inputs, and evaluates strategies for its control. Techniques such as crop rotation, cover cropping, and organic amendments emerge as effective measures to mitigate soil sickness and restore soil health. The abstract underscores the importance of holistic approaches to agriculture that prioritize soil regeneration and biodiversity conservation. Through targeted interventions, it is possible to alleviate soil sickness and foster resilient agricultural systems conducive to long-term productivity and environmental sustainability.

Introduction

One of the key elements influencing crop health and productivity in an agro-ecosystem is the quality of the soil. The ability of the soil to work within ecosystem limits in order to sustain biological productivity, preserve environmental quality, and advance plant and animal health is referred to as soil quality. Crop rotation, use of mineral fertilisers and organic amendments, tillage practises, and the use of agrochemicals are all agricultural practises that have a significant impact on soil quality.

In fact, physical, chemical, and microbiological factors interact to influence soil quality in relation to its water retention capacity, soil structure and aggregate stability, organic matter dynamics, nutrient mineralization, and pathogen suppression (Bennett *et al*, 2012). The growth of intensive agriculture in recent decades has resulted in a considerable decline in primary output worldwide. There are many factors that affect soil quality, including soil erosivity, salinity, sodicity, soil compaction, pollution by heavy metals and a decline in soil organic carbon, and the loss of beneficial microbiomes.

The term soil sickness is describes the phenomenon of the reduction in growth and yield caused by continuous monocropping (Mazarura *et al, 2012*). Soil sickness (SS) is the development of unfavourable conditions for plant vegetative and reproductive performances that the plant itself has introduced into the soil, this phenomena is referred to as "replant disease problem" or "soil fatigue" in agronomy (Cesarano *et al*, 2017). It has been shown that SS is very species-specific, i.e., it primarily affects members of the same species. Particularly, sensitivity to SS decreases as evolutionary distance between species increases (Huang *et al*, 2013).

In addition, during the past three decades, scientists have realised how crucial SS is to maintaining the species variety of natural plant communities as well as altering their structure. Negative Plant-Soil Feedback (NPSF), a term used by plant ecologists to emphasise the reciprocal, albeit unfavourable, interactions between plant and soil, is referred to as SS. In ecology, NPSF is frequently referred to as "Soil Carry-over Effects", "Legacy Effects", or "Historical Contingencies". Nevertheless, despite decades of research on SS and NPSF-related issues, the fundamental causal mechanisms remain poorly understood and hotly contested.

Impacts

- Soil sickness is the rise of negative conditions for plant vegetative and reproductive performances induced into the soil by plant itself.
- In natural ecosystem, plant ecologists refer to soil sickness as negative plant-soil feedback (NPSF).
- This phenomenon is known in agronomy as “soil fatigue”, or replant disease problem.

- It is a complex, multifaceted phenomenon determined by an overall deterioration of soil quality.
- Soil sickness is species specific
- Ultimate effect is decline in yield

Reasons behind Soil Sickness

- Soil nutrient depletion/imbalance
- Phytotoxic and Autotoxin compounds
- Continuous mono-cropping
- Use of agro-chemicals and others
- Synergic interaction between pathogens and toxins leads to Imbalance in soil micro-ecosystem.
- Dry land rice-based cropping systems
- Deterioration of soil physic-chemical properties
- Soil borne pathogens and microbial shift

Soil sickness in crop plants

Autotoxicity is regarded as a significant problem since it directly causes soil sickness or replanting disease in a number of crop species. The secondary metabolites or chemical compounds generated by the crop plant interfere with the germination, growth, or other biochemical processes of other neighbouring crop plants belonging to the same crop species. This is a unique intraspecific allelopathy occurrence. Autotoxicity encourages the development of plant dysplasia, which is brought on by repeated cultivation of the same crop species on the same plot of land over a number of years. This results in major plant diseases and a significant reduction in the quantity and quality of crop production.

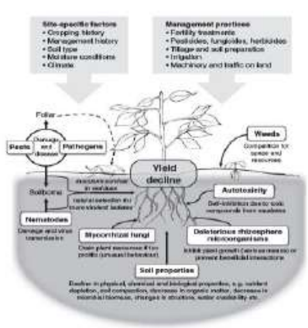

Fig.1. Biotic and abiotic factors implicated in yield decline of crops grown in short rotation or monoculture (Source: Bennett *et al*, 2012).

Control measures for soil sickness

Farmers face Soil Sickness since the time of ancient Greek and Roman Empire, being so forced to developed agronomic practices to overcome this problem. Following mechanisms to be used for overcome of soil sickness.

1. Proper Crop Rotation.

Crop rotation is likely the oldest agronomic strategy for treating soil sickness. Crop rotation minimises the inoculum of pathogens and the impact of autotoxic chemicals in the soil, which both help to treat soil sickness. To combat soil sickness, utilise the below strategies.

i. Deep rooted crops -shallow rooted crops such as cotton, castor, pea potato, lentil, green gram

ii. Leguminous crops - non leguminous crops (green gram-wheat)

iii. Exhaustive crops-restorative crops such as potato, sorghum, sugarcane, castor, black gram, and cowpea.

iv. Grain crops should be followed by foliage crops such as, wheat- dhaincha, black gram.

v. Long duration crops -short duration crops such as sugarcane cowpea, black gram, ground nut.

vi. Heavy irrigation to low irrigation.

2. Polyculture and Organic Amendment.

The best method to prevent SS is polyculture, which involves growing multiple plant species simultaneously in the same field. In actuality, SS cannot develop in polyculture since it takes time for a monoculture to establish itself in the soil. A natural ecosystem in which various plant species coexist in mixed populations is what polyculture most closely resembles. Polyculture minimises the occurrence of illnesses and pests through "herd" protection.

3. Soil sterilization:

Soil steam sterilization is a farming technique that sterilizes soil with steam in open fields or greenhouses. Pests of plant cultures such as weeds, bacteria, fungi and viruses are killed.

4. Removal of soil toxins

Another method to reduce SS and NPSF has been suggested: selective elimination of phytotoxic substances. Because of its powerful ability to absorb organic molecules, including contaminants and allelopathic substances, activated carbon (AC) has been used in this context

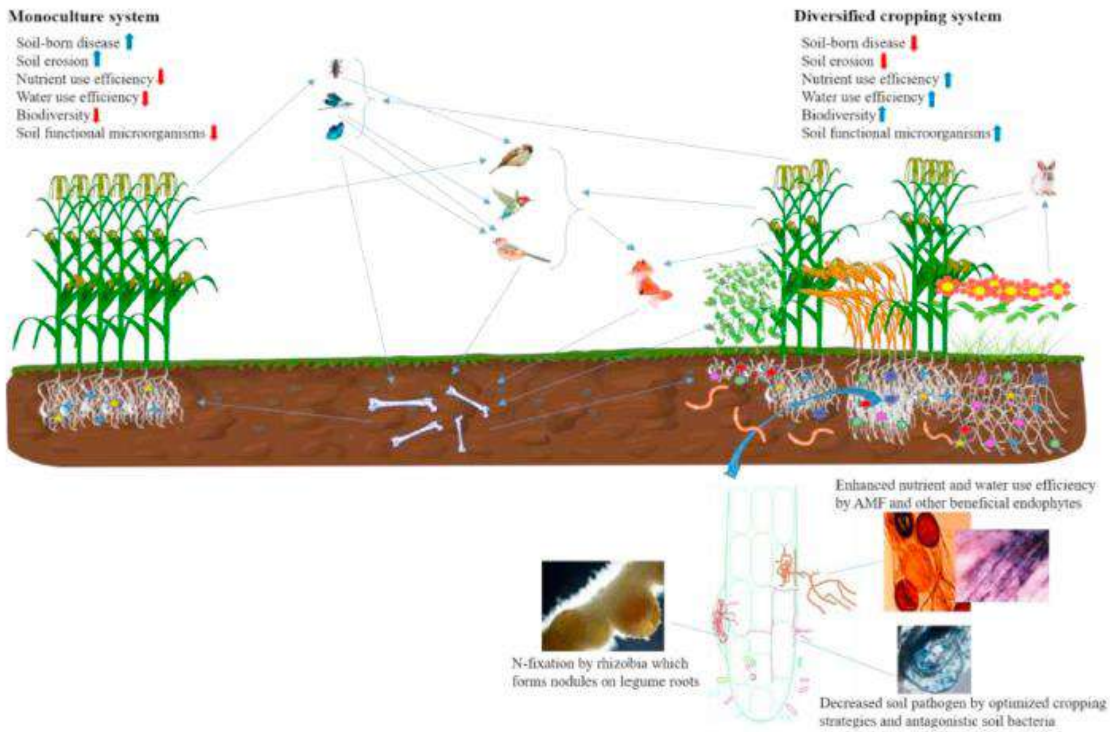

Fig.2. Soil health comparison in optimized cropping systems and monocultures (T. Yang *et al*, 2020).

5. Soil Flooding:

Soil flooding overcome Soil Sickness due to potentially leachate water soluble auto toxic substances and control some soil borne pathogens (Nie *et al*, 2009).

Conclusion

As a response to the dilemma of global food security, crop production in reduced rotations or monoculture appears certain to continue. So, in the near future, the issue of yield decline may very possibly become more significant. The aforementioned discussion suggests that auto-toxicity, also known as the phenomenon of self-toxicity, in which a plant's own compounds impede or reduce the growth of its own type, plays a key role in agricultural fields, wastelands, orchards, plantations, and natural forests. Biodiversity, which enables maintaining a balanced proportion between the species and their metabolites, is required to stop this phenomenon. Crop rotation, the use of cover plants, interspecies or intercultivar crop mixes, or other practises can help agro-systems reach higher levels of biodiversity.

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NURTURING NATURE: THE ESSENCE OF NATURAL FARMING

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Abstract

In a world increasingly dominated by industrial agriculture, there's a quiet revolution taking root. Natural farming, often referred to as "regenerative agriculture" is gaining momentum as a sustainable and environmentally friendly alternative to conventional farming practices. Let's delve into the beauty of natural farming and why it's becoming a popular choice for farmers and consumers alike. Natural Farming, deeply rooted in Indian tradition, is a farming approach that eschews chemical inputs in favor of a holistic understanding of ecology, resource recycling and on-farm optimization. It embodies the principles of agroecology, integrating crops, trees, and livestock within a biodiverse ecosystem. Emphasizing on-farm biomass recycling, it employs techniques such as biomass mulching and the use of cow dung-urine formulations to nurture soil health and maintain aeration without resorting to synthetic chemicals. This method aims to decrease reliance on purchased inputs, making it a cost-effective practice while also offering potential for rural development and increased employment opportunities

Understanding Natural Farming

At its core, natural farming is about working with nature rather than against it. Instead of relying on synthetic fertilizers, pesticides and genetically modified organisms (GMOs), natural farmers focus on nurturing the soil and creating a balanced ecosystem where plants, animals, and microorganisms thrive together. This approach emphasizes the use of organic matter, compost, cover crops, and crop rotation to improve soil fertility and structure naturally.

Hence, Natural Farming is defined as a chemical-free traditional method, integrates crops, trees and livestock within a diverse agroecology-based system to promote functional biodiversity and sustainable agriculture.

Principles of Natural Farming

A robust soil microbiome is essential for optimal soil, plant, animal, and human health. To nurture this, the soil should be consistently covered with crops throughout the year, promoting diverse crop rotations with at least eight different crops annually. Minimizing soil disturbance through practices like no-till farming or shallow tillage is crucial. Integrating animals into farming systems is also beneficial. Integrated farming systems play a pivotal role in advancing natural farming methods. Maintaining a healthy soil microbiome is vital for retaining and enriching soil organic matter, facilitated by the use of bio stimulants. In India, popular bio-stimulants are derived from fermenting animal dung, urine, and uncontaminated soil. Increasing the quantity and diversity of organic residues returned to the soil is paramount, including crop residues, cow dung, compost, etc. Pest management should prioritize agronomic practices outlined in Integrated Pest Management, supplemented by botanical pesticides when necessary. Synthetic fertilizers and other biocides are detrimental to the regenerative process and are not permitted in natural farming approaches.

Approaches to Natural Farming

Natural farming strives for soil health, biodiversity, animal welfare, efficient use of local resources, and ecological balance. It involves working with natural biodiversity, enhancing soil biology, and managing diverse organisms to support food production. Key practices include:

- Avoiding external inputs
- Using local seed varieties
- Employing on-farm microbial formulations like bijamrita for seed treatment
- Enriching soil with on-farm microbial inoculants such as Jivamrita
- Utilizing cover crops and mulching with organic matter for nutrient recycling and creating favorable soil conditions
- Implementing mixed cropping

- Integrating trees for biodiversity management
- Controlling pests through diversity and on-farm botanical concoctions like neemastra and agniastra
- Incorporating native livestock, especially cows, for dung and urine as essential inputs
- Prioritizing water and moisture conservation

Key goals of Natural farming:

The primary objectives of natural farming encompass a range of sustainable practices aimed at nurturing both the environment and agricultural productivity. Central to this approach is the preservation of natural flora and fauna, ensuring the ecosystem's resilience and biodiversity. By restoring soil fertility and promoting biological life within the soil, natural farming seeks to enhance agricultural productivity while minimizing reliance on external inputs. Emphasizing the diversity of crop production and efficient utilization of land and natural resources such as light, air, and water, it strives to create balanced and resilient farming ecosystems. Furthermore, natural farming advocates for the promotion of indigenous insects, animals, and microbes in the soil, harnessing their innate abilities to support crop health and resilience. Integrating local breeds of livestock into agricultural systems not only enhances genetic diversity but also strengthens the connections between farming and local ecosystems. Through the use of natural and locally sourced inputs, natural farming reduces the input costs associated with agricultural production, making it a financially viable and sustainable option for farmers. Ultimately, by improving the economy of farmers and promoting ecological stewardship, natural farming offers a pathway towards a more resilient and equitable agricultural future.

The Benefits of Natural Farming

1. Soil Health

The foundation of natural farming lies in healthy soil. By avoiding chemical inputs and tilling practices that disrupt soil structure, natural farmers promote the growth of beneficial microorganisms and earthworms that contribute to soil fertility. Healthy soil retains water more efficiently, reduces erosion, and sequesters carbon from the atmosphere, mitigating the effects of climate change.

2. Biodiversity

Conventional monoculture farming often leads to the loss of biodiversity as large swathes of land are dedicated to a single crop. In contrast, natural farming encourages diversity by incorporating a variety of crops, trees, and livestock into the agricultural landscape. This diversity not only enhances ecosystem resilience but also provides habitat for beneficial insects, birds, and other wildlife.

3. Reduced Chemical Inputs

One of the most significant advantages of natural farming is the reduction in chemical inputs. Without the need for synthetic fertilizers and pesticides, farmers can minimize their impact on the environment and protect the health of consumers. By promoting natural pest control methods and biological pest management, natural farming fosters a balanced ecosystem where pests are kept in check without the need for harmful chemicals.

4. Sustainability

Natural farming is inherently sustainable, as it seeks to mimic natural ecosystems and cycles. By closing nutrient loops and reducing waste, natural farmers minimize their reliance on external inputs and foster self-sufficiency. Additionally, the emphasis on local production and distribution reduces the carbon footprint associated with food transportation, further enhancing the sustainability of the agricultural system.

Case Studies: Success Stories in Natural Farming

1. Fukuoka's Natural Farming Method

Masanobu Fukuoka, a Japanese farmer and philosopher, pioneered the concept of natural farming in the 20th century. His "do-nothing" approach to farming, based on observation and minimal intervention, inspired generations of farmers around the world. By embracing the principles of simplicity, diversity, and harmony with nature, Fukuoka demonstrated that high yields could be achieved without the need for chemical inputs or heavy machinery.

2. The Rise of Permaculture

Permaculture, a design system that integrates human activities with natural ecosystems, shares many principles with natural farming. By designing agricultural systems that mimic the structure and function of natural ecosystems, permaculture practitioners aim to create regenerative landscapes that are productive, resilient, and sustainable. From urban gardens to rural homesteads, permaculture offers practical solutions for addressing food security, environmental degradation, and social equity.

3. Small-Scale Success Stories

Natural farming isn't just for large-scale operations; it's also thriving among small-scale farmers and gardeners. Across the globe, individuals and communities are reclaiming their food sovereignty by growing their own food using natural farming methods. From rooftop gardens in urban centers to community-supported agriculture (CSA) schemes in rural areas, natural farming is empowering people to take control of their food supply and reconnect with the land.

The Future of Farming: Embracing Natural Solutions

As the challenges of climate change, soil degradation, and food insecurity loom large, natural farming offers a ray of hope. By harnessing the power of nature and embracing sustainable practices, farmers can not only feed the world but also regenerate the land and protect the planet for future generations. As consumers, we have the power to support natural farming practices by choosing organic, locally grown produce and advocating for policies that prioritize ecological farming methods.

Conclusion

In conclusion, natural farming represents a paradigm shift in agriculture, away from the destructive practices of the past and towards a more harmonious relationship with the natural world. By working in partnership with nature, we can cultivate abundance while preserving the health of the planet. As we face the challenges of the 21st century, let us draw inspiration from the beauty of natural farming and sow the seeds of a brighter, more sustainable future.

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HERBAL BEVERAGES – BOON TO THE HUMAN HEALTH

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Introduction

About 70 – 80% of the world population still relies on traditional healers for day-to-day. In some rural areas the percentage is around ninety compared to 80% reported world-wide. WHO estimates that the usage of traditional medicine in developing countries is higher (Ramadan and Al-Ghamdi, 2012).This indicaes herbal medicine is important in primary health care provision in India. For centuries, cultures around the world have relied on traditional herbal medicine to meet their healthcare needs. Despite medical and technological advancements of the modern era, the global demand for herbal remedies is on the rise. In fact, it's estimated that this industry grosses about $60 billion annually. Some natural remedies may be more affordable and accessible than conventional medicines, and many people prefer using them because they align with their personal health. Herbal beverages can be made with fresh or dried flowers, immature fruits, leaves, seeds, and/or roots by steeping (infusion) or boiling (decoction) of the source materials including herbs.

Natural foods

Natural foods are associated with fewer side effects and consequently safer for use and for health management has stood the test of time and are often considered relatively cheaper compared to synthetic drugs. Diet alone cannot and should not replace medicine in all circumstances. Although many illnesses can be prevented, treated, or even cured by dietary and lifestyle changes, while many others cannot. Foods are typically deficient in vitamins and minerals and substantially increase the risk of disease. On the other hand, diets rich in plant foods and low in processed products strengthen our health. Genetics, stress, pollution, age, infections, occupational hazards, and lifestyle choices such as lack of exercise, smoking, and alcohol use also have an effect. Medicinal foods having specific therapeutic or preventive effects, compared with the ordinary similar types, when are consumed regularly in adequate amounts.

Formulation and industrial production of medicinal plants are rather difficult; because on one hand, they must preserve their medicinal effects in food matrices (which are much complex than drug matrices from variety, reactivity and perishability points) until the end of product shelf life, and on the other hand, they must render sensory characteristics (flavor, texture and appearance) as acceptable and pleasant as the control or ordinary products demanded by the consumers.

Herbal bevarages

An herb is a plant or plant part used for its scent, flavor, or therapeutic properties. Herbal medicines are one type of dietary supplement. They are sold as herbal bevarages, teas, and extracts of fresh or dried plants. People use herbal medicines to try to maintain or improve their health in traditional Indian system of medicine (Krupa,2008).It aims to preserve health and wellness by keeping the mind, body, and spirit in balance and preventing disease rather than treating it. To do so, it employs a holistic approach that combines diet, exercise, and lifestyle changes. Ayurvedic herbs and spices are also an important component of this approach. They're thought to protect our body from disease and offer a variety of health benefits, including improved digestion and mental health.

Plants were administered mostly in their crude forms as infusions (herbal teas), tinctures (alcoholic extracts), decoctions (boiled extracts), and syrups (extracts of herbs made with syrup or honey) or applied externally as poultices, balms, and essential oils (Rivera,2005). A strong connection existed between food and pharmacology for maintaining health and treating various ailments. Spices normally are used as flavour or taste enhancers in food were described as "influencers of body metabolism" (Srinivasan, 2005). Traditionally used in Indian cooking, turmeric (*Curcuma longa*) contains the active ingredient curcumin which is considered to have antioxidant, antiinflammatory and anticarcinogenic properties (Saunders and Wallace, 2010). This is thought to be mediated through inhibition of several cell signaling pathways, inhibition of enzymes.

Herbal teas

Herbal teas are long been considered warriors in the battle against bad health. Ginger, tulsi, mint, even pepper and cinnamon are all extremely healthy, landing a strong upper cut against illness of any kind. For instance, a gentle chamomile tea will ease anxiety and calm enough to put us to sleep – it's great for insomniacs; peppermint tea is well-known as an antidote to stomach ailments and has a mild laxative effect on our digestive system. Herbal teas – they aren't actually teas (hence they have no caffeine), but rather a decoction or infusion of herbs and spices. Herbal tea contained roots, flowers, leaves, seeds, and fruit. Herbal teas like chamomile, peppermint, and ginger tea offer several health-promoting properties and could help improve heart health, digestion, sleep quality, and more. Leaves of the *Camellia sinensis* plant, herbal teas are made from dried fruits, flowers, spices, or herbs. In addition to being delicious, some herbal teas have health-promoting properties and have been used as natural remedies for a variety of ailments for hundreds of years.

Ginger tea packs a punch of disease-fighting antioxidants and is a well-known remedy for nausea. Studies consistently find that ginger is effective at relieving nausea, especially in early pregnancy, although it may also relieve nausea caused by cancer treatments and surgery (Qian-Qian Mao,2019) Ginger is abundant in active constituents, such as phenolic and terpene compounds. The phenolic compounds in ginger are mainly gingerols, shogaols, and paradols. In fresh ginger, gingerols are the major polyphenols, such as 6-gingerol, 8-gingerol, and 10-gingerol. Echinacea tea is a popular remedy that's said to prevent and treat the common cold. Evidence has shown that echinacea may help boost the immune system, which could help the body defend against infections. Lemon balm tea has a light, lemony flavor and seems to have health-promoting properties. In one small study, drinking lemon balm tea for 6 weeks improved arterial stiffness, which is a risk factor for heart disease, stroke, and mental decline. Research has also found that drinking lemon balm may increase the body's natural antioxidant enzymes, which help protect the body from oxidative damage.

For example *Glycyrrhiza glabra* may be useful in conventional and naturopathic medicine is commonly used in herbal formulae to harmonize the other ingredients in the formula and to carry the formula to the twelve regular meridians and to relieve a spasmodic cough. (a) Demulcent, adrenal modulator, antibacterial, antiviral, antimutagen, anti-allergenic, expectorant with secretolytic and secretomotor activity, anti-inflammatory, nutritive, spasmolytic, antioxidant, estrogenic, immune modulator, mild laxative, hepato protective.

Natural antibiotics

Various nutrients and phyto- chemicals associated with benefits of herbal teas. One of the major issues of the WHO was to deepen investigation of plants as a promising source of therapies for human disease management. Rationally designed polyherbal preparations are progressively being developed as alternative for multi target therapeutic and prophylactic usage. This has resulted in growing lines of evidence to show that old molecules are finding new applications through a better understanding of traditional knowledge and clinical observations (Gurib-Fakim, 2011). Till date, a miscellany of phytochemicals has been identified in medicinal plants to have versatile profile of effectiveness (Konaté *et al*., 2012) One sole plant may, for example, contain bitter substances that stimulate digestion, anti-inflammatory compounds, polyphenols that can act as antioxidant, and venotonics, antibacterial, and antifungal tannins that perform as natural antibiotics (Gurib-Fakim,2011). In certain cases, when a combination of medicinal plants or extracts is consumed at the same time or mixed in appropriate formulation, the therapeutic effects could be a result of total sum of different classes of compounds present within them (Ncube, 2012). Indeed, there have been reports highlighting that intake of whole medicinal plants which have resulted in significantly better outcomes compared when an equivalent dose of single isolated active ingredient was given. Thus, it can be argued that synergism can occur when two or more compounds interact in ways that mutually enhance, amplify, or potentiate each other's effect (Williamson, 2001). The different plants included were based on the criteria that they are consumed as fruit or vegetable for their nutritive value but have also other parts which are in common use in folk medicine. Food plants that came from different families have previously gained scientific momentum and demonstrated to have medicinal virtues against panoply of ailments.

Conclusion

Herbal teas come in a variety of delicious flavors and are naturally free of sugar and calories. Many herbal teas also offer health-promoting effects, and modern science has begun to validate some of their traditional uses. However, keep in mind that more research is needed to understand the effects of drinking herbal tea rather than taking extracts or other supplements. Recent years there is seen growing interest on the part of consumers and the food industry focusing into herbal food ingredients to maintain human health? Herbal beverages need validation of plant components and always stressing on safety, efficacy and quality of phyto-medications.

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HYDROGEL – A SUPER ABSORBENT POLYMER

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Abstract

Polymer: Material that, according to its relative mass, can absorb and hold a large amount of liquid (IUPAC, 2004). Available under a variety of commercial names, including root watering, drought crystals, and super absorbent polymers, which are commonly referred to as "hydrogels," these three groups of superabsorbent polymers are typically used: natural, semi-synthetic, and synthetic polymers. These hydrogels have a great capacity to absorb available water and release it gradually so that plants can use it (Akhter et al., 2004). At first, hydrogel was a substance that could absorb 20 times its own weight in water. Hydrogel is a biodegradable, amorphous polymer that holds water approximately 400 times its original weight. Within the permanent wilting point (PWP) of 15 bar tension, at least 95% of the absorbed water is made available to the crop (Johnson and Veltkamp, 1985). Hydrogel particles are thought of as "miniature water reservoirs" in soil.

History of Hydrogel

In early 1960's, an American enterprise "Union Carbide" introduced the super absorbents in to the markets. Production was started at the later period of twentieth century and were manufactured from the chemically altered starch and cellulose, and from other polymers like polyvinyl alcohol or polyethylene oxide. Presently, hydrogels are prepared from moderately nullified, less cross-linked polyacrylic acid and are water swelling which were required in large quantities per hectare (Wallace and Wallace, 1986).

Water absorption mechanism of hydrogel

The hydrophilic groups (viz. acrylamide, acrylic acid, acrylate, carboxylic acid, etc.) of the polymer chain are responsible for water absorption in hydrogels. The acid groups stick off the main chain of the polymer. When these polymers are put in water, the latter enters into the hydrogel system by osmosis and hydrogen atoms react and come out as positive ions. This leaves negative ions along the length of the polymer chain. Hence the hydrogel now several negative charges down its length. These negative charges repel each other. This forces the polymer chain to unwind and open up. They also attract water molecules and bind them with hydrogen bonding. When exposed to water again, it will rehydrate. And repeat the process of storing water. This process can last up to 2–5 years, by which time biodegradable hydrogel decomposes.

General uses of Hydrogel

Diapers, hair gels, sanitary napkins, sweat, soaking body powder, sealing, artificial snow, agriculture, drug delivery systems, pharmaceuticals, biomedical applications, tissue engineering and regenerative medicine, wound dressing material, separation of biomolecules or cells, and barrier materials to regulate biological adhesion

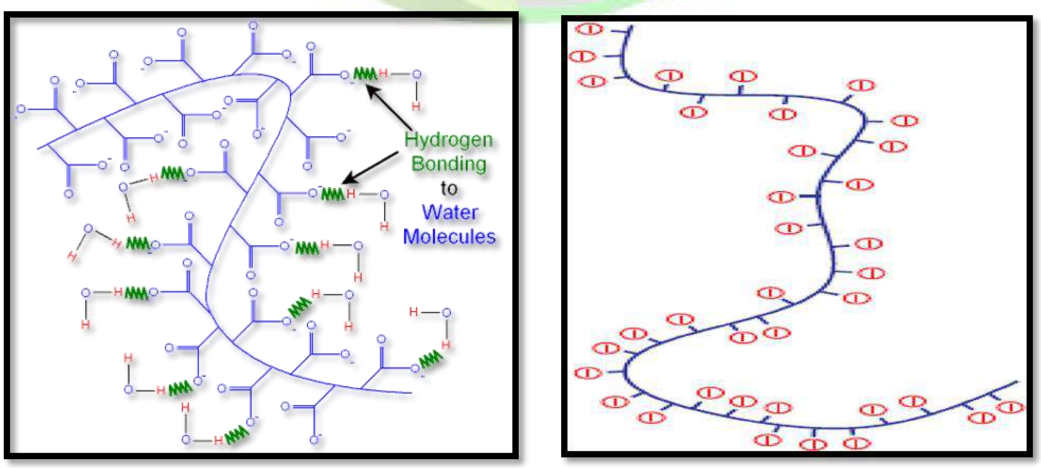

Fig. 1. Hydrogel polymer

Use of Hydrogel in Agriculture

- Improve the ability of soil to absorb water
- Enhance soil permeability and infiltration.
- Reduce irrigation frequency.
- Reduce fertilizer leaching.
- Reduce compaction tendency of soil.
- Reduce soil erosion and runoff.

Preparation of Hydrogel

- When cellulytic derivatives get irradiated, the radiation breaks some of carbon bonds of glucose molecules in the cellulose chain, resulting in free radical sites on the polymeric backbone.
- Cellulose radicals formed during irradiation add to one side of the acrylamide to form cellulose–acrylamide graft copolymer.

Key characteristics of Hydrogel

- Perform well at high temperatures (40°–50°C)
- They can absorb water 400 times than its weight
- They are neutral in P^H
- Increases the porosity of soil
- Increases the biological/microbial activities in the soil
- Delaying the onset of permanent wilting point

Application of Hydrogel

Area of application

Nurseries and seedling beds, crops requiring large quantities of water, and container gardens –pot cultures

Rate of application

- It depends upon the texture of soil
- For clay soil: 2.5 kg/ha (at the soil depth of 6–8 in)
- For sandy soil: up to 5.0 kg/ha (at the soil depth of 4 in)

Application methods

1) For field crops

Prepare an admixture of hydrogel and fine dry soil (1 : 10 ratio) and apply along with the seeds/fertilizer or in the opened furrows before sowing. For best results, hydrogel should be close to seeds

2). In nursery bed for transplants

Apply 2 g/m2 (or according to recommended rate) of nursery bed mix of hydrogel uniformly in the top 2 in of the nursery bed. In pot culture, mix 3–5 g/kg of soil before planting

3). While transplanting

Thoroughly mix 2 g (or according to recommended rate) of hydrogel per litre of water to prepare a free flowing solution and allow it to settle for half an hour. Dip the roots of the plant in the solution and then transplant in the field.

Hydrogels are environmental friendly

- Biodegradable hydrogels contain labile bonds either in the polymer backbone or in the cross-links used to prepare the hydrogels
- The labile bonds can be broken under physiological conditions either enzymatically or chemically over a period of time
- End-products after degradation are CO_2, water and ammonia. Acrylamide, a monomer used for hydrogel preparation is neurotoxic, but polyacrylamide itself is non-toxic
- The polyacrylamide can never reform its monomer. Hence there is no residual amount of acrylamide present in the soil after degradation of hydrogel, especially when cellulose is used as backbone
- Acrylamide residue is also not detected in crop products which are grown with hydrogel application

Conclusion

- Hydrogel can be use in almost all field crops especially in cereal crops the use is more
- Its application improves the germination percentage of crops like wheat and barley
- Application of hydrogel @ 2.5 to 5 kg ha^{-1} in fields and 10-20 grams’ kg^{-1} of seeds in case of seed coating can improve the nutrient uptake, WUE, growth and yield of the crops.
- Hydrogel improves the water holding capacity of the soil, especially in case of light soil which are having low water holding capacity
- Water absorption by hydrogel is well in case of water with less salts content than high salt content (saline water)

- Finally, the B:C ratio can have improved by the application of hydrogel when compared with without hydrogel application

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AGATHI TREE FODDER: NOURISHING THE LIVESTOCK AND GREENING THE FUTURE

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Introduction

Agathi or *Sesbania grandiflora L.* (Agast) is a well-known small, loosely branching, legume plant of the Tropical Asia including, India, Indonesia, Malaysia, Myanmar and Philippines. It belongs to the family Leguminosae. It is closely related to *Sesbania formosa*, an Australian species. Though the flowers feature in some traditional cuisines, one gets the impression that their inclusion was born from necessity rather than taste. Leaves, seeds, pods and flowers of *S. grandiflora* are edible. Flowers are the most widely used part, and white flowers are preferred to the red. In the Philippines, unopened white flowers are a common vegetable, steamed or cooked in soups and stews after the stamen and calyx have been removed. The raw flowers are eaten as salad in Thailand. Young leaves are also eaten, usually chopped fine and steamed, cooked or fried. Tender pods are eaten like string beans. Agathi leaves taste bitter, sour, and mildly tart. Most cooks counteract this bitterness with coconut milk, and some swear by the addition of garlic to combat the stomach pain arising from consuming too much Agathi.

The flowers are also bitter and astringent, but the white are less so than the red. It's possible to reduce the bitterness by removing the stamen. The flower's texture is mildly crunchy and fibrous, but pressure cooking or steaming for ten minutes will soften it.. In India, agathi is grown in abundance in many states, like Tamil Nadu, Andhra Pradesh, Kerala, Assam, Gujarat, and Bengal. It thrives well in hot, humid areas and can grow like weeds. Agathi known as agati sesbania, August flower, Australian corkwood tree, flamingo bill, scarlet wisteria tree, vegetable hummingbird, West Indian pea, white dragon tree in English; agasti, agati, anari in Sanskrit; agasti, bak, basma, basna, chogache, hatiya in Hindi; agati, agusta, bagphal, bak, bake in Bengali; kacang turi, petai belalang, sesban, sesban getih in Malayalam; agasti in Nepali; Avisi in Telugu; Heta in Marathi; Agase in Kannada and agathi, agati, peragathi in Tamil.

Origin and Distribution

Agathi originates in Asia, specifically India, Malaysia, and the Philippines. Its native range extends to Burma and Australia. According to the World Agro Forestry Centre, the precise origin is unknown, but there are links to a closely related species found in Australia ***(S. formosa)***. This close connection gives credence to the theory that the plant is native to Indonesia. One of the plants' earliest links to India lies in its namesake, agasthi. It is believed that Sesbania grandiflora is named after the Vedic sage, Agastya. Considered the father of Tamil literature, Agastya specialized in medicine, spirituality, and language, probably lived between 6th and 7th century BC. At present, agathi grows throughout Mexico and the south west USA, the warmer areas of South America, and parts of Africa. In West Africa, for example, agathi's been cultivated for the past 150 years. It's also an exotic plant in Cuba, the Dominican Republic, and Nepal. Agathi is distributed and cultivated in Benin, Mexico, Nepal, Niger, Nigeria, Puerto Rico, Senegal, South Africa, Tanzania, Togo, Uganda, United States of America. In India, the plant grows in abundance throughout many states, including Tamil Nadu, Andhra Pradesh, Kerala, Assam, Gujarat, and West Bengal. They thrive in hot, humid areas and can grow like weeds in close quarters.

Botany

The genus **Sesbania**, consisting of about 50 species, pantropically distributed, is placed in the family **Leguminosae**, sub family **Papilionoideae**. It was recently moved from the tribe Galegeae to the tribe Robinieae by Polhill and Souza (1981). The genus Sesbania is divided into at least four subgenera, of which two, Sesbania and Agati, contain species of potential agricultural value. The important species under the genus Sesbenia includes *Sesbania benthamiana*, *Sesbania dalzielii*, *Sesbania drummondii*, *Sesbania exasperata*, *Sesbania formosa*, *Sesbania goetzei*, *Sesbania grandiflora* , *Sesbania hirtistyla*, *Sesbania hobdyi* and *Sesbania javanica*. *Sesbania grandiflora* is a small, loosely branching tree that grows up to **8**- 15 m tall and 25-30 cm in diameter, stem is tomentose, unarmed, roots are normally heavily nodulated

With large nodules and the tree can also develop floating roots. Leaves are alternate, compound, and pinnate, 15-30 cm long with 12-20 pairs of oblong, round leaflets, **3-4 cm** long and about 1 cm wide and leaves borne only on terminal ends of branches. The leaves turn bright yellow before shedding. Flower clusters hanging at leaf base have 2-5 large or giant flowers. The colour of the flowers may be pink, red or white. The pea like flowers are 5- 10 cm in length, curved, about 3 cm wide before anthesis. The large-flowered hermaphroditic species appears to be pollinated by birds. Pods are long and narrow, hanging down 30-50 cm by 8 mm, septate, wide, flat, with swollen margins and about 15-40 pale coloured seeds. The seed is bean like, elliptical, red brown, 6-8 in a pod, 3.5 mm, each weighing 1 g.

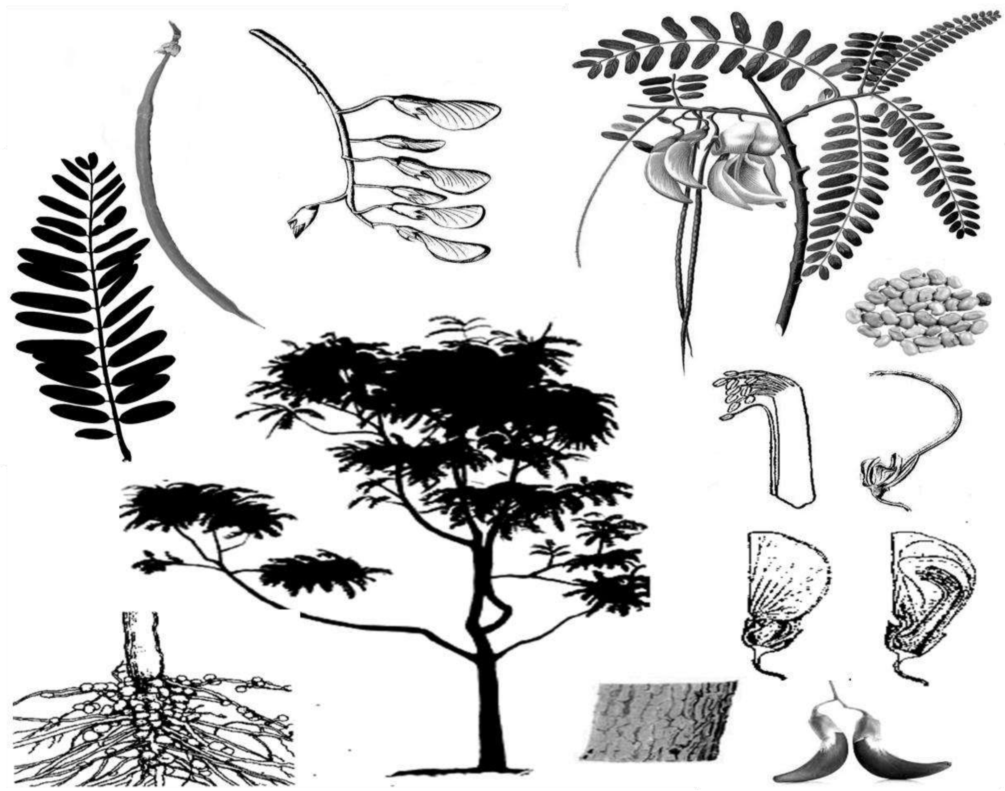

Fig. 1. *Sesbania grandiflora*- Agathi: Botanical illustration

Ecology

S. grandiflora is well adapted to hot, humid environments. It is a lowland species that lacks tolerance for cool temperatures (below about 10°C). It has an outstanding ability to tolerate water logging and is ideally suited to seasonally flooded environments. When flooded, it initiates floating, adventitious roots, and protects their stems. It seems to prefer a bimodal rainfall distribution, growing rapidly during the wet season, but is capable of withstanding prolonged dry seasons of up to 9 months. It is not wind resistant. It is commonly seen growing on rice bunds, along roadsides, in home gardens and in mixed crop lands.

Climate and Soil

It is best adapted to regions with annual rainfall of **2,000-4,000mm** and is also grown successfully in semi-arid areas with **800mm** annual rainfall and up to 9 months dry season. It is adapted to the lowland tropics up to 800m, occasionally to 1,000m msl and the environments with mean annual temperatures of 22- 30ºC. It is frost sensitive and intolerant to extended periods of cool temperatures. Poor shade tolerance, less than that of *S. sesban, S. grandiflora* is more suitable for the wetter/humid sites. It can be grown on a wide range of soils including those that are poor and waterlogged. It tolerates saline and alkaline soils and has some tolerance to acidic soils. Agathi may grow in alkaline, poorly drained, saline, low fertility soils. It is well adapted to heavy clay soils

Varieties

In agathi, no varieties have been identified till now through systematic breeding programme. But based on the flower colour, agathi can be classified in to four distinct groups, which are as follows:

- **Sita**: This group produce white colour flower.
- **Peeta**: It is a yellow flowered strain.
- **Neela**: This group of plant produce blue colour flower.
- **Lohita**: It is a red flowered strain.

Among these four groups, white and red flowered groups are used as vegetable and other two groups are more popular for their medicinal uses. Red flowered strain is more nutritious than white flowered one due to their high content of phenolic compound.

Propagation

Agathi is mainly propagated by seeds. It may also be easily propagated by stem and branch hardwood cuttings. Sesbania species tend to seed prolifically from early age. It is thought that *Sesbania sesban* is pollinated by bees, whilst the larger flowers of *S. grandiflora* are pollinated by birds. The seed can be easily harvested and can be grown without problems of dormancy. It is able to produce ripe pods within nine months of planting. The seeds are collected from the best trees in May and sown for raising of seedlings in nursery. Scarification may improve uniformity of establishment but is not considered essential. The viability of seed is about six months and 1 kg seed contains about 16000 seeds. The seeds are sown during May- June in polythene bags or in nursery beds. The seeds germinate in a week. The seedlings become ready for transplanting after 30-45 days of sowing. The seedlings are planted in 30cm3 size pits.

Sowing and Spacing

One should wait for warm weather for sowing. A soil temperature of at least **25°C** is needed for proper germination. In subtropical areas it is sown during **November – December**, while in tropical areas sowing should be done from **October to January**. Seedlings are planted at 1**.5m × 2 m spacing**

Harvesting

Harvesting leaves for fodder must be done selectively, to avoid complete defoliation, and cannot be done more than a few times per year. More intensive harvesting, such as managing as a hedgerow, reduces the life of the tree. For example, cutting at 1 m high five times a year can result in tree mortality. Because grandiflora establishes so rapidly, frequent replanting is a management option if heavy harvesting results in tree decline. Whereas leaves, flowers and pods of the agathi are harvested for consumption as vegetables at proper maturity stage. Ripe agathi leaves are green, edible. Dried, desiccated leaves ready to fall from the tree should be avoided from harvesting for human consumption. Young white agathi flowers have closed white petals. The full grown flowers are harvested for vegetable purpose.

Nutritive Value

According to the **USDA** nutrient database, **100g** of *Sesbania grandiflora* flower contains 91.58g water, 27kcal, 113 kJ, 1.28 g protein, 0.04g fat, 0.38g ash, 6.73g carbohydrates, 18mg calcium, 0.84mg iron, 12mg magnesium, 30mg phosphorous, 184mg potassium,15mg sodium,0.8mg selenium, 3mg vitamin C, 0.083mg thiamin, 0.081mg riboflavin, 0.430mg niacin and 102µg folate. On the other hand as per the book on “Nutritive Value of Indian Foods,” 100g agathi leaves contain 93kcal energy, 73g moisture, 8g protein, 1g fat, 3g minerals, 2g fibre, 12g carbohydrate, 1130mg calcium, 80mg phosphorus and 4mg Iron. Certainly, the leaves are an excellent source of calcium and iron. The plenty of these nutrients is one reason for its reputation as a bone strengthener.

USES

Culinary

Different plant parts of agathi viz., **the young leaves, giant white flowers, seeds, and**

tender pods are generally used in the preparation of several dishes. Ripe agathi leaves are green and malleable. Dried, desiccated leaves ready to fall from the main stem should be avoided for use as leafy vegetable. Young white agathi flowers having closed white petals in the shape of a crescent are used as vegetable. For vegetable preparation small, ovoid leaves are first removed from the stem by pinching the stalk with the thumb and forefinger, and then sliding down the main branch. The leaves should fall away with ease. Removed leaves are then rinsed in a colander to remove any dirt or sediment and are ready for sautéing, pressure cooking and boiling. To prepare the flower, the stamens and calyxes are removed. This step will improve the flavour of the preparation; otherwise, the prepared dishes will taste bitter. Dishes from flowers are prepared by deep-frying in butter, sautéing, stewing, steaming, grilling or simply sometimes eaten raw as salad. From the leaves, agathi keerai is one of the widespread dish is simply sauteed greens with oil, mustard seed, onion, garlic, urad or moong dal, asafoetida, green chilli, turmeric and salt. Sometimes leaves are also added in coconut milk soup. From the flowers, a Bengali delicacy blossom fritters is prepared by frying flower after removing the stamen and calyx. It is also prepared as stuffed flowers. In Myanmar sour soup is also prepared from the agathi flower. In Indonesian dish, pecel, agathi flower is used as one of the ingredients.

Fodder

Sesbenia grandiflora is valued as a fodder in many regions. In south-central Lombok, Indonesia, it is grown on bunds around paddy fields, provides up to **70 percent** of the diets of cattle and goats during the annual eight-month dry season. The leaves contain as much as **25-30 percent** crude protein. Leaves and pods are valued for fodder. The tree produces leaves for fodder within 4 months of establishment. The leaves also contain **9600 IU vitamin A** in every 100 g. For fodder production, the tree is cut when 90-120 cm tall (1.8 kg) and fed to animals mixed with rice straw.

Fuel

The wood is rather light and not highly regarded as a fuel because it smokes excessively when burnt. Having a weight of only **500 kg/square meter**, it burns rapidly without much heat. But its fast growth and availability within a year of planting make it a locally popular fuel wood. The wood should be well dried, as it deteriorates in storage and becomes corky, dusty and unfit for burning. Its calorific value is **17.91 MJ/ kg**, with a high **ash content (6%)** and **low percentage of carbon (11.7%).**

Soil improvement

Sesbenia grandiflora is often maintained in gardens and around crop fields for its nitrogen contribution to the soil. The light shade cast by its canopy does not block much light, allowing the growth of companion plants. Falling leaflets and flowers recycle nutrients to the ground. Due to its fast growing habit, seedlings are used for green manuring similar to annual green manure crops. Fruits, falling leaflets and flowers make excellent green manure or mulch and improve soil fertility. It is a well-suited annual for dense planting, growing for short periods and ploughing under to improve soil before planting food crops. *S. grandiflora* is ideal for rehabilitating eroded soils.

Fibre

At a very short rotation of 3-4 years, *S. grandiflora* is capable of producing much higher cellulose raw material per unit area than most of the other pulp woods. Even trees 3-4 years old can be pulped without debarking and are suitable for chemical pulping for use as cheap printing, writing, magazine and newsprint paper. The fibres are short. Fibre can also be blended with long-fibred bamboo pulp in suitable proportions to provide good strength. On a 3 year rotation, about 41 ton of pulp can be harvested from one hectare area in a year.

Gum or resin

Bark exudates and seed endosperm gums are produced from agathi. The clear gum from the bark is used in foods and adhesives as a substitute for gum arabic. The bark also yields tannins.

Ornamental, boundary or barrier or support

S. grandiflora is widely planted for beautification because of its giant showy flowers and long pods. It can be used as a live fence or a live support for crops such as vanilla and pepper

Health benefits and therapeutic uses

Agathi has several health benefits and the plant features in a number of traditional therapies for thousands of years. In Ayurveda, agathi leaves are used to treat fever, sinus, and respiratory problems. It also acts as a coolant, purgative, and worm-killer. According to thebook, **"Home Remedies,"** the agathi leaves are anthelmintic, diuretic, laxative, and can aggravate pitta. It has the potential for the treatment of toxicosis, itching, and excess kapha. The flowers are acrid, bitter, and astringent. Local healers use the flowers to treat night blindness, headaches, catarrh, cough, an fevers. Several studies confirm these benefits, and illuminate several others.

Antioxidant property of the aqueous suspension of agathi leaf protected rats from oxidative heart damage resulting from exposure to cigarette smoke. Ethanol flower extracts had great wound healing potential. Agathi also help to decrease serum cholesterol levels in hyper lipidemic rats. Ethanol extracts of agathi plant exhibited anticancer activity in carcinoma induced rats.

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AMARANTHUS CAUDATUS THE FOXTAIL GRAIN AMARATH –A PROMISING PSEUDOCEREALS

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Introduction

The foxtail amaranth (*Amaranthus caudatus* L.) having 2n = 32 is one of the most popular species of domesticated amaranths. It has been cultivated for a long time as a multipurpose pseudocereal of high nutritive value, as a vegetable and as an ornamental plant . It belongs to the group of grain amaranths, along with Amaranthus cruentus . The plant residue after grain harvest may be fed to livestock or used for thatching. A. caudatus is most recognizable for its striking flowering panicles that can reach up to 90 cm (35.4”) long. The colour of these highly dense flowering panicles ranges can be black, red and more commonly white. The red varieties of A. caudatus are due to a high content of betacyanins.

Botanical description of *Amarathus caduatus*

Habitat:

Native to the Andes region in South America. It grows between 1 to 2.5 meters, reaching maturity in 4–6 months (or up to 10 months in highland regions). It is having loam and loam-sandy soils with rich organic matter and good drainage. Soil pH is 6-7 but can tolerate up to 8.5.

Habit: *Amaranthus caudatus* is an annual herbaceous plant, meaning it completes its life cycle within one year. It grows as a herb, with a relatively short life span. It is erect, reaching up to 1.5 meters in height.

Root: Amaranth has a primary root with deeper spreading secondary fibrous root structures. It has well-developed root system that aids in nutrient absorption and anchoring.

Leaves: Surface of leaves glabrous or ± sparingly pilose along the margins and lower surface of the primary venation. Petiolate are Long-petiolate, with petioles up to about 8 cm but not longer than the lamina. Lamina Shape has broadly ovate to rhomboid-ovate or ovate-elliptic. Dimensions is 2.5-15 x 1-8 cm. Apex of Obtuse to subacute at the mucronulate tip. Base is Shortly cuneate to attenuate below.

Inflorescence: Inflorescence is called as glomerule. The inflorescence is in the form of a large panicle, which varies in terminal or axial position, color, and sex. The tassel of the inflorescence can be either erect or bent and varies in width and length between species.

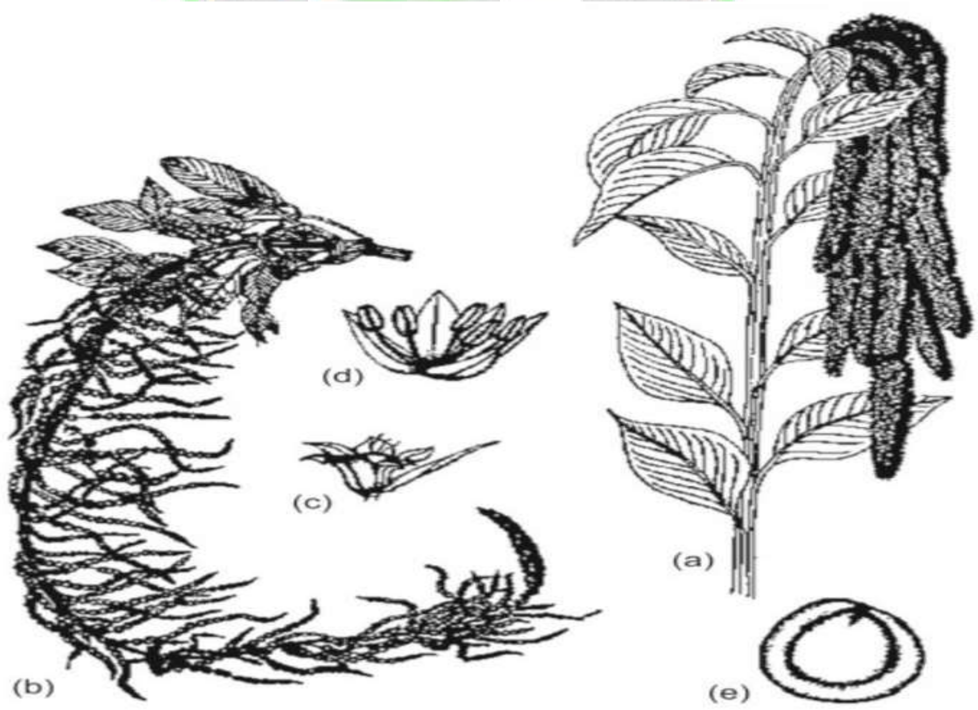

Fig. 1. *Aarathus caudatus*—Grain amaranth: a. Plant, b. Inflorescence, c. Female flower, d. Male flower and e. Grain or fruit

Flowers: Male and female flowers are intermixed throughout the spikes. Deltoid-ovate, pale-membranous, acuminate, with a long, pale or reddish, rigid, erect arista formed by the yellow-green or reddish stout, excurrent midrib. The longest bracts may be up to twice as long as the perianth . Male Flowers are Oblong-elliptic, 2.5-3.5 mm, acute, aristate. Female Flowers are 1.75-2.5 mm, broadly obovate to spathulate, distinctly imbricate, abruptly narrowed to a blunt or sometimes faintly emarginate, mucronate tip. Stigmas are 3, approximately 0.75 mm, erect or flexuose.

Calyx: The passage mentions that flowers in Amaranthus have three to five tepals. Tepals are structures that cannot be clearly differentiated into sepals and petals, and they often look similar. The number of tepals can vary among species.

Corolla: In many wind-pollinated plants, including some Amaranthus species, the corolla may be reduced, inconspicuous, or absent.

Androceuim: Filaments are almost completely fused and 5-toothed at the apex with entire or deeply lobed teeth . Anthers are 1-2-locular, meaning they have one or two compartments. They usually dehisce (open) by one or two slits.

Gynoceuim: ovary is superior and unilocular, indicating that it has a single chamber. Ovules are usually solitary, sometimes two to numerous. They can be erect to pendulous, and the placentation is basal. The style is described as very short or obsolete to long and slender. Stigmas are capitate (simple or penicillate) or up to 2-3 (-6) and long and slender.

Fruit: Irregularly rupturing capsule. Alternatively, it may be less frequently circumscissile, rarely a berry, or crustaceous.

Seed: Black, shiny. 2-2.5 mm long, ovoid-globose, circumscissile (splits open at maturity).

POLLINATION: Each panicle is self-pollinating. Grain type is cross pollination

CENTRE OF ORIGIN: Central and South America.

RELATED SPECIES:

Amaranthus caudatus var. caput-medusae .

Amaranthus tricolor.

Amaranthus palmeri.

Uses of *Amaranthus caduatus* :

1**. Food Source:**

In India and South America, Amaranthus caudatus is used as a source of food. Known as kiwicha in Peru, its seeds are flavorful, highly nutritious, and do not contain saponins (unlike quinoa).

2. **Culinary Uses:**

- The seeds of foxtail amaranth can be used in various recipes and preparations.
- They produce a crunchy, nutty "popcorn" when heated and can be used as a snack or in sweets.
- The seeds can be used in cold cereals with milk and honey, or as a "breading" on chicken or fish.
- The grain can be ground into flour, rolled into flakes, "puffed," or boiled for porridge.
- The flour can be blended with other cereal flours to enhance their nutritive value, providing higher protein, better amino acid balance, and increased vitamin content.
- Foxtail amaranth can be used in bakery specialties.

3. Traditional Uses in Ethiopia:

In Ethiopia, foxtail amaranth seeds are considered a famine food during scarcity and are combined with teff to make injera flatbread in times of abundance.

4. Food Coloring:

The plant contains pigments that can be used for food coloring.

5. Edible Greens:

Young leaves and stems of foxtail amaranth can be boiled and consumed as greens, similar to spinach.

6. Livestock Feed:

After grain harvest, the stover (the residual plant material) can be fed to livestock.

7. Ethnomedicinal Applications:

All parts of foxtail amaranth have ethnomedicinal applications. The plant has been reviewed for its potential health benefits, including anti-diabetic, anti-hyperlipidemic, anti-atherogenic, and cardioprotective properties.

8. Widespread Cultivation:

Although not reported in statistics, various amaranths, including foxtail amaranth, may be among the most widely grown vegetable crops in the humid tropics.

FODDER VALUE OF CADUATUS:

GREEN FODDER: *Amaranthus caudatus* get well established after every 2 to 4 weeks on the growing condition , with a focus on the nutrient-rich leaves as the primary fodder source, while that the stems, though less palatable. The maximum yield of amaranth green mass (245.5 t/ha) and the yield of dry matter (62.5 t/ha) was obtained in the phase of wax maturity..

Nutritive value: A. caudatus is high in dietary fiber and minerals such as iron, magnesium and manganese. Its frequent consumption could help to reduce hypertension and cholesterol.

Palatability: While some livestock, notably horses, may show reluctance to consume *Amaranthus caudatus*, animals like goats, sheep, rabbits, and poultry generally find it palatable, especially in its young, leafy stage. Amaranthus caudatus leaves are rich in nutrients, including protein, vitamins, and minerals

Toxicity: It was concluded that the low concentration of saponins in amaranth seeds and their relatively low toxicity guarantee that amaranth-derived products create no significant hazard to the consumer.

Hey and Silage: Typically grass or legumes, that is cut, dried, and then stored for later use as animal feed. The nutritional composition of amaranth silage can include proteins, fibers, vitamins, and minerals.

Advantages of *Amaranthus Caudatus*

- High nutritional content, including proteins, vitamins, and minerals.
- *Amaranthus caudatus* is adaptable to various climates and soil conditions, making it a versatile and cosmopolitan plant.
- The plant has culinary versatility, with its seeds used in various recipes, including snacks, cereals, and as a breading on chicken or fish.
- Various parts of the plant have ethnomedicinal applications, contributing to potential health benefits, such as anti-diabetic and cardioprotective properties.
- Its cosmopolitan distribution allows for widespread cultivation and utilization in different regions, contributing to food security.
- In times of scarcity, the seeds of Amaranthus caudatus are considered a famine food in regions like Ethiopia.
- The plant has potential as a forage crop, producing a large amount of biomass with high protein content.
- Amaranthus caudatus requires little fertilization, contributing to its ease of cultivation.
- Once established, foxtail amaranth is drought-tolerant, providing resilience in varying environmental conditions.

Limitations of *Amaranthus Caudatus*

- In some regions, Amaranthus caudatus may exhibit invasive tendencies, competing with native vegetation.
- Certain species within the Amaranthus genus, including some varieties of A. caudatus, may be considered weeds in agricultural settings.
- Seed shattering during harvest can be a challenge, as it may result in loss of seeds and affect overall yield.
- Effective management practices are needed to control potential weediness and optimize cultivation practices.
- While the absence of saponins in the seeds is an advantage for consumption, it may limit certain industrial uses where saponins are desired.
- Seed yields of grain amaranths, including Amaranthus caudatus, can be variable, influenced by factors such as climate and cultivation practices.

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BROWN TOP MILLET – AN UNDERUTILIZED RARE MILLET

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Introduction

Brown top millet *(Urochloa ramosa)*) is small-seeded annual grass cultivated as grain crop, primarily on the marginal lands in dry areas in temperate, subtropical and tropical regions. It is increasingly receiving attention of the scientific community. The scientific literature based on brown top millet has been found scanty. According to the few studies available energy ranges from 338.0 kcal to 368.62 kcal. The, crude fiber and fat content of BTM is 71.32 gm, 8.06–16.08%,1.89 gm, respectively. Protein is between 11.64% and 10.72%. Brown top millet contains phytochemicals such as flavonoids, quinones, tannins, and resin. There is galore scope for development and standardization of value added products made from brown top millets such as ready to eat foods (cookies, bars, deserts, etc) and ready to cook foods (idli mix, poha, etc) in which the millet can be used in combination with other cereal grains. Thus, brown top millet holds great potential in alleviating food and nutrition insecurity. It has good nutritional value. It can be used for the prevention and management of several non-communicable diseases. In order to make this smart food popular among farmers and consumers, systematized studies in the field of agriculture, nutrition, toxicology, naturopathy and biomedical sciences need to be done and documented properly. From ancient times BTM has been used in many forms such as forage, staple food or in many traditional dishes. An e-repository can be made of the traditional Indian foods made from BTM to popularize its use among the younger generations (Figure 1).

Common name	Brown top millet
Scientific name	*Urochloa ramosa*
Chromosome no.	2n = 8
Origin	Africa
Family	Poaceae
Name of the inflorescences	Panicle
Duration of the crop	70-80 days

Fig. 1. ***Urochloa ramosa***

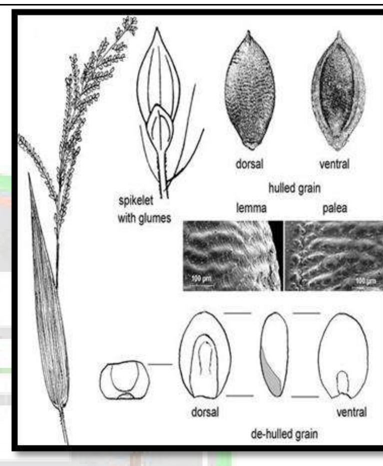

Fig. 2. Grains of *Urochloa ramosa*

Distribution

The domestication of brown top millet probably occurred in South India, in the Deccan, and it spread during prehistory outward to other parts of India. Charred grains identified as *"Brachiaria ramosa* type" have been recovered from most Neolithic South Indian sites where systematic archaeo-botanical work has occurred. On these sites brown top millet has a high ubiquity and relative frequency. Dating the time of domestication is complicated by the fact that little archaeobotanic work has been carried out on early Neolithic or preceramic period (Mesolithic sites); however, the evidence suggests that this crop, along with other South Indian crops (i.e., *Macrotyloma uniflorum*, *Vigna radiata* and *Setaria verticillata*), developed from indigenous wild populations around the beginning of the third millennium BCE. During this period, local millets and legumes were incorporated into an agro-pastoral system, part of the ash-mound culture of the southern Neolithic of India, which employed both mobile cattle pastoralism and small-scale crop cultivation. Brown top millet spread out from the Deccan to Tamil Nadu in the south and Gujarat in the north by the end of the second millennium BCE. Small quantities of the grain have also been found from Chalcolithic (late second–early first millennium BCE) sites in Odisha (Orissa) in the east and some sites in the Ganges plains, however, the number of grains recovered does not suggest cultivation and may represent wild plants. Over time, brown top millet has seen reduced use, although it was still present at the site of Paithan in Maharashtra up to the seventh century CE.

Its gradual reduction in use can be attributed to Brown Top Millet displacement by alternative, more productive millets, including the African millets (*Sorghum bicolor, Eleusine coracana*), as well as foxtail millet *(Setaria italica*) that probably contributed to this. Today brown top millet is a relict cultivar but one with some important ritual uses.

Cultivation practices

Browntop millet is drought-hardy and heat tolerant, but can also be planted in low areas that get flooded. The shadow tolerant nature of browntop millet makes it distinct from other crops. The shade loving crop grown often as cover crop well even under perennial trees Maximum cultivation happens in both the kharif & rabi seasons in areas that receive more than 800 mm of rainfall. The crop can be grown Sea level up to 8,000 ft

Land Preparation

Ploughing with a mould bould plough will help to plough soils deeply and to conserve moisture. Green manuring involved distributing dhanica seeds. To improve the soil's fertility and condition, a dhanicha crop was added after one month, also with 2 MT of FYM, which was spread

Seed Rate & Seed Treatment

The seeding rate for browntop millet will depend upon the seedling method. For line sown crop 4-5 kg/ ha and for broadcasting seed rate @ 10-12 kg/ha is recommended for the healthy stand and better yield. Treating the seeds with carbendazim or thiram @ of 2 g/kg before sowing is highly recommended to manage the seed borne diseases.

Varieties

BTV1/ 2/ 3/ 5/ 6/ 9/ 10 & 12 are the promising varieties of Brown top millet that gives assured yields under optimal conditions.

Soil

It grows best in sandy loam soils with a pH 5-6.5 under full sun. Browntop millet grows in rocky, shallow soils from It is adaptable to almost all upland soil, but does not grow well in water- restricted, droughty conditions.

Time and Method of sowing

Brown top millet can be planted from mid-April until mid-August in most locations, though later plantings will result in lower yields. Whereas, in rainfed conditions farmers sow seeds with the onset of monsoon. Recommended spacing is 45 X 15 cm. Plant population in rainfed conditions is 1.35 lakh/ha and in irrigated conditions is 1.5-1.8 lakh/ha.

Cropping System

Brown top millet + pulses in 4:1 row ratio is recommended cropping system for major growing areas of India.

Fertilizers and manures

Farm yard manure (FYM) should be incorporated @ 10 T/ ha one month before sowing will improve the yields significantly. The suggested fertilizer dosage per hectare is 40:20:20 kg of nitrogen, P205, and potassium. When planting, all of the fertilizer should be incorporated into the soil. After 25-30 DAS and if irrigation facilities are available, half of the nitrogen should be top dressed in standing crops.

Weed Management

To manage weeds, it is best to plant in a well-tillaged field, weed-free bed with narrow row spacing. Chemical weed control options are limited. Up to 25- 30 days after sowing, the field should remain weed- free. The weeds in the field of browntop millet can be controlled with just two weedings. In a line-sown crop, 4 weeding may be done using a hand or wheel hoe

Diseases/ Insect Pest & Management

Generally the diseases and insect pests infect the browntop millet are of lesser importance.

Water Management

Like other millets, irrigation is not necessary for browntop millet. However, if a prolonged dry spell occurs, 01-02 irrigations must be administered at the critical stages. It is always preferable to drain the field of extra water after a heavy storms.

Harvesting

Harvesting will be done at the physiological maturity. It is cut from the ground level with the help of sickles and stacked in the field for about a week before threshing. Threshing is done by trampling under the feet of bullocks. The grains should be dehusked before consumption.

Nutritional and health benefits

Millets have unique nutrient composition which is good for physical and mental health. They have high fiber and vitamin content, low simple carbohydrates. Brown top millet is high in nutrition and has high energy content; 100 grams of BTM contains 338 Kcal of energy, 71.32 g of carbohydrate, 8.98 g of protein, and 1.89 g of fat. It is a rich source of natural fiber i.e., Consumption of dietary fiber has long been associated with health benefits like bowel movement, and maintenance of normal blood cholesterol and glucose levels. Further, it is rich source of micro nutrients such as **iron, calcium, potassium, magnesium, zinc, phosphorus, and B group Vitamins**. Therefore, BTM may serve as budding grain for therapeutic diets. The fiber content i.e., 12.5 gm per 100 gram (Indian Institute of Millets Research (IIMR), 2022) and fiber helps to detoxify the body by removing the waste from the intestine. Millets have low glycemic index (GI). Because of the low GI, millets help in gradual increase in the post-prandial blood glucose levels. This is particularly helpful for patients suffering from impaired glucose tolerance as well as diabetes.

BTM contains good amount of minerals. It has significant levels of magnesium which is 94.5 mg/100 gm. Magnesium is a vital mineral which aid in increasing the efficiency of insulin and glucose receptors by supporting many carbohydrate digesting enzymes, which manages insulin action and it also helps to reduce the pressure on blood vessels (BTM is gluten free and an excellent choice for people suffering from celiac disease. BTM contain 276mg per 100 gm phosphorous. Phosphorous is involved in the structure of every cell in the body, forming the mineral matrix of bone essential component in molecule i.e., adenosine triphosphate (ATP).

Besides fiber and minerals, millets are also rich in health-promoting phytochemicals like polyphenols, liganins, phytosterols, phyto-oestrogens, phytocyanins, phenolic compounds, tannis and flavonoids like, anthocyanins, carotenoids, and tocopherols. They are natural antioxidant that protect the phospholipid membrane around heart, nerves, muscles, and red blood cells from the attack of free radicals and thus prevent carcinogenesis, and aging. Carotenoids are reported to prevent cardiovascular diseases like atherosclerosis, maintain normal functioning of immune system, and retina of eyes. These also function as, immune modulators and detoxifying agents. BTM being rich in secondary metabolites (phytochemicals) can help to reduce the risk for gastric ulcers and colon cancer.

Conclusion

The comparison of macronutrients and micronutrients of different millets and staple cereals with the browntop millet (in percent), BTM contains 8.98 gm/100 gm of protein which is higher than protein of rice, wheat, sorghum, Proso millet, finger millet, little millet, barnyard millet and Kodo millet. Fat content of BTM is 1.89 gm/100 gm which is much higher than fat content of rice, wheat and sorghum. 71.32 gm/100 gm is the carbohydrate content of BTM that is higher than wheat, sorghum, pearl millet, proso millet, finger millet, little millet, barnyard millet and foxtail millet. Crude fiber value of BTM is 8.06 gm/100gm which is higher than rice, prosomillet, littlemillet, foxtail millet and kodo millet. The energy value of BTM is 1414 kj/100 gm which is greater than energy value of wheat, sorghum, prosomillet, finger millet, barnyard millet and foxtail millet. Calcium content of BTM is 28 mg/100 gm which is higher than calcium content of rice, pearl millet, proso millet, little millet and barnyard millet. Iron content of BTM is 8.86 mg/100 gm which is higher than iron content of all the millets and staple cereal grains i.e., rice and wheat. So we can increase the production of the crop and increase the productivity and create the awareness of that millet and consume it we get good healthy life.

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ROLE OF EARTHWORM AS A REPLACEMENT FOR FISHMEAL IN AQUACULTURE

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Introduction

Aquaculture refers to the use of or in freshwater, seawater, brackish water, and inland saline water for the farming of aquatic organisms such as fish, crustaceans, molluscs and algae. Aquaculture is the highest-ranking food sector with an annual growth rate of 8.8 percent for the past 25 years. It is one of the fastest growing animal food sectors and provides over 13% of the animal protein for the human consumption. The aquaculture sector in India is expanding at a greater frequency, surmounting significant obstacles including disease outbreaks and pollution during its expansion. Feeding makes up the majority of the aquaculture farms' costs (approximately 60% of the total economic balance). Therefore, the cost of feed must be decreased while the effectiveness of its utilization must be raised. The primary and most expensive component of a shrimp diet is protein. As a result, research efforts have been focused on identifying efficient sources and optimal dietary levels. In shrimp, dietary protein is initially used to replenish tissue proteins lost during normal metabolism. If there is excess, it is next used to develop new tissue for growth and reproduction. Fishmeal, as well as other marine animal meals such as krill, shrimp, squid, and scallop waste are often included in aquatic diets as they are considered an excellent source of high-quality proteins, highly unsaturated fatty acids, minerals, and attractants. An another novel approach to replace fish meal is the supplementation of earth worm meal as it contains crude protein and crude lipid around 52% and 18% respectively. Because earthworm meal contains both required and non-essential amino acids, it actually improved the nutritional and health condition of cultured animals when added to their meals.

Earthworm

Earthworms are renowned for being "farmers friends" since they are essential in the process of turning organic waste and litter wastes into organic manure, which is the best kind of natural fertilizer for the soil because it adds nutrients. In the same way the earthworms can become best friend for “fish farmers” too if they are properly utilized. They serve as a good feed for the ornamental fish industry, acting as a best nutritional food for the brood stocks. They are also very easy to be produced with small capital rather than taking risks to collect some other worms as feed for the fishes. *Eisenia feti*da is one of the several earthworm species that can replace fish meal since it thrives in tropical climates. Normal reproduction for these species occurs in the temperature range of 20 to 29°C. This epigeics earthworm lives on soil surface and mainly feeds on plant litter and other organic debris. Consequently, these earthworms are the most suitable for converting the organic wastes into useful organic manures. This species are rich in amino acids and fatty acids such as omega 3. Some of the difficulties of the aquaculture are the unavailability, the poor nutritive quality and the expensive cost of fish meal. Yet, because of its nutritional quality and palatability properties, this feed stuff is still the main dietary protein source.

Eisenia fetida

Earthworm Meal and Its Importance

By employing earthworms as a feed element in supplement diets, farmers in rural regions may be able to participate in semi-intensive aquaculture through the integration of earthworm production (vermin culture) into small-scale farms in developing nations. Under laboratory conditions and without access to natural food resources, partial replacement of fish meal protein by earthworm protein in full feeds for common carp (*Cyprinus carpio*), Rohu (*Labeo rohita*) and tetra had a positive effect on growth performance while total replacements in feeds resulted in growth rates similar to those of fish on test diets that contained fish meal. However, in pond conditions, where fish also have access to naturally occurring food sources that are known to be of high nutritional value and contain high levels of protein and essential amino acids, it is unknown if completely replacing fishmeal with earthworm meal generated on the farm would be advantageous for growth. As an additional farming activity in integrated farming systems, earthworm production methods (vermin culture) are being introduced into rural areas of developing countries. Vermiculture accelerates nutrient cycling within the farms and generates additional financial benefit due to utilization of underutilized wastes and by products of low quality by producing a high qualitative feed resources for fish.

Earthworm Meal

Earthworm, a non-conventional protein source with 520-530 g protein kg^{-1} on dry matter basis was used in three forms viz.

1) Whole earthworm

2) Earthworm custard

3) Pelleted earthworm

As a result, three trial diets can be made at first, using earthworms in the three ways that are detailed below:

Whole earthworm diet

The whole earthworm (after 48h of fasting) were boiled with a pinch of common salt in water thoroughly washed with a clean and chopped into pieces (0.5mm size) using a sharp knife and stored in a refrigerator at 4ºc until use.

Earthworm custard

The earthworms were first boiled for 45 minutes in water with a pinch of common salt, followed by a thorough washing in clean water, and then ground using a household mixer grinder (Philips India Limited, Mumbai) to make earthworm custard. The required quantities of skimmed milk powder and hen's egg (yolk + albumin) were added to the ground earthworm and mixed thoroughly. A desired quantity of water was heated in a 1-L beaker to 80°C by using an electric heater and the required amount of gelatin was dissolved in to it with slow stirring. Once the gelatin had completely dissolved, it was mixed into the feed mixture. Then, using a kitchen mixer grinder, the mineral and vitamin combination was added, and the entire feed mix was thoroughly blended. After adding the necessary amount of lukewarm water to the feed mix and thoroughly blending it, a dough of feed mix was created. The dough was placed into an aluminum container and cooked with steam for 20 minutes using a home pressure cooker to produce a custard made of insects. After being allowed to cool to ambient temperature, the earthworm custard was refrigerated at 4°C until it was needed. The earthworm custard was collected and chopped into tiny (0.5 mm) pieces for the earthworms' daily feeding.

Pelleted earthworm

The earthworms were first cooked in water for 45 minutes while adding a pinch of common salt. They were then properly cleaned in clear water using the previously mentioned method in order to prepare the pelleted food. The earthworm meal was then made after it was oven-dried for 24 hours and ground into a powder using a household grinder. The required quantities of dried earthworm meal, fish meal, groundnut oil cake, prawn meal, mineral and vitamin mix and vegetable oil were mixed thoroughly using a kitchen mixer. Using an electric heater, the desired amount of water was heated to 80°C in a 1-liter beaker, and the necessary amount of gelatin was dissolved into it while stirring slowly. The gelatin was added to the feed mix when it had fully dissolved. The feed mix was combined with the necessary amount of warm water, well mixed, and formed into a dough. To create feed pellets with a diameter of 2 mm, the dough was run through a hand pelletizer. The pellets were dried at 60°C and stored in a refrigerator at 4°C until use.

Conclusion

The present studies indicate that the earthworm species had almost similar nutrional values to that of the fish meal, and thus it would be a potential source of animal protein in supplementing fish meal. Naturally, the organically produced fish will have a high demand among all section of consumers. There are several ways for the marketing of organically produced food as it claims a high demand among the people. The farmers are to be given awareness about the importance of earthworm meal as a supplement of the fish meal to augment their production at the low cost. In an implication, year round production of this earthworm species through standard mass culture system, and its radical use could play a pivotal role in the sustainable fisheries and aquaculture production.

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WATER POLLUTION WITH REFERENCE TO AQUATIC FAUNA

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Abstract

Freshwater is a crucial natural resource that use for a variety of daily activities, including drinking and numerous developmental goals. The natural environment becomes unstable when pollution levels rise, causing harm to the ecosystem's living beings and physical processes. Toxic substances released into the aquatic ecosystem from polluted water bodies include insecticides, pesticides, heavy metals, mill waste, and crude oil. Water is an all-purpose ion solvent that is essential for cellular signalling, enzyme activation and the mineralization of organic molecules. Acute and chronic impacts of water pollution include suppression of the immune system, slowed metabolism, damage to the fish species gills, and epithelial layer. Fin rot, tail rot, gill illness, damage to hepatic tissues, and ulceration are a few of the ailments brought on by the pollution. This article tries to review the multiple effects of the water pollution has on the environment and the health of different fish species.

Keywords: water pollution, environmental impacts, immune suppression, gill damage, fish diseases

Introduction

The most valuable resource on planet is water. One oxygen atom, two hydrogen atoms, and two shared electrons make up the molecule of water. Being a polar V-shaped molecule, it was positively charged near the hydrogen atoms and negatively charged near the oxygen atom. Earth is made up of two thirds water and one third lands. The earth contains both fresh and salt water.

Only 2.7% of the water on earth is fresh, with salinity making up roughly 97.3%. Rivers, streams, ponds, and lakes all contain fresh water. Water is a vital natural resource utilised for drinking and other developmental functions. It also plays a significant part in the recycling of nutrients. Typically, aquatic systems are used to remove and reuse sewage and hazardous waste, as well as to drain off any overflow into the ocean. Significantly less of their assimilative volume results from the overuse of water resources for various developmental activities, such as agriculture, construction, industrial processes, and thermal power plants to meet the needs of the large population, as a result of the rise in pollution levels. Fish perish as a result of pesticide pollution in the water from fields adjacent to agriculture. Pesticides that are released into the environment endanger aquatic life.

Sources of Water Pollution

Pure water does not occur in nature. It contains-natural and manmade impurities. Natural impurities are not essentially dangerous, but human activities are serious cause of water pollution. Water pollution reduces the ability of the body of water to provide the eco-system services. Water pollution results when contaminants are introduced into the natural environment. Mainly two main sources of water pollution are-

1. Point sources - It includes factories, waste water treatment facilities, septic systems and other sources that are discharging pollutants into water sources.

2. Non-point sources - Non-point sources are more difficult to identify because they cannot be traced back to a particular location. It includes run off sediment, fertilizer, chemical and animal wastes from farms, fields, construction sites and mines.

Types of water pollution

a.Marine Pollution

Marine pollution occurs when harmful effects result from the entry into the ocean of chemicals, particles, industrial, agricultural and residential waste, noise, or the spread of invasive organisms. For instance, fertilizers used by farmers in the field are gradually washed into surrounding surface waters or groundwater by rain, which contaminates the water body. Many particles combine chemically in a manner highly depletive of oxygen, causing estuaries to become anoxic. Pesticides readily enter marine food webs after being introduced to the marine ecology. These pesticides can cause mutations and diseases once they enter food webs, which can be hazardous to humans and the entire food chain.

b.Groundwater Pollution

Complex interactions exist between surface water and groundwater. Because of this, groundwater pollution, which is also known as groundwater contamination, is more difficult to categorise than surface water pollution. Groundwater aquifers are by their very nature prone to contamination from sources that might not directly impact surface water bodies. In some circumstances, the distinction between point and non-point sources may not matter. The analysis of groundwater contamination may concentrate on the geology, hydrology, hydrogeology, and hydrology of the location as well as the nature of the contaminants.

c.Surface Water Pollution

Our oceans, lakes, rivers, and all the other blue areas on the world map are made up of surface water, which makes up about 70% of the earth. More over 60% of the water distributed to American houses is surface water from freshwater sources, meaning sources other than the ocean. But a sizable portion of that water is in danger. Although these nutrients are necessary for plants and animals to develop, farm waste and fertiliser runoff have turned them into a significant contaminant. Toxins are also contributed by the discharge of municipal and industrial garbage.

d.River Water Pollution

Most of the Indian rivers and their tributaries viz., Ganges, Yamuna, Godavari, Krishna, Sone, Cauvery Damodar and Brahmaputra are reported to be grossly polluted due to discharge of untreated sewage disposal and industrial effluents directly into the rivers (Agrawal *et al*., 2010). Identically Yamuna is another major river, has also been threatened with pollution in Delhi and Ghaziabad area. Approximately 515,000 kilolitres of sewage waste water is re-ported to be discharged in the river Yamuna daily. In addition, there are about 1,500 medium and small Indus- trial units which also contribute huge amounts of untreated or partially treated effluent to the river Yamuna every day. According to a report, over 32 thousand dead bodies were cremated at the major burning Ghats per year in Varanasi alone in the year 1984.

Impact of pollutants on the aquatic fauna

1.Impact on Marine mammals

Marine animals include bottlenose dolphins, fins, humpback whales, sperm whales, rights, sei whales, manatees, cetaceans, seals, sea otters, and pinnipeds. Because they rely on their outer coats for buoyancy and warmth, furred mammals are negatively impacted by the direct contact of oil with them. As a result, "Oil flattens and adheres to the outer layer, causing these animals to drown and suffocate frequently.

2.Biological effects on fish

Pollutants might effect a given population without being lethal to adult organisms in many ways.

a. Migration

Mechanism used for orientation and navigation by migrating organisms is not well known, but in some cases chemo-toxicants clearly plays an important role. Sub-lethal concentration of pollutants may interfere with the normal migration pattern of organisms thereby change the composition of population or species diversity. Pollution has kept salmon, trout, and many other anadromous fish out of their native streams, but it's unclear if this is because a chemical cue has been obscured or because the fish don't like the general chemical environment of pollution. On the other hand, heavy siltation and flow of heated coolant water may block migratory channels and long distance migratory fishes during some phases of their life history may be adversely affected by highly localized pollution of river .

b. Incidence of diseases

A long-term exposure of sub lethal concentration of pollutants may make an organism more susceptible to a disease. It is possible that some organic pollutants will provide an environment suitable for the development of disease producing bacteria and viruses. In such case, even though the pollutant is not directly toxic to the adult organism, it could still have a profound effect on the population of the species over a longer period.

c. Behaviour

Much of the day-to-day behaviour of a species may also be mediated by means of chemo-toxic responses. The finding and capture of food and the search for a mate during the breeding season are included in this category of activity, and again any pollutant interfering with the chemo-receptors of the organism would interfere with the behavioural patterns essential to a survival of the population.

d. Physiological Processes

Pollutant may interfere with various physiological processes without necessarily causing death, which may interfere in the survival of a species. DDT depresses photosynthesis in planktonic algae, but only at concentrations greater than its solubility in water. Respiration might also be adversely affected, as could various other enzymatic processes. The toxic substances and suspended sediments when injure the mucous membrane of the gills effects the respiration. Heavy metals particularly mercury inhibit the activities of digestive enzymes but it has most damaging effect on the nervous system.

e. Life cycle:

The larval forms of many species are much was sensitive to pollution than the adults. In many aquatic species millions of eggs are produced and fertilized but only two of the larval produced need to grow to maturity and breed in order to maintain the standing stock of the species. For these species, the pre-adult mortalities rate is enormous even under the best of natural conditions. An additional stress on the developing organisms might cause failure of enough individual to survive and maintain the population of the species. Interrupting any stage of the life cycle can be as disastrous for the population as death of the adults from acute toxicity of the environment.

Ex: Silt sedimentation, eutrophication and increased pollution level had affected fish stock in many Indian rivers by spectacular mass mortalities.

3.Effects of pollution on eggs, spawn, fry on breeding grounds and feeding grounds

Effects on fish eggs; spawn and fry

Fish eggs are much more resistant than the adult fish. Toxicity thresholds for lead, zinc and nickel is about 20, 40 and 2000 ppm respectively, values are higher than those found for adult animal. Eggs would develop normally between pH 4 to 5 on the acid side and 8 to 9 on the alkaline side. In water more acid than pH 4.0, the eggs displayed exosmosis and collapsed. Water more alkaline than pH 9.0 there was endosmosis, the eggs swelled and yolk became white. The critical oxygen tensions are about 40 mm Hg for newly fertilized eggs and rises, as the embryo develops, to about 100 mg Hg (about 60% saturation) at the time of hatching.

4.Survival of larval fish fry and fingerlings

(a) Food acquisition:

Larval fish is able to feed only on the tiniest of zooplankton and phytoplankton, thus early growth and survival of fish depends upon the densities of small cladocerans and rotifers and phytoplankton. Aquatic pollution is toxic to this plankton and poses threat to survival of fish fry.

(b) Predation

Survival of larval fish is probably influenced more by predation than by feeding. These very small fish are vulnerable to virtually every other predator. Not only visual feeding fish but also other predators such as predaceous copepods may have considerable influence on larval fish densities. Protective cover, such as aquatic macrophytes must be especially critical in minimizing fish predation on small fish. Reducing or lowering the water level (due to siltation) below the vegetative zone would seem to be especially disastrous to larval fish. Structural complexity, especially aquatic vegetation, while providing refuge for larval and fingerlings fish, may reduce the ability of piscivorous fish to feed on small fish. Fry and fingerlings are more susceptible to pollution than adult fish. Resistance to pollution: Egg> Adult>Larvae.

5.Respiratory Changes

Amongst other alterations dichlorvos induces respiratory distress and calmness and spontaneous air gulping at different rates in *Clarias gariepinus* fingerlings and juveniles at (250, 275, 300 and 325µg/L) and (400, 450, 500 and 600µg/L) respectively.*Oreochromis niloticus* was shown to exhibit dose-dependent tail fin beats, with beats/m decreasing with increasing toxicant concentration, while *Ctenopharyngodon idella* exposed to lethal (13.1mg/L) and sub-lethal (1.31mg/L) concentrations of nuvan showed a decrease in oxygen consumption in a 24h static bioassay.

6.Reproductive Changes

In a 4-week chronic exposure test, the fish *Pimephales promelas* (a fathead minnow) was exposed to various concentrations of fluoxetine (from 100ng/L to 100g/L), and these exposures significantly altered mating behaviour (primarily the ability to escape from predators in both male and female as well as defending and nest building in males). In *Danio rerio* larvae and embryos exposed to various doses of DDVP for 96 hours, developmental problems such as delayed hatching, no blood flow, vertebral malfunctions, and cardiac edoema. After subjecting the fathead minnow fish *Pimephales promelas* to clofibric acid, alterations in the sperm motility and variations in plasma testosterone concentration were observed. After exposure to sublethal levels of nuvan, histopathological alterations in the liver of *Channa punctatus* were recorded.

7.Mortality

Although the deadly effects of aquatic pollution on biota are widely known, a famous example that illustrates the potential severity of such effects is the Exxon Valdez Oil Spill, which released approximately 11 million gallons of crude oil into the ocean on March 24, 1989. It was impossible to quantify the damage done to the planktonic, benthic, and other fishing populations. According to the Exxon Valdez Oil Spill Trustee Council's report (EVOSTC 2006:6), only 8 out of the 22 species had fully recovered as of 2006. Similar to this, Pounds et al. (2008) observed that exposure to ibuprofen from sewage treatment plant influent at LC50 resulted in mortality after 96 hours in the fish O. latipes.

Water Pollution—Related Legislation

The first significant law regarding the protection of environmental resources appeared in the 1970's with the setting up of a National Committee on Environmental Planning and Coordination, and the enactment of the Wildlife Protection Act, 1972. Since then, three main texts have been passed at the central level that is relevant to water pollution: the Water (Prevention and Control of Pollution) Act, 1974, the Water (Prevention and Control of Pollution) Cess Act, 1977 and the Environment (Protection) Act (1986). The Water Act 1974 established the Pollution Control Boards at the central and state level. The Water Cess Act 1977 provided the Pollution Control Boards with a funding tool, enabling them to charge the water user with a cess designed as a financial support for the board's activities. The Environment Protection Act 1986 is an umbrella legislation providing a single focus in the country for the protection of environment and seeks to plug the loopholes of earlier legislation relating to environment. The law prohibits the pollution of water bodies and requires any potentially polluting activity to get the consent of the local SPCB before being started (Agrawal *et al.*, 2010).

1. The water (prevention and control of pollution) Act, 1974
2. The water (prevention and control of pollution) Rules, 1975
3. The water (prevention and control of pollution Cess) Act, 1978
4. The Environment (protection) Act, 1986.

Conclusion

Diverse pollutants and toxins infiltrate the aquatic ecosystem, impacting the water quality and causing disruptions to aquatic creatures' life cycles. Some contaminants have a strong tendency to harm aquatic animals in ways that are both morphological and metabolic. However, there is insufficient proof that water contaminants and impurities are actually to blame for the spread of disease in aquatic creatures. Therefore, it is crucial to develop some strategies using molecular biology methods that will modernise affordable toxicological bids and do not require aquatic animals to detect ecological stressors. It is crucial to prove that all pollutants have significant fatal and sub-lethal impacts on aquatic organisms. More research is needed to determine the concentration level and exposure time of all pollutants.

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FONIO MILLET- AN UNDERUTILIZED RARE MILLET

Article ID: AG-VO4-I03-31

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Introduction

Fonio millet (also called Acha / Findi / Iburura / Hungry millet / Hungry rice/ Crab grass millet), botanically called *Digitaria* spp with 2n= 28,34, 36 & 54, belonging to family Poaceae, subfamily Panicoideae is the one of the oldest cereal crops domesticated by farmers in West Africa. Its cultivation seems to have started about 7000 years ago. It is one of the world's fastest maturing cereals. It is staple food in some parts of Africa, like in regions of Mali, Burkina Faso, Guinea and Nigeria. It is also known as "Grain of life" to eliminate hunger. It is tiniest grain in the millet family, The fonio genome shows a systemic relationship with the genome of foxtail millet. It is often considered to be one of the nine millet species. Unlike other cereals, there has not been a big expansion of crop acreage, as fonio has been considered a secondary crop in most countries where it is grown.

Origin and Wild Relatives

Origin: West Africa

Species	Wild relatives	Authors	Characteristics
D. exilis	*D. longiflora**	Stapf (1915)	Annual and aggressive weed, widely distributed in the tropics, well found in West Africa.
	D. barbinodis	Henrard (1950)	Annual, tropical Africa; present in

	D. fuscescens	Henrard (1950)	fonio fields in Nigeria, Togo. Same section but rather closed to *D. longiflora.*
D. iburua	*D. ternata**	Stapf (1915)	Annual and aggressive weed, hot regions of Africa and Asia.
	D. barbinodis	Porteres (1956)	Annual and aggressive weed, hot regions of Africa and Asia.
	D. tricostulata	Henrad (1950)	Botanically closed, but different geographical areas (North Kenya, South Africa).
	D. atrofusca	Haq & Ogbe (1995)	Botanically closed but geographically more remote from the areas of diversity of the crops.

*Most probable progenitors

Cultivated Species

1. ***Digitaria exilis*** (White fonio) – 2n: 36
2. *Digitaria iburua* (Black fonio) – 2n: 36
3. *Digitaria sanguinalis* (Euro- pean millet or red manna) – 2n: 28, 34, 36 & 54
4. *Digitaria cruciata* (Raishan) – 2n: 38 (grown in India)

Fonio seeds germinate one week after planting. Fonio can be grouped into several types of varieties:

- Very early varieties with a 70–90-day life cycle
- Early varieties with a 90–110-day life cycle
- Intermediary varieties with a 110-130-day life cycle; and
- Late varieties with a lifecycle of more than 130 days.

Botanical Description of Fonio Millet

Habitat: Fonio is tolerant to soil stress and seasonal droughts. It is grown on the plains as well as in mountains, i.e., under annual rainfalls from 400 to 3000 mm. It is able to grown on poor, shallow, sandy or rocky soils, where other cereals cannot grow. It thrives in rainy seasons only if the soil has good drainage. Fonio is also less sensitive to pest damage and less vulnerable to disease.

Habit:

Fonio is a small annual herbaceous C4 plant, which produces very small (∼1 mm) grains that are tightly surrounded by a husk. Plants grow about 40- 50 cm tall.

Roots:

The roots are well developed and attached firmly with soil with many fine roots and abundant lateral rooting. The particular size of this root system, which can extend down to more than one meter depth, helps explain the good behaviour of the plant during periods of drought and its adaptation to poor soils, which it exploits efficiently.

Stem:

The stubble, cylindrical and hollow, is very fine (less than 1 mm in diameter), and on maturity the stems lie on the soil. Fonio millet has good tillering (2 to 6 tillers or more for late varieties)

Leaves:

The leaves are blade like or linear and tapering and can reach up to 15 cm length.

Inflorescence:

The single inflorescence possesses 2-5 racemes with spikelets arranged in pairs or in threes or fours giving it lacy appearance of 5-12.5 cm length. Flowering starts about 6 to 8 weeks after emergence.

Spikelets: The plant produces spikelets where the grain is produced on branched spike like panicles.

Florets: The spikelet contains two bisexual florets with the lower unfertile whilst the upper is fertile having three stamens with yellowish anthers, two lodicules and a pink or purplish stigma.

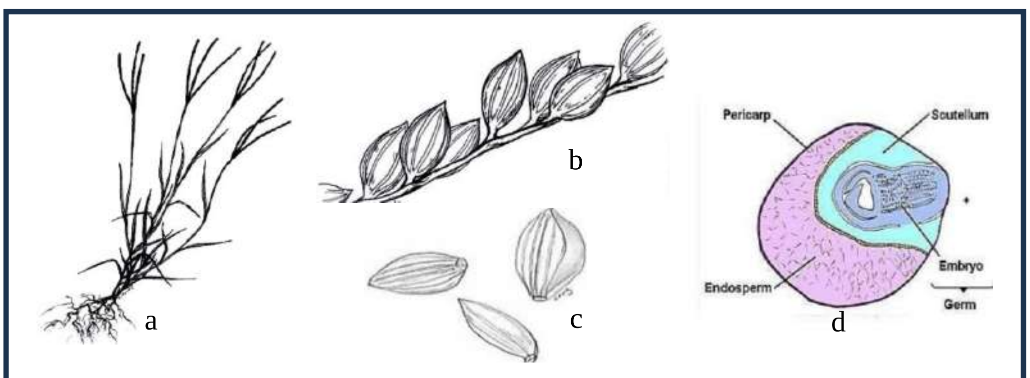

Fig 1. (a) Fonio plant; (b) Raceme portion; (c) Raw fonio grain; (d) Schematic cross section of fonio caryopsis (Ezekiel et al., 2012)

Fig 2. Inflorescence off fonio millet and its components. (A) fonio plant in the field; (B) inflorescence; (C) spikelet; (D) outer glume; (E) lemma; (F) ovary; (G) palea; (H) grain enclosed in lemma and palea; (I) grain; (J) spikelet cluster; (K) matured spikelet (Abrouk et al, 2020)

Fig 3. Grains of maize, wheat, rice and fonio (from left to right) – grain size comparison (Abrouk et al, 2020)

Fruit:

The fruit caryopsis is tightly enclosed within two brown husks (lemma and palea). In *D. iburua*, the husks are intensively dark brown (black fonio) and in contrast to *D. exilis* known as white fonio.

Pollination: Self - pollinated flower (cleistogamous nature).

Harvest and Yield

The grains are ready to harvest between 60 and 120 days after emergence. The plants are usually harvested with a knife or a sickle, tied into sheaves, dried and stored under cover.

Some variety of grain matures so quickly – in just six or eight weeks during the rainy season so that they are ready to eat long before other staple grains. It also shatters at maturity and if it is not harvested in time 10-30% of grains can be lost. The grains are small and the individual grain weight is 0.5-0.6 mg. The grain yield varies from 600-800 kg/ha, but have reached over 1000 kg/ha. However, poor yields can only yield 150-200 kg/ha are obtained with poor weeding.

Post Harvest

The grains of fonio are difficult to process. Because it is so small, which makes it difficult to remove from the chaff. Traditionally, fonio sheaves are threshed by beating or trampling and the grains are dehulled in holes (made in the soil) or in a mortar, a difficult and time-consuming process. With the traditional husking methods, some sand remains with the grain which is partially removed by a long process of cleaning in water before cooking.

Processing

To increase the market value of fonio, farmers can process fonio at home by:

Packaging: Package precooked and dried fonio for sale

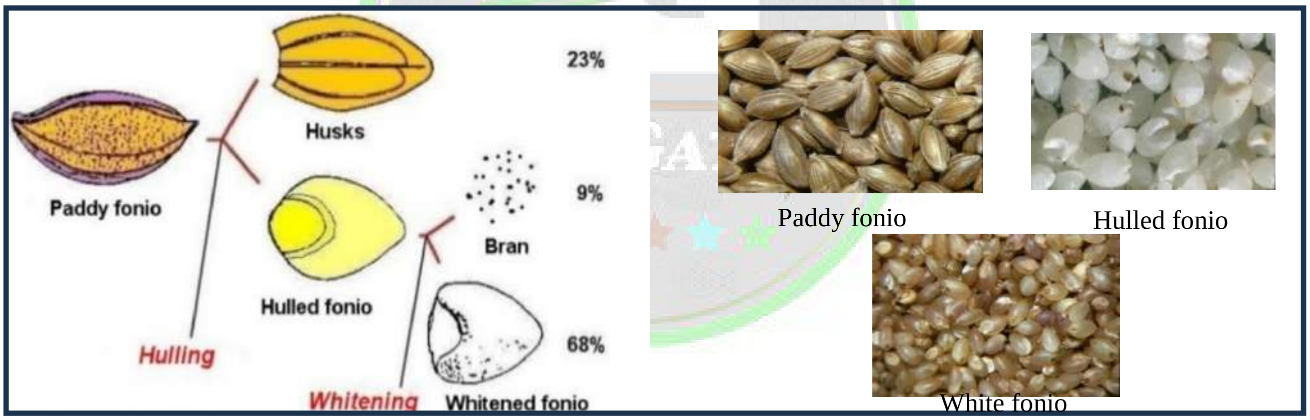

Fig 4. Processing of fonio millet (Zan Ibrahima, 2019)

Hulling/ dehusking:

Remove the outer coating of fonio grains (“raw” or “paddy fonio”) with pestle and mortar.

Whitening: Remove the fonio germ and fruit wall (pericarp) from the grains.

Washing: Wash whitened fonio to remove impurities such as sand.

Pre-cooking: After washing, precook by steaming.

Drying: Dry moist, precooked fonio.

CHEMICAL COMPOSITION

Carbohydrates	67-91%
Protein	9-12%
Crude fiber	0.4-11.3%
Ash	1-6%
Vitamins	0.05-3%

The grain is also rich in phytochemicals including phytic acid, which is believed to lower cholesterol and phytate which is associated with reduced cancer risk.

USES

- Because of its high methionine content, it is used to feed ruminant livestock like cattle, sheep, goats and others, which can efficiently digest it.
- The crop can also be grown for hay and used to build houses or walls and can provide heat for cooking or ash for potash.
- It also plays a critical role for food and nutrition security for several millions of people in African region, especially due to short time life cycle.
- Besides, its grain is nutritiously valuable due to the presence of two human-vital amino acids methionine and cysteine, which are absent in other staple food cereals such as wheat, rice, maize or sorghum.
- Some antithyroid properties have been reported due to high flavonoid content in the crude fonio grain.
- The grains are poor in gluten and beneficial for people suffering from coeliac disease and overweight people, pregnant and breast-feeding women, as well as diabetic people.
- The husked grain of white fonio has been shown to contain 8% protein and in black fonio 11.8% protein.
- Fonio also has low sugar content and low glycemic index which ensures less fluctuations in blood glucose and insulin levels, providing beneficial protection against diabetes.
- It is also rich in iron with 8.5 mg per serving, meeting at least half of the daily requirement.
- In West Africa, fonio is traditionally cooked as couscous, made into porridge and included in local beverages.

- Like other grains, it can be milled into a flour and used in baked goods, such as bread, cookies and cakes.

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DRAGON'S EYE FRUIT – LONGAN : LITTLE BROTHER OF LITCHI

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Introduction

Longan (*Dimocarpus longan*) belongs to Sapindaceae family is a close relative of litchi, accepted by consumers over the world due to its sweet and juicy sensation in the mouth and health benefits. This fruit is similar to litchi and is being referred as 'little brother of litchi' and also known as 'Dragon's eye' fruit because it resembles an eyeball when its fruit is shelled. Longan originated in subtropical China or possibly in area between Myanmar and India (Menzel *et al*., 2002). The Sapindaceae family contains more than 1,000 species from 125 genera, mostly trees and shrubs, but rarely herbs and with wide distribution in the tropics and warm subtropics.

The majority of species are native to Asia although there are a few in South America, Africa and Australia. Other popular cultivated species from Sapindaceae family with economic importance are litchi (*Litchi chinensis*), rambutan (*Nephelium lappaceum*) and pulasan (*Nephelium mutabile*). Longan is a medium to large (10 to 20 m tall) evergreen tree with dense canopy, brittle wood and corky bark which splits and peels. Tree shape mainly depends on the cultivar, varying from erect to spreading. The compound leaves are arranged alternately on the branches. The young flushes are red-brown in colour changing to light green with maturity.

Longan grow and crop satisfactorily in a range of tropical and subtropical countries, but are exploited commercially only in China, Taiwan and Thailand. The best growth and cropping of longan are achieved on deep, well drained, fertile soils with a pH of 5.5 to 6.0 and low salinity. Also it does well in areas with short, cool, frost free winter and long, hot, humid and wet summer. Temperatures of 14 - 15°C and rainfall of 40 – 50 mm were favourable for flower bud differentiation. Temperatures of 22 - 24°C were found to be best for flowering. Longans are sensitive to wind damage. Strong cyclonic winds cause branch splitting, fruit fall and total tree loss. Persistent cold winds may retard vegetative growth, while hot dry winds cause the flowers to dry out and fruits to shed prematurely.

Longan can be readily propagated by seed. However, most seedlings do not bear upto 7-8 years and often have biennial bearing, small fruit, poor flesh recovery, poor eating quality and low market returns. The preferred method of vegetative propagation in longan is air-layering. Air layers are removed after two to four months, when the roots have turned from white to creamy brown. Plants should be established in nursery bags or pots under warm humid and partial shade conditions which become ready for planting after 6 to 12 months. Also inarching, whip and tougue grafting, forkert budding and cutting are possible.

In Southern China there are over 300 to 400 longan cultivars out of which about 30 to 40 are cultivated commercially. Different genotypes vary with respect to tree size, shape and canopy density, leaf size, colour and arrangement, bark characteristics, fruit yielding ability, disease and wind resistance, fruit size, pulp recovery and eating quality. Fu Yan is the most important cultivar which yields large fruit of 18g with thin skin, small seed and thick crisp pulp. Other choicest varieties for postharvest processing in Asia- pacific region are Wu Yuan (canning), She pi (largest fruit), Kohala (large fruit, small seed, aromatic flesh), Chuliang (drying purpose), Shixia (crisp flesh, high TSS), Fuyan (canning), Daw (early-maturing cultivar), Chompoo (pink colored, sweetish, aromatic), Biew Khiew (thick skinned longer shelf life), Fengko (yellow fleshed), and 'Kohala' (high aril recovery).

Longan trees produced from seedlings can grow upto 12-18m which causes great difficulty in harvesting and tree management. Pruning produced well formed tree crowns, strengthens fruit bearing branches, ensures annual cropping and limits insect, pests and diseases. Fruit thinning is also practiced to increase the fruit size as only large fruits (2.5 cm in diameter or 18 g in weight) attract a premium price and to reduce biennial bearing. It is done four to six weeks after fruit set when they are of pea size.

Longan fruit are non-climacteric, and will not continue to ripen once removed from the tree. Maturity can be determined by fruit weight, skin colour, flesh sugar concentration, flesh acid concentration, sugar : acid ratio, flavour and/or days from anthesis. The fruits of longan resemble with that of litchi in structure, but are smaller, smoother and yellow tan to brown in colour. Fruits are also milder in flavour and less acidic. People in China and Thailand relish longan like litchi and therefore, it is more popular in these countries.

Composition of longan fruit

Composition	**Content (per 100g)**
Moisture (%)	72.4
Protein (g)	1.0
Fat (g)	0.5
Carbohydrate (g)	25.2
Fibre (g)	0.4
Ca (mg)	2.0
P (mg)	6.0
Fe (mg)	0.3
Vitamin A (IU)	28.0

Vitamin B_1 (mg)	0.04
Vitamin B_2 (mg)	0.07
Niacin (mg)	0.6
Vitamin C (mg)	8.0

Fruits are small (about 1.5 to 3.0 cm in diameter), globose to round shaped sometimes with distinctive shoulders. Fruit skin is thin, lethery and changes in colour from green yellow to yellow brown with advancing maturity. The aril (flesh) constitutes 60 to 70 percent of the total fruit weight is translucent white to off-white in colour, sometimes with a pinkish tinge and ranges in texture from juicy to very crisp and flavour from blend to sweet and aromatic. Seeds are glossy red brown, dark brown to black in colour, small, round to ovoid in shape and easily separated from the flesh.

Fruits are harvested by removing the whole cluster along with one or two leaves. Removal of too much leaf and wood with the fruit panicles at the time of harvest will reduce flowering in the next season. Unlike litchi, longan fruits do not separate from the fruit stalk easily without the loss of some skin. This could hasten breakdown of the fruit after harvest. Longan fruits consequently do not look as attractive as litchi in punnets. It has been suggested than longan fruits should be marketed attached to the fruit stalk in bunches of about 15 to 20 fruits.

Longan fruits deteriorate rapidly once harvested and has a quite short shelf life under normal ambient conditions due to peel browning and fruit decay. As the colour loss and quality deterioration seriously reduce its commercial value, these have been considered the main post harvest problems. Proper storage is very important for this crop to extend shelf life for few days. Longan is subjected to hydro cooling or forced air cooling which leads to longer storage period when coupled with low temperature during storage. In general, longan fruit can be stored at 1-5°C for about 30 days depending on cultivars.

Longans can be eaten fresh, dried or quick frozen. The fruits can be peeled, pitted and canned. Canned longans are more acceptable than canned litchi. Flavour and sweetness are normally correlated in longan fruits. The juice of most of the cultivars are sufficiently sweet and can be processed into various beverages without adding sugar. Fresh or processed fruit can be used alone or with other fruits in tropical fruit salads. Sweet fruits are best used for drying whereas fruits with lower sugar content are preferred for canning. Dried longan is one of the main exportable items of Thailand where it is grown commercially. In India, it is still under utilized.

Apart from the commercial postharvest use, there are several household uses of this fruit. An alcohol is made from longan by macerating it and is known as Liqueur (Koslanund *et al*., 2008). Also the fruit of *Dimocarpus longan* was used as a traditional Chinese medicine for different treatments, such as promoting blood metabolism, soothing nerves, and relieving insomnia (Rangkadilok *et al*., 2005). The seed of longan is also used as shampoo due to the high content of saponin which serves as a styptic. The dried leaves and flower of longan contain quercetin which is anti-cancerous in nature. A decoction of the dried flesh is taken as a tonic and for the treatment for insomnia and neurasthenic neurosis.

Selection of recommended cultivars and proper postharvest management is a must for high returns from this crop. Postharvest management of this crop not only enhances its production and export in the Asia pacific region but it will also ensure good returns to the growers.

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JOB'S TEAR OR ADLAY MILLET (*COIX LACRYMA-JOBI*)- THE RARE MILLET

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Introduction

Job's tears a cultigen of great antiquity is grown in South Asia mainly by the natives of various ethnic groups of Mongolian origin. a crop closed related to maize *(Zea mays L.)* and sorghum *(Sorghum bicolor L.)*, The plant is used as a minor cereal and fodder. The northeastern region of lndia is a centre of variability for the genus *Coix*. It is considered that this plant was introduced here either by the pestoral Aryan invaders, who grew it on the slopes of the Himalayas or during Mongolian conquests when the crop got distributed from the eastern Himalayas to lower subtropical terrains. During plant explorations conducted since 1970 in the northeastern region of India, much variability has been recorded for this crop. The various soft-shelled races now grown in this tract by the tribes are the result of conscious folk domestication and must have been selected for easy hulling and good kernel type.

Food diversity can be divided into two types: simple food diversity and complex food diversity. Simple food diversity is the consumption of carbohydrates not only from one source, while complex food diversity is when food comes not only from carbohydrate sources but also based on protein, fat, or fiber sources. Many countries has the potential plant to develop healthy food sources that can be used as an option for diversification; one of the potential cereal crops that can be created is job's tears or adlay millet. Job tears have nutrients equivalent to rice and contain essential amino acids and vitamin E, which are beneficial as antioxidants and increase the body's immunity.Job's tears are divided into two types, consisting of the cultivated type (var. Ma Yuen) and the wild type. Var. Ma Yuen has a thinner epicarp and is easier to break, therefore making it easier to process as a food source. This type also has a slight variation, including rice job's tears and waxy job's tears.Meanwhile, wild species (var. *Stenocardia*, var. *Moniliform*, etc.) are frequently considered weeds because they are straightforward to grow wildly.

This type has an epicarp that is very hard, like a stone, difficult to break,but it can still be consumed.Grouping the morphological characterization of job tears found in 11 provinces in China, by their seed color (six accessions were grouped in brown-seeded job’s tears, and five accessions were grouped in whitish-yellow seeded job's tears); based on the hardness of the seed (two accessions of tough seeds, four accessions with medium seed hardness, and five accessions with low seed hardness); based on kernel color (four accessions with a brownish-red kernel and six yellow accessions); based on seed size (two large-sized accessions, six medium-sized accessions, and three small-sized accessions) showed that they were greatly influenced by genetic and environmental factors(Figure 1).

BOTANICAL DESCRIPTION:

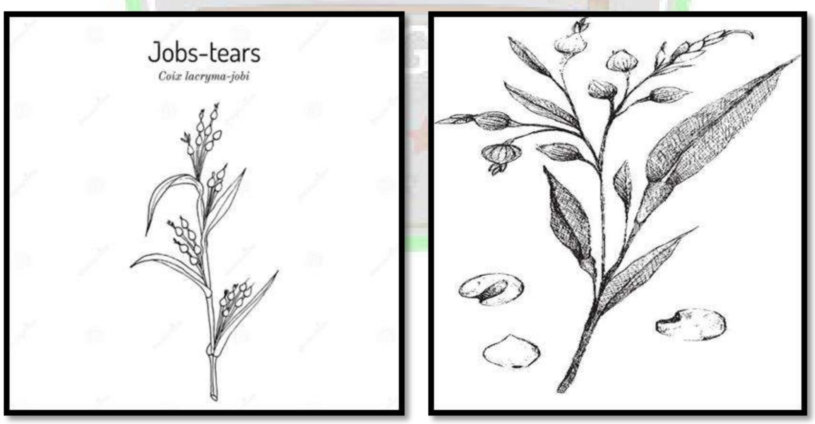


Fig 1. *Coix lacryma-jobi*

Common Name: Job’s tear ,Adlay millet

Scientific Name: *Coix lacryma-jobi*

Family: Poaceae

Chromosome Number:2n = 10,20 & 30

Origin: Tropical/subtropical regions of Asia and Africa.

Producing countries -India, Burma,China and Malaysia

Distribution: Meghalaya,Mizoram, Manipur, Nagaland and Arunachal Pradesh (Figure 2).

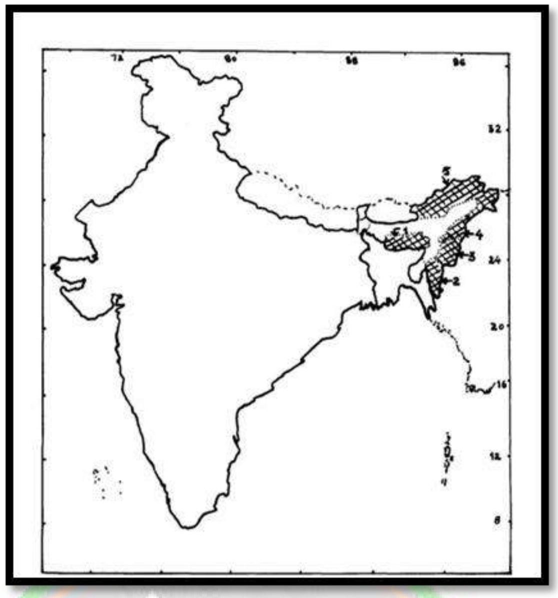


Fig 2. 1. Meghalaya, 2. Mizoram, 3. Manipur,4. Nagaland & 5. Arunachal Pradesh

Etymology:

The genus "*Coix*" is the Latin version of a Greek name for the Egyptian palm *Hyphaene thebaica.* The species epithet "*lacryma-jobi*" means Job's tears which is a common name of this plant. The reference is to the teardrop shape of the dried fruits. Job was a man in the Bible who lived a righteous life, but suffered much hardship.

Habitat:

Occurs in swamps, forest edges, lowlands, ditches and on stream banks. It is typically found in hot climates with moist soil.

Habit:

Perennial grass in tropical & sub-tropical regions.

Leaves:

Leaves are linear or lanceolate with an entire leaf margin and a pointed apex (1.5 - 4 cm wide, 20 - 50 cm long). This species is a monocotyledon, so it lacks petioles, but has leaf sheaths and parallel venation.

Stem: The stem is round and herbaceous.

Floral biology:

Monoecious; the hollow, bead-like structure is known as an involucre. It houses 3 femaleflowers : one fertile flower and two sterile flowers. The fertile female flower produces 2 purple, feathery stigmas that emerge out of the hole at the apex. The male inflorescence occurs on a thin stalk that also emerges from the hole at the apex of the involucre. The male inflorescence resembles a head of wheat. It has green, herbaceous bracts that partially cover the male flowers(Figure 3).

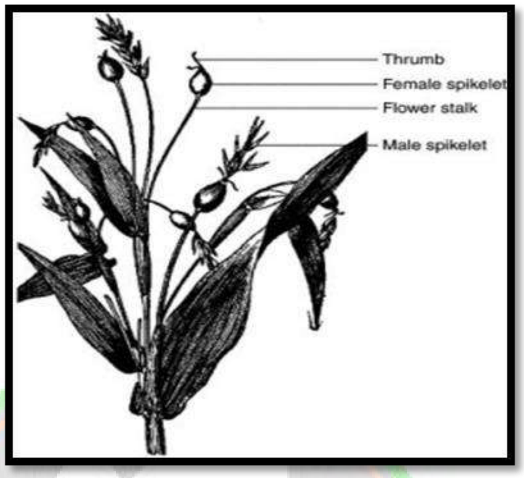


Fig 3.Floral biology

Inflorescence type: Raceme

Fruit type: Grain

Cultivation: This species grows best in warm, tropical climates. Plant it in soil with good drainage. Involucres containing grain should be planted at a depth of 2.5 cm with 60 cm of spacing on all sides between plants. Immature plants should be well-watered. Fertilize by regularly adding manure to the soil. As the grain sets, reduce watering to maximize yield.

Soil Type: Waterlogged Soils, Fertile Loamy Soils

Maximum height:0.9m to 1.8m

Mode of nutrition: Autotrophic

Economic part: Seed

Species: Coix included five species of *C. aquatica*, *C. chinensis*, *C. lacryma-jobi*, *C. puellarum (*Balansa), and *C. stenocarpa.*

The following are some morphologically distinct forms of recognisable taxonomic identity:

1. Cultivated types: Fruit-case soft, usually thin-shelled, breakable, coarse, not shining, bold, occasionally exceeding 2 cm in diameter.

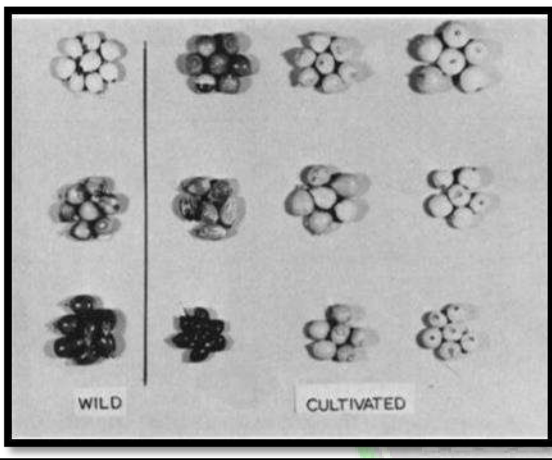
In **var. *mayuen*,** Plants tall, annual, all soft- shelled types with above charactristics, fruit case of variable shape--pear-shaped to spheroidal.

2. Wild types: Fruit-case strong, hard and stony, unbreakable by hand, polished/ shining, usually 1 cm or less in diameter, perennial forms.

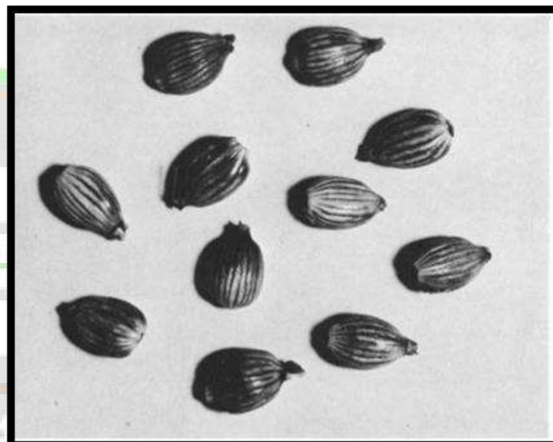
In **var. *stenocarpa***,Plants akin to cultivated forms, but with coarser leaves, fruit as above, hard and stony, elongate-cylindrical.

In **var. *monilifer***, A variation of stenocarpa with more variable fruits; roundish types broader than long prevail.

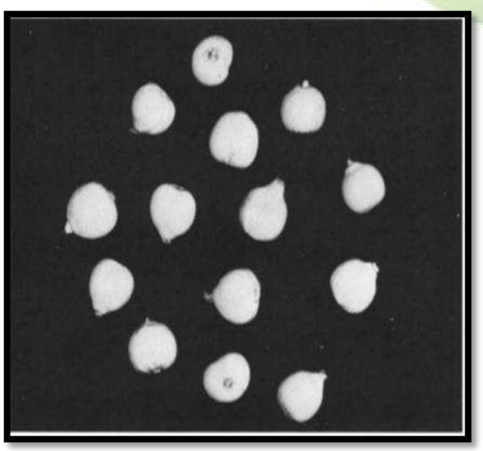
The characters common to all forms are: "female spikelets completely enclosed in a metamorphosed leaf-sheath which takes the form of a bead-like structure varying from ovoid to spheroid and exhibiting various colours."



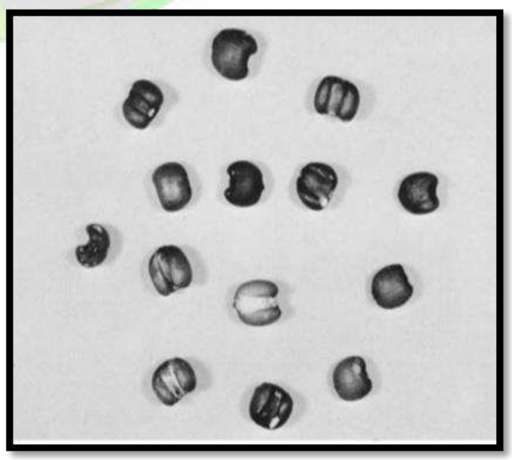
Variability of grain types in *Coix lacryma-jobi* in cultivated and wild forms



A representative soft-shelled form (var. *mayuen*) with striped shell



A representative soft-shelled form (var. *mayuen*) with non-striped shell



The de-hulled kernel

Fig 4.Adlay (*Coix lacryma-jobi L.)* of Southeast Asia. (A) Seedling, (B) inflorescence, (C) immature shelled seeds, (D) ripe hulled seeds, (E) threshed hulled seeds, (F) threshed seeds, (G) field, (H) adlay seed flour, (I) coix seed oil.

Nutritional values:

- PROTEIN CONTENT:

  Seed kernels: 20% protein

  Wild-type coix seed:31.72% protein

  Coix shell:2.17-2.80% protein

- Tocopherols in coix seed oil:0.64-1.57 mg/g,
- Phosphorus(seed kernels):1.93mg/g
- Zinc (seed kernels):0.15mg/g
- Copper (root):0.01mg/g
- Iron (root):1.46mg/g
- Chromium (root) :0.04 mg/g
- Potassium(leaf):4.18mg/g
- Calcium(leaf):15.65mg/g
- Sodium(leaf):1.90mg/g
- Magnesium (leaf):5.85 mg/g

USES:

- The sun-dried grains are stored in gunny bags and used in various ways by the tribes for food and fodder.
- Coix has been more familiar for its colourful, glossy, shining beads used for making pendants, necklaces, etc. The local tribes, particularly women, also adorn themselves with these white/grey /black shining beads--collected locally from the wild forms.
- The soft-shelled types are becoming popular now, also as a poultry feed.
- Another very popular use of Job's-tears by the tribes is the brewing of beer from the pounded grain.

HEALTH BENEFITS:

- It has anti-tumor, anti-inflammatory, anti-viral, anti-bacterial, hypoglycemic, and immune-regulatory functions.
- Coix seeds are most frequently used to treat diseases of the gastro-intestinal tract such as dysentery, persistent diarrhea of children, appendicitis and enteritis.
- Different pulmonary conditions such as bronchitis, pulmonary abscess, pleurisy, pneumonia, lung cancer and hydrothorax have been claimed to be cured by coix seeds consumption.
- Coix roots are used for treatment of ascariasis.
- Seeds and roots of coix have been used in the diuretic in nature so used in treatment of genito-urinary diseases.
- Anti-cancer activity. Anti-diabetic and anti-obesity activity.
- Treat ailments of the lungs, large intestines, spleen and stomach
- Promotes arveer flow of urine and also helps in treating swelling due to water
- Relieves arthritis and rheumatism
- Relieve swelling and inflammation caused by mastitis and beipfal in encouraging lactation in women
- Effective in treating infection beneath the nails
- Reduces sparnis, control blood sugar levels and serve as a mild, natural sedative
- Treat menstrual problems.
- Heln in prevent osteoporosis
- Treat problem areas on the skin such as redness and demisies

Conclusion

A range of phytoconstituents, such as polysaccharides, proteins, oils, phytosterols, phenols, flavonoids,lignans, lactum, policosanols, and vitamins, are found in different parts of coix such as whole seeds, hulls,bran, endosperm and testa. These phytoconstituents have been shown to have strong therapeutic functions in various in vitro and in vivo models. Many different health benefits are recognized from the seeds of coix, but scientific community should also study the benefits of other parts of the coix plant body and other family members of the coix species. Consumption of whole grain or extracts of coix are potentially beneficial. Large-scale development and utilization of genetic resources are necessary conditions for developing nutritional traits and cultivating nutrient rich commercial coix varieties. These needs include: (i) reliable and high-throughput screening of genetic resources for nutritional traits and biologically active compounds, (ii) multilocation testing to quantify the genotype and environmental interactions of nutritionally important traits,and (iii) strengthening the use of unexplored wild coix seeds for nutritional development.

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BRINJAL PEST AND THEIR MANAGEMENT

Article ID: AG-VO4-I03-34

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Introduction

Brinjal is one of the most commonly grown vegetable crop in the country. India produces about 10.378 MMT of Brinjal from an area of 0.6 Mha with an average productivity of 17.3 mt/ha.There are various insect pests which are causing damage to crop at different stages and responsible for huge yield losses.

1. Shoot and fruit borer, *Leucinodes arbonalis*; F: Crambidae; O: Lepidoptera

General symptoms of damage are withered terminal shoots, bore holes on shoots plugged with excreta, shedding of flower buds, drying of leaves due to boring on petioles by larvae. Larva is pink in colour. Adult is medium sized moth with forewings having black and brown patches and dots. Hind wings are opalescent with black dots.

Management

Shoot and fruit borer

- Collection and destruction of infested plant parts like shoots, buds and fruits.
- Avoid ratooning to minimize shoot and fruit borer infestation.
- Spray anyone of the following twice at 30 days after planting at fortnightly interval.
- Quinalphos 25 EC 2 ml/lit + NO 2 ml/lit + Teepol 1 ml/lit.
- Neem Seed Kernel Extract (NSKE) 5% (50 g/lit).
- Growing resistant varieties like Pusa Purple cluster, Arka Kusmak, Doli 5.

Brinjal Shoot and fruit borer

2. Stem borer, *Euzophera perticella*; F: Pyralidae; O: Lepidoptera

Stunted growth, withering and wilting of plants. Bore holes on stem and leaf axils are covered with excreta. Infestation is caused by larva. Larva is yellowish or light brownwith red head. Moth is greyish brown, forewings with transverse lines and white hind wings.

Brinjal stem borer

3. Spotted beetle (or) Hadda beetle, *Henosepilachna vigintioctopunctata, H. demurille, H. implicate;* F: Coccinellidae; O: Coleoptera

Both grubs and adults feed by scrapping chlorophyll from epidermal layers of leaves which get skeletonized and gradually dry up. Grub is yellowish in colour and stout with spines all over the body. Adult is spherical, pale brown and mottled with black spots (6 or 14)on each elytra.

Management: Collect and destroy severely affected leaves along with grubs, pupae and beetles. Spray fipronil 2 ml/lit.

Spotted beetle

4. **Ash weevils,** *Myllocerus* sp.; F: Curculionidae; O: Coleoptera

Adults cause notching of leaf margins. Grubs feed on roots resulting in wilting of plants. Grub is small, apodous and white in colour. Adult: *M. subfasciatus*: Brown; M. *discolor*: Brown with white spots; *M. viridanus*: Small light green weevil.

Management: Apply carbofuran 3G @ 15 kg/ha, 15 days after planting.

Ash weevils

5. **Brown leafhopper,** *Cestius phycitis (Hishimonas phycitis)*; F: Cicadellidae; O: Hemiptera

Small light brown leaf hopper. Both nymphs and adults suck plant sap and serve as vector of little leaf disease.

Brown leafhopper

6. **Aphid,** *Aphis gossypii*; F: Aphididae; O: Hemiptera

Both nymphs and adults suck the sap and cause stunted growth, gradual drying resulting in death of the plants. Development of black sooty mould due to the excretion of honey dew. The aphids are greenish brown, soft bodied and small insects. The alate as well as apterous females multiply parthenogenitically and viviparously. A single female may produce 8-22 nymphs in a day which become adults in about 7-9 days. They are often attended by ants for the sweet honey dew secretion. Winged forms may be seen under crowded conditions.

Management : Release the first instar grubs of *Chrysoperla carnea* @ 10,000/ha. Spray methyl demeton 25 EC or dimethoate 30 EC @ 2 ml/lit when situation warrants.

Integrated pest management

Main crop

- Bird perches @ 10/ acre should be erected for facilitating field visits of predatory birds
- Delta and yellow sticky traps @ 2-3/ acre should be installed for hoppers, aphids and white fly etc.
- Give 2 to 3 sprays of 5 % NSKE against sucking pests. Sprays of NSKE also bring down the borer incidence significantly. Neem oil (2%) application is also helpful in reducing borer infestation, though marginally. If incidence of leaf hopper and other sucking insect pests is still above ETL, then apply imidacloprid 17.8 SL @ 150 ml/ha.
- Pheromone traps @ 5/ acre should be installed for monitoring and mass trapping of shoot & fruit borer *Leucinodes orbonalis*. Replace the lures with fresh lures after every 15-20 day interval.
- Release egg parasitoid *T. brasiliensis* @ 1 – 1.5 lakh/ ha for shoot & fruit borer, 4-5 times at weekly interval.
- Apply neem cake @ 250 kg/ ha (in two splits) in soil along the plant rows at 25 and 60 DAT for reducing nematodes and borer damage. Don't apply neem cake when there is heavy wind velocity or temperature is above 30 0C.
- Clipping of borer damaged shoots and collection & destruction of damaged fruits i.e. clean cultivation helps in the management of borer and phomosis disease effectively.
- If the borer incidence crosses ETL (5% infestation), apply cypermethrin 25 EC @ 200 g a.i/ha (0.005%) or carbaryl 50 WP @ 3 g/litre of water or endosulfan 35 EC @ 0.07%.
- Continuous cropping of brinjal leads to more borer and wilt infestation. Therefore, crop rotation with non- solanaceous crops should be followed.
- Periodically collect and destroy the egg masses, larvae and adults of hadda beetle.

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ROLE OF MOLECULAR TECHNIQUES AND BIOREMIDIATION IN ENVIRONMENTAL ISSUES

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Introduction

Environmental biotechnology is expanding rapidly, driven by the needs of society for a cleaner environment and emerging developments in biotechnology research. There is an increasing interest in environmental biotechnology owing to a worldwide need to feed the world's growing population and to maintain clean soil, air and water (Wackett, 2000). Industrialization, economic growth, and increased standards of living have exacted a heavy toll on our environment over the last century. A major problem that as emerged over the last two decades is the dangerous accumulation of recalcitrant compounds, such as PAH, PCB, TNT, PCE, TCE etc., in soil, sediment, and surface or ground waters as a result of chemical spills, industrial activities or careless disposal strategies. Petroleum fuel spills which are a prime example, have resulted in accumulation of petroleum products at refineries, fuel storage areas, airports, military bases, fuel distribution lines, and gasoline service stations. This considerable effort is being spent on developing cheap and feasible strategies for clean-up of contaminated sites (Jansson *et al*., 2000) and a prime candidate for many types of cleanup are bioremediation technologies.

Bioremediation

Bioremediation is a branch of biotechnology that employs the use of living organisms, like microbes and bacteria, in the removal of contaminants, pollutants, and toxins from soil, water, and other environments (Cory mytchell, 2022). Bioremediation is defined as the environmentally friendly process for the removal of harmful pollutants from soil, water and air using microbes (Alexander and Loehr, 1992).According to EPA(Environmental Protection Agency) bioremediation is a treatment that uses naturally occurring organisms to break down hazardous substances into less toxic or non-toxic substances. Bioremediation is one of the most economic remedial technique presently available for treating organic fuel based contaminations (Eg: benzene, naphthalene).

Bioremediation relies on stimulating the growth of certain microbes that utilize contaminants like oil, solvents, and pesticides for sources of food and energy. These microbes convert contaminants into small amounts of water, as well as harmless gases like carbon dioxide (fig. 1).

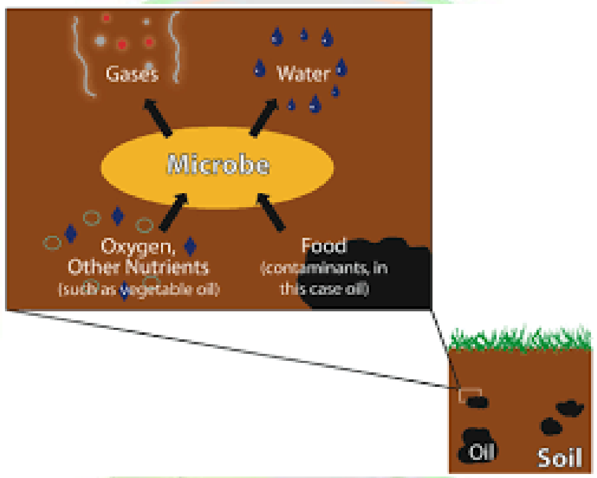

Fig. 1.schematics of microorganisms requirement (USEPA, 2012)

Bioremediation can either be done "in situ", which is at the site of the contamination itself, or "ex situ," which is a location away from the site. Ex situ bioremediation may be necessary if the climate is too cold to sustain microbe activity, or if the soil is too dense for nutrients to distribute evenly. Ex situ bioremediation may require excavating and cleaning the soil above ground, which may add significant costs to the process (Cory mytchell, 2022).

Types of Bioremediation

Bioaugmentation

Bioaugmentation is the method of application of autochthonous or allochthonous wild type or genetically modified microorganisms to polluted hazardous waste sites in order to accelerate the removal of undesired compounds.

Fig. 2 outlines the process of bioaugmentation. Bioaugmentation is mainly undertaken in oil contaminated environments as an alternate strategy for bioremediation.

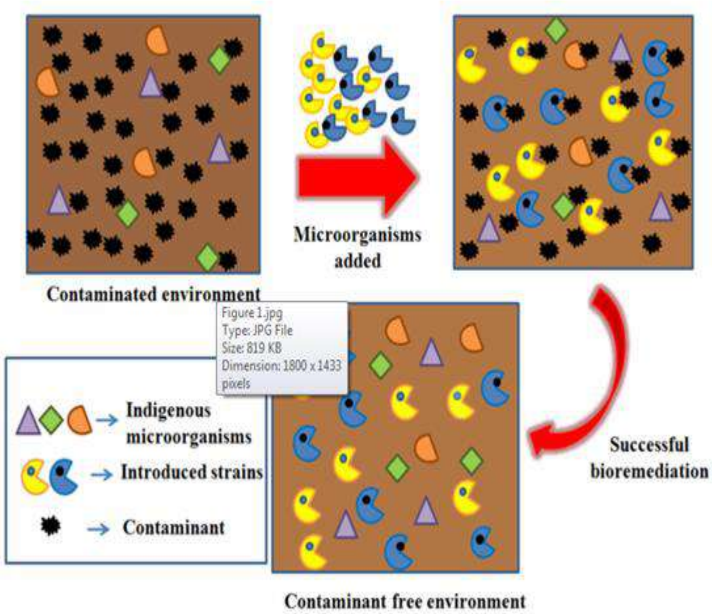

Fig. 2 - *The pictorial diagram of bioaugmentation.(Madhurankhi Goswami and* et al.*,2018)*

Biostimulation

Biostimulation is a remediation technique that is highly efficient, cost effective and eco-friendly in nature. Biostimulation refers to the addition of rate limiting nutrients like phosphorus, nitrogen, oxygen, electron donors to severely polluted sites to stimulate the existing bacteria to degrade the hazardous and toxic contaminants (Tyagi M *et al., 2010)* . Fig. 3 outlines the process of biostimulation.

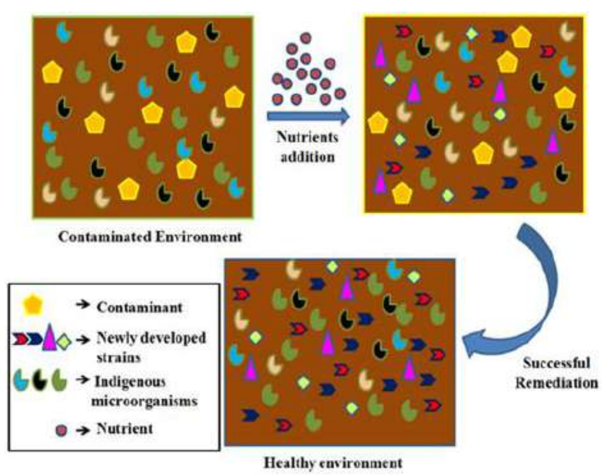

Fig. 3. *The pictorial diagram of biostimulation (Madhurankhi Goswami* et al.*,2018)*

Intrinsic bioremediation

The conversion of environmental pollutants into harmless compounds by the naturally occurring microbial population without specific help by human activity. The process of intrinsic bioremediation is most effective in the soil and water because of these two biomes which always have a high probability of being full of contaminants and toxins (Van Bemmel, 2010).

Selection of appropriate microorganism

The selection of a suitable strain or a suitable microbial consortium requires the consideration of few of the features of microorganisms like fast growth, easily culturable, ability to withstand high concentrations of contaminants and to survive in a wide range of environmental conditions. There are several approaches that can be considered for selection of a suitable bacterial strain.

Microorganism used	**Pollutants degraded**
Pseudomonas putida PaW340/pDH5	4 Chlorobenzoic acid
Cupriavidus necator RW112	Chlorobenzoates Arochlor 1221 and 1232
Burkholderia xenovorans LB400 (ohb)	Arochlor 1242
Pseudomonas fluorescens RE	2,4-dinitrotoluene
Pseudomonas fluorescens MP	2,4-dinitrotoluene
Pseudomonas putida KT2442	Napthalene
Pseudomonas fuorescens F113rifpcbrmBP1::gfpmut3	Biphenyl, polychlorinated biphenyl
Rhodococcus sp. StrainRHA1	4-chlorobenzoate
Eschirichia coli AtzA	Atrazine
Pseudomonas sp.Pseudomonasputida B13ST1(pPOB)	3 phenoxybenzoic acid
Pseudomonas fluorescens F113rifPCB	Biphenyl, polychlorinated
Pseudomonas fluorescens CS2	Biphenyl Ethylbenzene
Pseudomonas putida BCRc14349	Phenol, trichloroethane
Rhodococcus sp.F92	Various petroleum products
Arthrobacter, Burkholderia, Pseudomonas, Rhodococcus etc.	Petroleum hydrocarbons

Table 1. Microbes involved in bioremediation of polluted environment (Madhurankhi Goswami *et al*.,2018)

One of the approaches involves isolation of bacterial strain from a contaminated soil followed by its culturing under laboratory conditions for its pre adaptation and finally augmented back into the same contaminated soil. This approach is called as re inoculation of soil with indigenous microorganisms. Table 1 shows the success of bioremediation in polluted environments.

Roles of environmental genomics on bioremediation

Environmental functional genomics is crucial for understanding the gene arrangement and metabolic properties of microorganisms in specific environments. It is particularly important for studying non-cultured, potentially crucial microorganisms that play a pivotal role in ecological balance (Quaiser A, Ochsenreiter T, Lanz C, *et al*.,2003). Environmental genomics is essential for habitats with a wide array of microorganisms involved in the transformation of organic nitrogen, carbon, and phosphorus (Whitman WB, *et al.* 1999). This study helps reveal the gene pool of the microbiota associated with the specific habitat (Nesbo CL *et al* 2001).. Despite advancements in microbial techniques, there is limited knowledge about the degradation pathways in bioremediation and biostimulation (Amann, *et al,* 1995). Environmental genomics or metagenomics plays a significant role in analyzing existing microbial communities and helping to search for new catabolic genes for degradation of various xenobiotic and aromatic compounds. It also enables screening clones capable of expressing desired traits on specific media (El Fantroussi S*et al,* 1998).

Molecular techniques in bioremediation

Bioremediation is a strategy that utilizes the pollutant-degrading or transforming capabilities of microorganisms to optimize conditions for in situ growth and biodegradation. However, many commercial bioremediation strategies treat microbial communities as black boxes without analyzing their constituent populations or understanding their functions or syntrophic relationships. One challenge faced by scientists in bioremediation is identifying and characterizing microbial communities living at contaminated sites. Traditional microbiological studies involve isolation, classification, and physiological characterization. Culture-dependent techniques, such as Biolog-generated community level physiological profiles (CLPP), estimate the ex situ metabolic potential of members isolated from various environments. However, these studies fail to reflect the true microbial diversity and activities occurring(Juck *et al*., 2000).Microbial consortia involved in environmental biotechnology, such as activated sludge and soil/sediment consortia, are complex and able to act on various pollutants. In the early 1990s, molecular biological techniques were developed to study microbial ecology, leading researchers to analyze microbial populations relevant to pollutant degradation in the environment (environmentally relevant microorganisms).

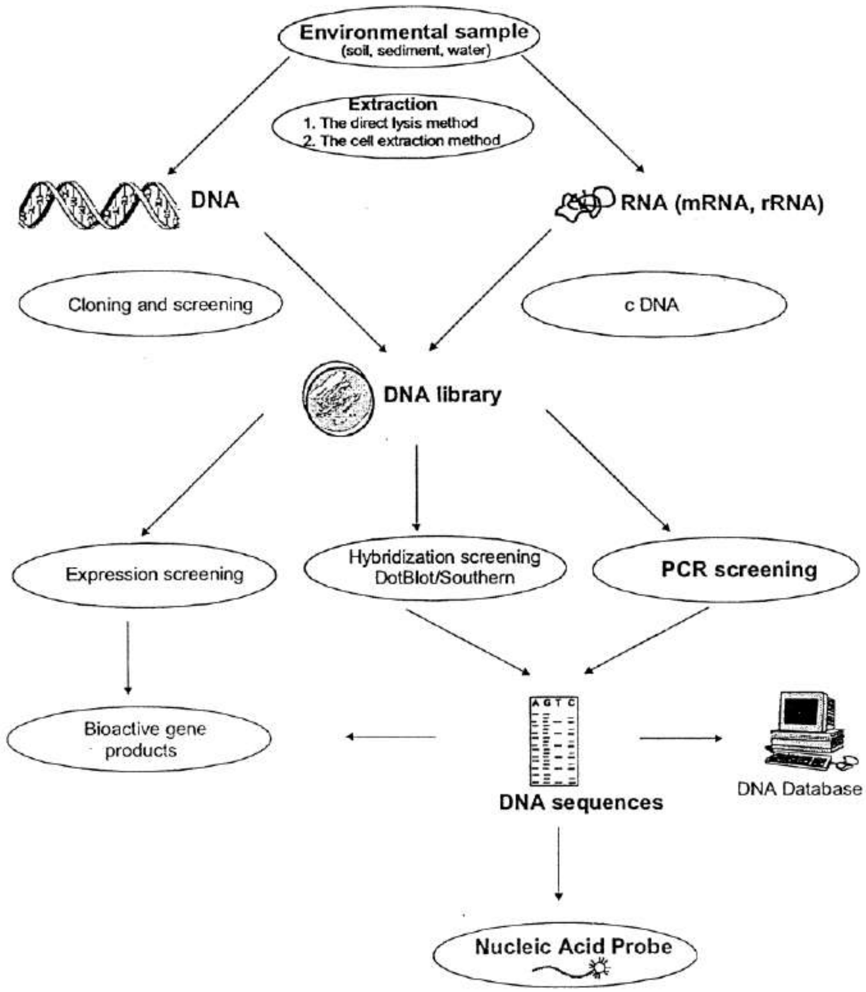

Fig. 4 Characterization of microbial biota in environmental samples by using molecular techniques (modified from Sayler and Layton, 1990; Amann *et al*., 1995; Cowan *et al*., 2000)

This led to studies using molecular techniques, such as direct DNA isolation from environmental samples and determining the sequences of specific genes(Watanabe and Baler, 2000). Several combinations of molecular techniques are used to analyze microbial communities, such as denaturing gradient gel electrophoresis (DGGE), PCR, TRFLP, and nucleic acid hybridization (DNA-DNA, DNA-RNA, RNA-RNA)(Hazen and Jimenez, 1988; Harry et al., 2000). These techniques have advantages over traditional methods that lack the specificity and sensitivity required for bioremediation monitoring. Methods based on isolation and identification of the nucleic acids of target organisms overcome these problems and have significant potential for detecting and monitoring the frequency maintenance and dispersal of natural microorganisms and microorganisms released into the environment.(Holben and Tjedje, 1998; Holben et al., 1988; Pickup, 1991; Bej et al., 1991; Bej and Mahbubani, 1992; Amann et al., 1995; Onuki et al., 2000). Fig. 4 shows the characterization of microbial biota in environmental samples.

The goal of environmental scientists may not only be to prevent further contamination but also to clean up highly polluted areas to avoid migration of contaminants to ground and/or surface water. Direct soil DNA extraction techniques are now an important part of microbial ecology investigations, as they are useful for determining the presence of native bacteria, GMOs, or GEMS genetically modified organisms (Torsvik, 1980; Steffan *et al*., 1988; Sommerville *et al*., 1989; Tsai and Olson, 1991; Saano and Lindstrom, 1995).

Table 2

Isolation of DNA from environmental samples by various methods
(modified from Pickup, 1991)

Environmental samples	Sample size	Method of DNA extraction	Cell numbers per g	DNA yield
Water	> 1 litre	Direct cell lysis/ethanol precipitation or CsCl centrifugation	10^{6*}	1 ng
Soil	50 g	Cell lysis after dispersion and PVPP treatment/CsCl centrifugation	10^6	ND
Soil	100 g	Direct cell lysis/ethanol precipitation or CsCl centrifugation Cell lysis after dispersion and PVPP treatment/CsCl centrifugation/hydroxyapatite chromatography/ethanol precipitation	10^9 10^9	350 μg 40 μg
Sediment	100 g	Direct cell lysis/ethanol precipitation or CsCl centrifugation Cell lysis after dispersion and PVPP treatment/CsCl centrifugation/hydroxyapatite chromatography/ethanol precipitation	10^9 10^9	1.9 μg 30 μg
Sediment	100 g	Direct cell lysis incorporating glass beads/DNA precipitation/CsClcentrifugation/ethanol precipitation	10^7	2.6 μg

ND – not determined, PVPP – polyvinylopolypyrrolidone, * – cells per ml

Two different techniques for isolation of DNA from soil can be carried out:

- The cell extraction method and subsequent lysis, or
- The direct lysis method

DNA extraction techniques involve the extraction of microbial cells from soil or directly from soil. The goal is to obtain the highest yield of extracted DNA that is pure enough for molecular analysis. The quantity of extracted and purified DNA can be assessed on agarose gels and compared with DNA markers. The direct lysis technique has the advantage of recovering DNA from organisms that are strongly sorbed and poorly removed by cell extraction methods. However, it has the disadvantage of humic and pH interferences from the soil or water being extracted (Ogram *et al*., 1987; Atlas, 1992; Saano and Lindstrom, 1995; Zhou *et al*., 1996). Table 2 shows different method in isolating DNA from environmental samples

All DNA isolation protocols aim to obtain a high yield of DNA that is pure enough for molecular analysis. However, humic and clay compounds in many soil samples inhibit analysis, and the presence of colloids renders the extraction of pure DNA problematic. To address this, anextensive purification step is necessary in DNA isolation protocols. Typically, DNA isolation involves the lysis of cells, separation of DNA from cell components, purification of DNA extract from soil particles and components, and precipitation of DNA(Sambrook *et al*., 1989; Dijkmans *etal*.,1993;Volossionk*etal*.,1995).Approximately 300 ng DNA and 100 ng RNA can be extracted from 10 g soil. Purification procedures can be any combination of CSCI-EtBr ultracentrifugation, hydroxylapatite or affinity chromatography, phenol/chloroform extractions, ethanol precipitation, dialysis, or repeated polyvinylpolypyrrolidone (PVPP) treatments(Sambrook *et al*., 1989; Pickup, 1991). In many cases, standard purification protocols do not work with every environmental sample, and the required conditions must be adapted to an individual analysis(Holben *et al*., 1988; Sayler and Layton, 1990; Pickup, 1991).

PCR, or polymerase chain reaction, is a significant methodological discovery in molecular biology that has been used in various laboratories for diagnostics and research. Its high specificity, sensitivity, and reproducible consistency have significantly contributed to the advancement of knowledge in environmental microbiology and other areas of research. The most obvious application of PCR is to enhance gene probe detection of specific gene sequences. By amplification of a target sequence, PCR enhances the detection of rare sequences in complex mixtures of DNA isolated from environmental samples(Steffan and Atlas, 1991). In environmental studies, PCR is used for the detection of microorganisms, such as genetically engineered microorganisms (GMOs), pathogens, and indicator organisms. For example, Steffan and Atlas (1988) used PCR to amplify specific regions of a 1.0-kilobase (kb) length, which was an integral portion of a larger 1.3-kb repeated sequence present in the genome of the herbicide-degrading bacteria Pseudomonas cepacia AC11000 to increase the sensitivity of dot-blot detection of the organism. Chaudhry *et al.*, (1989) also used PCR for detecting the genetically engineered microorganism *Pennisetumpurpureum*.

Historically, genes have been cloned from targeted organisms by generating a gene library of the genome investigated in phages like 2, M13mp, pUC, or cosmide vectors, and then screening the library (usually in host cells – E. coli) for expression of the desired phenotype by selecting plating(Glick and Pasternak, 1988; Albert *et al*. 1999). PCR provides a relatively simple alternative to these procedures, allowing one to specifically amplify the region of DNA to be sequenced without developing gene libraries or performing extensive screening. This feature makes PCR particularly attractive for cloning and analyzing mutants of known genes, cloning genes from different organisms, subcloning genes or regions of genes where the nucleotide sequence is known, and even for isolating genes directly from natural, environmental samples.

Another important use of PCR techniques is the analysis of ribosomal RNA sequences for identification and phylogenetic characterization of microorganisms. The wealth of information presently available concerning highly conserved and variable regions within 5S and 16S rRNAs allows for relatively simple selection of primer target sites for amplifying desired rRNA gene sequences. Manz *et al*. (1994) showed how specific oligonucleotides probes could be applied for the rapid in situ characterization of microbial communities in activated sludge of two wastewater treatment plants. Holben *et al*. (1988) developed the use of sequence-specific DNA probes to detect specific genes and microorganisms in soil. Both naturally occurring sequences, the rbcL gene, and sequence engineered into Bradyrhizobium strains, the npt II gene, were used as probes.

The use of molecular techniques in bioremediation processes can be seen in the classification of the methanotrophic bacterial community present in a trichloroethylene-contaminated subsurface groundwater site. Contamination of subsurface environments with chlorinated hydrocarbons, particularly trichloroethylene (TCE) and tetrachloroethylene (PCE), poses a significant threat to drinking-water sources. The complete mineralization of TCE to CO_2 is most efficiently carried out by the combined action of methanotrophic and heterotrophic microbial communities. Metanotrophic bacteria, being relatively ubiquitous in nature, can serve as an instrument in in situ bioremediation of contaminated sites. DNA extraction and gene probe analysis were used to determine the distribution and characteristics of the methanotrophic population involved in TCE degradation(Bowman et al. 1993).

16S rRNA gene sequencing is a method used to identify unknown microbes among known microorganisms, based on their phylogenetic position. This method is most effective when PCR is used, which replicates the 16S rRNA strand and sequences it. The sequenced 16S rRNA is then compared to other microorganisms in a database. Woese *et al*. (1990) have structured all three classes of organisms into relationships based on differences in their 16S rRNA strand, which can help measure evolutionary distance between organisms. Table 3 shows some examples of bacterial DNA probes used for environmental studies.

Table 3. Examples of bacterial DNA probes used for environmental studies (Hazen and Jimeneze, 1988)

Examples of bacterial DNA probes used for environmental studies (according to Hazen and Jimenez, 1988)

Target	Probe	Use	Sample
Tn5 mutants	Tn5	quantify	soil
Yersinia spp.	O plasmid	identification	water
Escherichia coli	ETEC	detection	water
Vibrio vulnificus	cytotoxin	identification	oyster
Vibrio cholerae	ETEC (LT)	identification	isolates
Salmonella spp.	chromosomes	detection	water
Bradyrhizobium japonicum	nptII	detection	soil
Legionella spp.	chromosomes	identification	water
Campylobacter spp.	chromosome	detection	water
Bacteroides thetaiotamicron	chromosome	detection	soil
Rhizobium spp.	chromosome	detection	soil
Pseudomonas fluorescens	rDNA	identification	soil
chitin degradation	chitobiase	functional	water
toulene degradation	TOL plasmid	functional	sediment
naphtol degradation	NAH-7 plasmid	functional	sediment
nitrogen fixation	nif	functional	sediment
mercury resistance	mer	functional	estuary
PCB degradation	4CB	functional	sediment

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NATURAL PLANT-BASED REMEDIES IN FISH HEALTH MANAGEMENT

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Introduction

Aquaculture, the fastest growing food-producing sector, the highest ever total of aquaculture production was 126 million tonnes weight (FAO, 2023a). The major farmed species include carps, shrimps, and salmonids. The Indian aquaculture has demonstrated a six and half fold growth over the last two decades. Among the three Indian major carps (IMC) rohu (*Labeo rohita*), catla (*Catla catla*) and mrigal (*Cirrhinus mrigala*) rohu is the most important cultivable species due to the fast-growing nature and taste, contributing as much as 30-40 percent of the total Indian major carp production.

Enhancement of production and intensification of culture practices are needed for insuring profitability and sustained supply of fish protein. The intensification of aquaculture practices with farming priorities has shifted to supplementary feed-based culture. Ultimately, the feed-based aquaculture has led to more demand and high price of almost all feed ingredients.

Plant based ingredients are widely available, renewable and many are already being used for aqua feed. The long-term viability of the industry will be determined by its ability to reduce cost of formulation and ability to adopt with different alternative ingredient having cost effective and flexible formulation. Plant sources have been considered as the important alternative ingredients for formulating fish feeds. Nowadays, most researchers focused on consumption of less expensive and readily available resources in fish feed, without sacrificing nutrition, quality of feed and fights against the disease as an immune booster (El-Sayed 1999).

Health Management

Fish health management in terms of aquaculture describes management practices which are designed to prevent fish disease. Successful fish health management begins with prevention of disease rather than treatment. The fish is constantly bathed in potential pathogens, including bacteria, fungi, and parasites. Suboptimal water quality, poor nutrition, or immune system suppression generally associated with stressful conditions allow these potential pathogens to cause disease.

For many years, fish farmers have applied conventional treatments such as anti-parasitic and chemical treatments to control fish parasites. Previous studies have revealed an accumulation of these chemical residues in fish tissues, and a negative environmental impact from farms to aquatic organisms. As an alternative to conventional methods, many plant-derived compounds such as essential oils and plant extracts have been used as an efficient treatment to control parasites in aquaculture systems.

Methods used for protecting fishes from disease

1. Chemotherapy

Chemotherapy usage has been widely used to prevent and treat disease outbreaks, although use of chemical drugs has multiple negative impacts on environment and human health e.g. resistant bacterial strains and residual accumulation in tissue. If any overdose of chemotherapeutants (formalin) resultants in severe gill damage to fishes (Punitha *et al*., 2008). The use of chemotherapy in treating and enhancing the growth of fish has been widely criticized due to its negative environmental consequence. The abuse of chemotherapeutics in fish farming has led to development of drug-resistant bacteria and multiple antibiotic-resistant in the aquaculture industry. This approach has sometimes resulted in the spread of epizootic diseases and severe economic losses.

2. Vaccination

A vaccine is defined as a biologically based preparation that is developed to improve the immunity towards a specific disease or a group of diseases. Vaccines are considered as biological agents that elicit an immune response to a particular antigen obtained from a disease-causing infectious pathogen most effective method. Till now, over twenty-six fish vaccines are reported to be licensed for use in a wide variety of fishes and are commercially available around the globe. However, they are relatively expensive and pathogen specific.

Use of expensive chemotherapeutants and antibiotics bring:

- Accumulation in the tissue as residues.
- Development of the drug resistance pathogens.
- Immuno-suppression.
- Reduced consumer preference (Anderson, 1992).

Therefore, instead of antibiotics and chemotherapeutic agents, increasing attention is being paid to the use of immunostimulants for disease control measures in aquaculture. So, what is the alternative method to protects the fishes from pathogen?

3.Medicinal Herbs

Medicinal plants are rich in various secondary metabolites and phytochemical compounds, such as tannins, alkaloids, and flavonoids, which affect various diseases in fish. reported that some mode of action of medicinal plants includes stimulation of the cellular and humoral immune response, monitored through elevation in immune parameters.

Herbal Importance

Many herbs and plants have been used in many cultures around the world for both human and animals as well as fish. Some of these remedies have anti-viral properties as well as anti-bacterial and anti-fungal properties. These natural plant products have been reported to have various properties such as anti-stress, growth promoters, appetizers, tonic and immunostimulants. Moreover, these substances also possess other valuable properties; they are nontoxic, biodegradable and biocompatible. Although the properties of herbs and plants are in use in herbal medicine around the world.

Scope of Natural Remedies

- Many herbs and plants have been used in many cultures around the world for both human and animals as well as fish.

- Some of these remedies have anti-viral properties as well as anti-bacterial and anti-fungal properties.
- These natural plant products have been reported to have various properties such as anti-stress, growth promoters, appetizers, tonic and immunostimulants.
- Moreover, these substances also possess other valuable properties; they are nontoxic, biodegradable and biocompatible.
- Although the properties of herbs and plants are in use in herbal around the World.

Application of some herbal medicinal plant as immunostimulants:

Medicinal Plant	Extraction Method	Application to Fish
Allium sativum	Powder	*Piaractus mesopotamicu*
Cinnamomum cassia	Water and methanol extracts	*Carassius auratus*
Lindera aggregata	Methanol extract	*Carassius auratus*
Pseudolarix kaempferi	Methanol and ethyl acetate extracts	*Carassius auratus*
Allium sativum	Water extract	*Carassius auratus*
Dryopteris crassihizoma	Methanolic extract	*Carassius auratus*
Kochia scoparia	Methanolic extract	*Carassius auratus*
Polygala tenuifolia	Methanolic extract	*Carassius auratus*
Asparagopsis taxiformis	Water extract	*Lates calcarifer*
Eupatorium fortunei	Chloroform extract	*Carassius auratus*
Artemisia argyi	Ethyl acetate extract	*Carassius auratus*
Lysima chiachristinae	Ethyl acetate extract	*Carassius auratus*
Allium sativum	Aqueous extract	*Poecilia reticulata*
Allium sativum	Garlic oil	*Oreochromis niloticus*
Macleaya cordata	Dried ethanol extract	*Ctenopharyngodon idella*
Hericium erinaceum	Ethanol extract	*Paralichthys olivaceus*
Cynodon datylon	Ethanolic extract	*Catla catla*
Tinospora cordifolia	Ethanol and petroleum ether extracts	*Oreochromis mossambicus*
Withania somnifera	Powder	*Labeo rohita*

Conclusion

Herbal drugs are currently used in commercial aquaculture as

- Growth-promoting substances
- Antimicrobial agents
- Stress resistance boosters
- Nutrients and other applications

The presence of active principal components in plant based herbal drugs such as alkaloids, flavonoids, pigments, phenolics, terpenoids, steroids and essential oils were showing potential to prevent and control fish diseases.

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CONSERVATION AGRICULTURE: CONCEPT, PRINCIPLES AND BENEFITS

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Abstract

Conservation agriculture is an important practice to be taken up as it aims to increase the agronomic, economic and environmental benefits in the modern era. Agronomic benefits like increased productivity, improvement in soil quality and efficient utilization of resources can be achieved. The increased farm income and reduction in cost of cultivation are the major economic benefits. The environmental benefits involve reduction of green house gases emission in agriculture and enhancing climate adaptation and resilience. Therefore there is a need to practice conservation agriculture keeping in view the benefits it provides. The rate of adoption of conservation agriculture is slow and it is essential to implement it faster after knowing its overall impact. Conservation agriculture can be effectively adopted after studying the specific requirements of the crops and the local conditions of the agricultural regions.

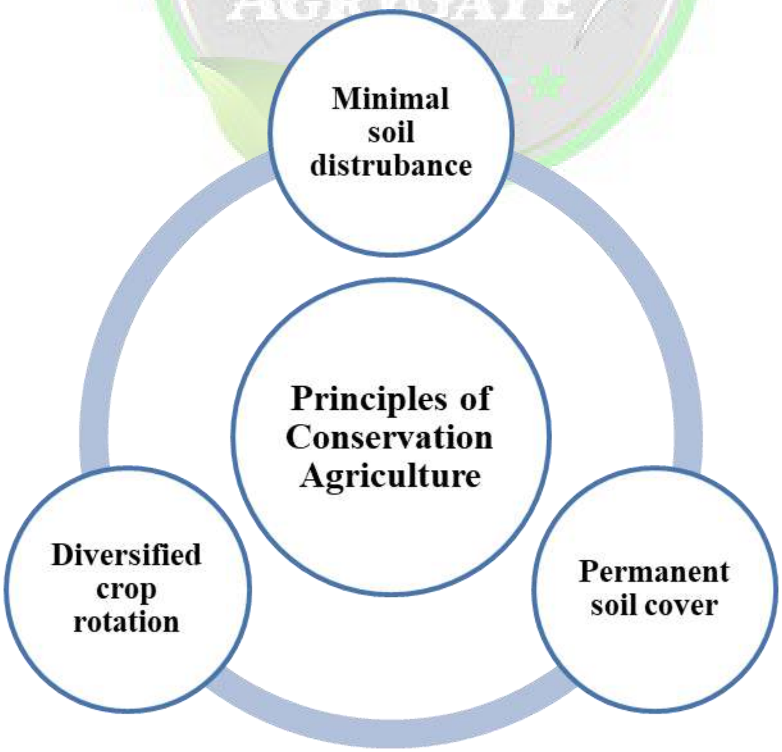
Keywords: Conservation Agriculture, Minimal tillage, Soil cover, Crop rotation

Introduction

The conventional agriculture emphasizes on the adoption of high yielding varieties, intensive tillage practices, heavy machinery and frequent application of synthetic chemical fertilizers, herbicides and pesticides. This involves the practice of monoculture and improper irrigation practices. The practice of conventional agriculture on the long run has led to the degradation of soil. The nutrient and water use efficiency has been drastically reduced over the years due to the soil degradation. The accumulation of pollutants and heavy metals due to the heavy application of fertilizers and pesticides is also a major concern. The conventional agricultural practices have hampered the soil physical, chemical and biological properties affecting the soil health and fertility. The reduction in soil organic matter, soil compaction, soil erosion and desertification are the major problems caused by conventional agriculture. It has degraded the soil making it less feasible for agricultural practices. Therefore it is necessary to shift to better agricultural practices which can reduce the soil degradation and restore the degraded soils.

Conservation agriculture is a farming system which promotes the soil quality and has the potential to conserve soil and regenerate the degraded soils. Conservation agriculture constitutes minimum soil disturbance, maintenance of permanent plant cover and diversification of crops[1]. It enhances the nutrient and water use efficiency and increases the beneficial microbial activity and biological processes in the soil. It is an effective tool for the management of natural resources and improves the crop productivity. Conservation agriculture reduces the land degradation and helps increase the food security. It also plays an important role in improving soil fertility and achieving sustainability in agriculture[2].

Principles of Conservation Agriculture



1. Minimal soil disturbance

The minimum soil disturbance can be achieved through minimal or no tillage practices. Minimal tillage involves either direct sowing or dissemination of seed with least disturbance to the soil by opening the slot with the use of a khurpi or other equipment[3]. The maintenance of good soil structure, organic matter content and beneficial microbial activity is important for good aeration and water retention in the soil. The heavy tillage disrupts the stable soil aggregates affecting the soil. So it is essential to protect the soil with minimal soil disturbance.

2. Permanent soil cover

The permanent soil cover with cover crops, crop residues and mulches is necessary to protect the soil from the detrimental effects of wind, rain and sun[4]. It is very important to keep the soil covered with permanent soil covers. It prevents the soil from erosion. The soil cover provides the necessary nutrients and creates favourable conditions in soil required for the growth of micro organisms which improves the soil structure, aggregation, carbon sequestration, suppression of weeds and important biological processes.

3. Diversified crop rotation

The adoption of crop rotation with different crops in rotation is beneficial and avoids monocropping. Rotating crops helps farmers manage soil and fertility while handling a number of challenges that affect greatly affect crop health and yields. The addition of legumes in crop rotation will help in biological nitrogen fixation, reduce the incidence of pest and diseases by disrupting their life cycles and enhances the soil biodiversity. The crop rotation increases the addition of crop residue to the soil which decreases the bulk density, increases soil aggregate size and water retention[5].

Benefits of Conservation Agriculture

- **Increased crop yield:** The practice of conservation agriculture will improve the soil fertility, physical, chemical and biological properties of soil and prevents soil from degradation. The improved water holding capacity, nutrient and water use efficiency will enhance the yields of the crops on the long run.
- **Reduction in cost of production:** The adoption of minimum and no tillage will reduce the production charges involved in land preparation. It will save the money spent on labour, diesel and herbicides.

- **Nutrient use efficiency:** The growing of deep rooted cover crops and addition of crop residues to soil will reduce the nutrient losses. It improves the microbial activity and nutrient cycling thereby improving the nutrient use efficiency.
- **Soil and water conservation:** The minimum tillage reduces the physical disturbance in soil and protects the soil aggregates. The permanent soil covers will reduce the soil erosion caused by water and wind. The crop residues in the soil increase the beneficial microbial activity that secretes aggregate binding chemicals in the soil. It also improves the water retention capacity in the soil and reduces runoff.
- **Improvement in soil quality:** The quality of the soil depends on the physical, chemical and biological properties of the soil. With the adoption of conservation agriculture the soil quality is improved. The physical properties like soil structure, soil texture, bulk density, water holding capacity and porosity are improved. The chemical properties like increase in organic matter of soil and availability of essential plant nutrients is noticed. The biological properties like beneficial microbial activity and nutrient cycling are increased.
- **Reduction in pest, disease and weed incidence:** The crop rotation with different crops helps break the life cycles of pests, diseases and weeds and reduce the incidence.
- **Environmental/Ecological benefits:** The conservation agriculture improves the biodiversity of flora and fauna below and above the ground. It also helps recharge the ground water bodies and reduces runoff and pollution of water bodies. It reduces the release of green house gases to the environment as it avoids the burning of crop residues and biomass.

Conclusion

Conservation agriculture minimizes the disturbance of the soil's structure, conserves soil water and enhances biodiversity. It effectively utilizes the farm resources and boosts the agricultural productivity and increases the farm income. It reduces the emission of green house gases and helps in climate change mitigation. It promotes the conservation of natural resources and reduces its widespread degradation. It improves the use efficiency of the inputs and helps achieve sustainable crop production and improves the livelihood. Therefore the practice of conservation agriculture is need of the hour.

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INSECTS AS A PROTEIN SOURCE

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Introduction

Currently global population increasing day by day and this upsurge in population necessitates roughly double the existing food production. Terrifyingly, global warming is progressively declining the areas used for food production worldwide. The climate change and the ecological devastation from industrial expansion also negatively affect the food productivity. In light of deteriorating reserve shortage, several foods have been projected as substitutes, with insects getting the most consideration. Insects are institutionally acknowledged as a food in many areas and traditionally consumed, providing adequate nutritive value for humans. Though, the quick rise in food production through scientific improvement has mainly excluded insects from our diets.

Numerous insects have been consumed globally and more than 2300 species of 18 orders have been reported as edible insects, of which 5 orders are with at least 100 species in accounts. Orders like Lepidoptera, Orthoptera, Isoptera, Coleoptera and Hymenoptera are all consumed as common protein sources in many areas worldwide. These insects inhabit in both aquatic and terrestrial environments. Mostly adult insects are eaten by so many groups of peoples and the immature forms of insects (pupae and larvae) are also favoured for their abundant amino acids and fatty acids, which not only warrant the nutritional importance, but also provide a unique and wonderful flavour. Most of them are collected from nature however some insect species are reared in a large scale.

The production of animal protein is under enormous pressure as the global population is hastily increasing. Subsequently, people are facing the stable protein malnutrition and looking for alternative protein resources. Insect source is seen as one of the best choices of stable protein. As it could make available huge amounts of various nutrients swiftly, it might provide a solution for malnutrition and famine. Great consideration has been paid to the use and production of edible insects everywhere. Increasing number of people is joining together in edible insect's food industry. Though, the industrial chain of edible insects, from essential research to marketing, still requires to be developed. Presently, Europe and the United States have the fastest increasing edible-insect industry, where a tendency is accompanying with high meat intake. Now, Insect foods are in an intermediate stage, and a favourable new technique involves rising new food products via merging protein-processing technology with insects.

Insects as a food

For hundreds of years, native peoples in South America, Asia, Africa and Europe include the eating of numerous species of insects. An insect of 164 species was identified being sold for food in a survey of markets at Bangkok and Thailand. The most frequently eaten insects are beetles, caterpillars, bees, ants, crickets, grasshoppers, and locusts. In Zimbabwe, Zambia, and Nigeria, edible insects are usually available in school and college cafeterias and open marketplaces, developing a commercial business. Really, up to 50% of dietary protein is derived from insects, and they actually have greater market significance than other protein sources. Some insects are valued for their organoleptic features and consumed in high-class restaurants. For example, (*escamoles*) ant eggs are considered a delicate gourmet dish in Europe, Mexico, Laos and Cambodia. An attention in edible insects has improved quickly because the Food and

Agriculture Organization (FAO) has initiated encouraging insects as viable dietary options for humans. Internationally, the edible-insect market is predictable to exceed USD 571 million by 2030.

Awareness about edible insects

Governments and NGOs can afford the information about benefits associated to nourishment and environmental sustainability. Educational workshops and tasting programmes can also provide openings to learn about edible insects. Another method for educating consumer insight is the creation of recipe book with insect recipes. Generally, the recurrent positive acquaintance to edible insects promotes attentiveness and could boost consumption of insects. Furthermore, a growth in approachability to edible insects is to develop insect-based ingredients instead of final food products showing their original appearance. Combining edible insects in already-familiar foods may be more acceptable for an insect-phobic culture than providing insects directly as a food option, and using insects as food ingredients is helpful for the development of supportable business prototypes.

Nutritional value of palatable insects

Edible Insect dietary value differs with intake, growing stage, sex, species, growing atmosphere and measurement methods. However, scientists usually agree that insects are enormously rich in protein, fat and vitamins. Nitrogen is a critical nutrient and proteins directly involved in N supply comprise 16.5% of an adult human body. On average, the protein content of edible insects' ranges 35%–60% dry weight or 10%–25% fresh weight, which are higher than plant protein sources, including cereals, pulses like soybeans, blackgram, green gram and lentils.

Even insects provide more protein than meat, chicken and eggs. Edible insects in Orthoptera particularly in crickets, grasshoppers and locusts are rich in protein. Nevertheless, insect protein digestibility is greatly variable due to the presence of a hard body wall or integument. Exoskeletons with high quantity of chitin and protein component are especially problematic to digest. Certainly, we presently do not know whether human beings are capable of digesting chitin which is present in exoskeleton. Obviously, the removal of exoskeleton through a part of processing is a viable option to overcome the digestibility problem in human beings. Some researchers made studies and have found that insect protein digestibility is 77%–98% without after the exoskeleton.

Certain insects like grasshoppers, crickets, termites, and mealworms are rich in iron, zinc, calcium, copper, phosphorus, magnesium, and manganese. Most invertebrates without a mineralized skeleton have very little calcium content. Maximum edible insects have similar iron content to beef, but we presently know minute about mineral bioavailability of insects. One of the research study found that consuming insects can afford the high quantities of daily mineral recommendations for humans, particularly in terms of iron and calcium. The studies of vitamin content are also inadequate, but existing data specify that edible insects contain carotene, vitamin B_1, B_2, B_6, C, D, E, and K and particularly, Orthopteran insects and Coleopteran beetles are rich in folic acid content. Carbohydrates in insects largely exist in two forms of chitin and glycogen. The previous is a polymer of N-acetyl-D-glucosamine that is the main component of exoskeleton, though the latter is an energy source deposited in cells and muscle tissues. The averaged carbohydrate content of edible insects ranges from 6.71% in stink bug to 15.98% in cicada.

Nutrient composition of eatable insects (for dry matter):

Type of insects	Scientific name	Protein content (%)	Fat content (%)	Carbohydrates content (%)	Reference
Larvae	*Allomyrina dichotoma*	54.18	20.24	-	Ghosh *et al.* (2017)
	Anaphe infracta	20.00	15.20	-	Banjo *et al.* (2006)
	Gonimbrasia belina	56.95	10.00	7.80	Siulapwa *et al.* (2012)
	Gynanisa maja	55.92	12.10	10.70	Siulapwa *et al.* (2012)
	Protaetia brevitarsis	44.23	15.36	-	Ghosh *et al.* (2017)
	Rhynchophorus phoenicis	22.06	66.61	5.53	Ekpo and Onigbinde (2005)
	Tenebrio molitor	46.44	32.70	-	Ravzanaadii *et al.* (2012)
Beetle	*Heteroligus meles*	38.10	32.01	20.10	Jonathan (2012)
	Rhynchophorus phoenicis	50.01	21.12	20.23	Jonathan (2012)

Type of insects	Scientific name	Protein content (%)	Fat content (%)	Carbohydrates content (%)	Reference
Grasshopper	*Ruspolia differens*	44.59	49.00	8.40	Siulapwa *et al.* (2012)
	Zonocerus variegatus	26.80	3.80	-	Banjo *et al.* (2006)
Cricket	*Brachytrypes* spp.	6.25	2.34	-	Banjo *et al.* (2006)
	Gryllus bimaculatus	58.32	11.88	-	Ghosh *et al.* (2017)
	Teleogryllus emma	55.65	25.14	-	Ghosh *et al.* (2017)
Termites	*Macrotermes bellicosus*	20.10	28.20	-	Banjo *et al.* (2006)
	Macrotermes falciger	43.26	43.00	32.80	Siulapwa *et al.* (2012)
	Macrotermes notalensis	22.10	22.50	-	Banjo *et al.* (2006)
Bee	*Apis mellifera*	21.00	12.30	-	Banjo *et al.* (2006)
Dragonfly	*Aeschna multicolor*	54.24	16.72	-	Ramos-Elorduy *et al.* (1998)
	Anax sp.	26.22	22.93	-	Ramos-Elorduy *et al.* (1998)

Intake of insects in ancient days

The absence of refined tools and well-developed pursuing capacity mean that ancient cultures likely consumed insects regularly. Upon the growth of agriculture and taming of livestock, though, eating insects' habits have been vanishing in the many parts of the world. The subsequent abundance of food naturally occurring could also cause a decline in the necessity for insect consumption. With changing cultural mores, insects have changed from a primary food source to refreshments, luxury components and bait. Nevertheless, some countries have still continued to use insects as regular food resources to this day. Overall, about 255 species are used as food, although the intensity varies depending on seasonal or regional differences in culture.

Food processing technologies used for insects

Insects, normally prepared using traditional approaches such as sun-drying, roasting, boiling, steaming, baking, frying, and stewing, among others. Today, they are naturally consumed as complete insects (raw or cooked), processed (non-recognizable form), and in the form of extracts. The food industry is viewing attention in this novel protein source, as supported by several start-up firms and number of scientific publications. Other methods to preparing insects must depend on in processing means that render insects into non-recognizable forms, like flours or powders, protein hydrolysates, fermentable substrates, etc.

The use of different drying technologies seems to be the most commonly used approach for preserving and processing edible insects. However, each drying method used will have different effects on the insects' nutritional composition and stability. For example, (Kröncke *et al.*, 2018) reported that drying techniques caused minor changes in protein, fat, and fiber content of yellow mealworms (*Tenebrio molitor*). However, oven drying, microwave drying, fluidized bed drying, and drying with a vacuum decreased ($P < 0.05$) the protein solubility, while freeze dried mealworms exhibited the highest lipid oxidation compared to the other drying methods. Overall, vacuum oven and microwave drying technologies were reported to be an alternative to conventional oven drying and freeze drying.

Conclusion

Eating edible insects could be the solution to progressively crucial food-security problem challenging the world. As we have detailed, many countries already use insects as a substitute food protein and feed sources. Prevailing investigates authorise the significant nutritional and medicinal values of edible insects. Innumerable approaches have been arranged to increase the edible-insect marketplace and to neutralize existing attitude among the western societies toward eating insects as a protein source. Edible insects are having attention as possible protein sources that could help improve the forecast protein demand. The lower eco-friendly impact of insect farming places them as leaders in the future growth of more sustainable foods worldwide. The combination of these novel protein sources as viable components will largely depend on consumers' awareness and recognition of products containing edible insects. Like with traditional protein sources, the incorporation of insect protein into food items will present its tasks and boundaries that will require wide-ranging investigation to ensure that processing skills and preparation policies work in the same form as they have done for traditional proteins. Findings show that insects can be treated using similar technologies to those applied for traditional proteins; therefore, the possibilities of developing convenient, safe, palatable, or even shelf-stable, insect-based food products is vast and consumers, scientists and the food industry need to consider the value of farming insects as promising protein sources.

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ORGANIZED AWARENESS PROGRAMME ON NEW KISAN BILL AMONG THE BUNDELKHAND FARMERS DURING 2020 : CASE STUDY

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Introduction

A new kisan bill farmers awareness programme have been done by Rani Lakshmi Bai Central Agricultural University, Jhansi at different village of Datia, Jhansi & Tikamgarh Districts under the Chairmanship of Honb'le Vice-Chancellor. In this programme scientist were go to village and aware the farmers about new kisan bill without any violence during 18-12-2020 and 19-12-2020.

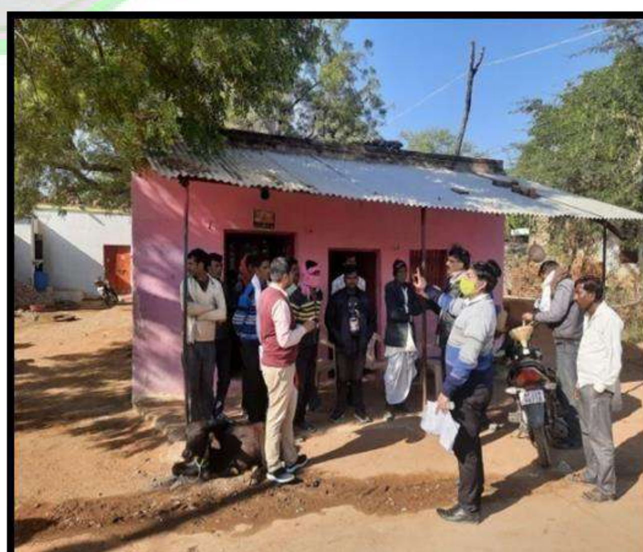

Table-1: List of villages and number of farmers under new kisan bill awareness programme.

S.No.	Village	District	No. of farmers	S.No.	Village	District	No. of farmers
1.	Noner	Datia	50	31.	Jwaharpura	Niwari	35
2.	Biloni	Datia	100	32.	Jeron	Niwari	30
3.	Khadroni	Datia	30	33.	Achrra	Niwari	35
4.	Dinara	Datia	50	34.	Majra Sewda	Niwari	40
5.	Tarai	Datia	60	35.	Boresar	Niwari	30
6.	Dhakra	Datia	70	36.	Koyali	Niwari	40
7.	Samwa	Datia	90	37.	Rotera	Niwari	50
8.	Berkheri	Datia	80	38.	Babri	Niwari	60
9.	Jhanha	Datia	50	39.	Mamora	Tikamgarh	80
10.	Karai	Datia	40	40.	Keshavgarh	Tikamgarh	70
11.	Fatehpur	Datia	80	41.	Hatheri	Tikamgarh	50
12.	Sanora	Datia	100	42.	Manjra	Tikamgarh	35
13.	Ramnagar	Jhansi	100	43.	Gadaryana	Tikamgarh	40
14.	Chirgaon	Jhansi	100	44.	Barahampura	Tikamgarh	90
15.	Garotha	Jhansi	80	45.	Tapriyana	Tikamgarh	100
16.	Shiya	Jhansi	100	46.	Talbehat	Tikamgarh	45
17.	Sultanpura	Jhansi	100	47.	Mohangarh	Tikamgarh	35
18.	Badagaon	Jhansi	80	48.	Kunwarpura	Tikamgarh	70
19.	Paharhi Bujurge	Jhansi	100	49.	Tiladath	Tikamgarh	75

20.	Maheba	Jhansi	90	50.	Daryan Kala	Tikamgarh	80
21.	Paricha	Jhansi	100	51.	Panchampura	Tikamgarh	90
22.	Bachawali	Jhansi	80	52.	Mustapur	Tikamgarh	100
23.	Jhansi Dehat	Jhansi	100	53.	Panihar	Tikamgarh	25
24.	Kargua	Niwari	50	54.	Jatara	Tikamgarh	60
25.	Bhopalpura	Niwari	60	55.	Bajranggarh	Tikamgarh	75
26.	Nayakhera	Niwari	70	56.	Derna	Tikamgarh	82
27.	Keripura	Niwari	80	57.	Khurakh	Tikamgarh	90
28.	Majal	Niwari	60				
29.	Tatarpura	Niwari	50				
30.	Bamroli	Niwari	60				

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PROMISING ROLE OF BIOGAS IN WASTE MANAGEMENT AND ENVIRONMENTAL PROTECTION

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Abstract

The prosperity of agricultural based country like India depends upon its capability of energy production which does not have any adverse impact on environment. Biogas production is a key environmental technology for integrated solid and liquid waste treatment and for climatic protection. Anaerobic treatment and gas use contributes to the reduction of greenhouse gases. In this article, we delve into the promising role of biogas in environmental protection. We explore its environmental benefits, its potential to address waste management challenges, its contribution to reducing greenhouse gas emissions, and its role in fostering energy independence and sustainability. Additionally, we examine the barriers associated with widespread biogas adoption. As we navigate the complexities of our environmental predicament, biogas emerges as a beacon of hope, offering a tangible pathway towards a greener, more sustainable future.

Key words: Biogas, Anaerobic, Technology

Introduction

Biogas – a renewable energy source derived from the breakdown of organic matter in the absence of oxygen. In the face of escalating environmental challenges, humanity is increasingly turning to sustainable alternatives to mitigate the adverse impacts of modern living. With the increasing global population, there is a rising demand for food production, which often leads to environmental degradation and resource depletion. Biogas, produced through anaerobic digestion of organic materials such as agricultural residues, animal manure, municipal solid waste, and sewage sludge, is a convincing solution to environmental pollution. Unlike fossil fuels, which release carbon dioxide, biogas production is part of the natural carbon cycle, making it carbon-neutral. The utilization of biogas offers a dual benefit of producing renewable energy but also addressing waste management challenges. Organic waste, a significant contributor to greenhouse gas emissions in landfills, becomes a valuable resource through biogas production. By diverting organic waste from landfills and using it for biogas generation, we can reduce methane emissions, which is a potent greenhouse gas.

The usefulness of biogas extends beyond electricity generation. It can be utilized as transportation fuel, cooking, heating, and in multiple ways while reducing reliance on fossil fuels. This versatility makes biogas particularly appealing for both developed and developing regions seeking sustainable energy solutions tailored to their specific needs and infrastructural capacities.

Biogas plays a promising role in urban waste management due to its potential to address several environmental, economic, and social challenges associated with waste disposal. Here are some key aspects highlighting its significance:

1. Boon to Farmer: Biogas technology promotes fertility of the soil and reduces desertification. The major advantage for farmers is the improved quality of anaerobically treated manure. Anaerobic digestion not only produces biogas but also generates digestate, a nutrient-rich byproduct that can be used as organic fertilizer in agriculture. Digestate contains valuable nutrients like nitrogen, phosphorus, and potassium, which help improve soil fertility and promote crop growth. By recovering these nutrients from organic waste, biogas facilities contribute to closing nutrient cycles and reducing reliance on synthetic fertilizers, which can have negative environmental impacts This manure is easy to use as these are less clogging, with increased ammonia content and crop yield.

2. Reduced Environmental Impact: Anaerobic digestion of organic waste in biogas facilities helps mitigate environmental pollution by preventing the release of methane, a potent greenhouse gas, into the atmosphere. The nutrient-rich digestate, which can be used as organic fertilizer, promote soil health and reduce the need for synthetic fertilizers.

3. Climate Resilience: In the face of climate change, biogas offers resilience to farmers. Extreme weather events, such as droughts and floods, pose significant challenges to traditional agricultural practices. Biogas production provides a decentralized energy solution that is less susceptible to disruptions caused by climate-related disasters.

4. Organic Waste Utilization and Cost Saving: Biogas production involves the anaerobic digestion of organic waste materials such as food scraps, agricultural residues, animal manure, and sewage sludge. By converting these waste materials into biogas through microbial fermentation in anaerobic digesters, biogas facilities provide an environmentally friendly alternative to landfill disposal or incineration. This is cost savings by reducing landfill disposal fees and generating revenue through the sale of biogas and digestate products.

5. Reduction of Landfill Burden: By diverting organic waste from landfills, biogas facilities help alleviate the pressure on landfill capacity and reduce the environmental impact associated with landfilling, such as groundwater contamination, soil degradation, and methane emissions. This contributes to more sustainable waste management practices and helps extend the lifespan of existing landfill sites.

6. Green Energy Generation: Biogas primarily consists of methane (CH_4) and carbon dioxide (CO_2), with methane being the main component. Methane is a potent greenhouse gas, and capturing it for energy production mitigates its release into the atmosphere, thereby reducing greenhouse gas emissions and combating climate change. It is a renewable energy source for electricity generation, heating, and cooking, providing a sustainable energy option for communities.

7. Promotion of Circular Economy: Biogas production aligns with the principles of the circular economy by converting organic waste into valuable resources. By integrating biogas technology into waste management systems, communities can create a closed-loop system where waste materials are recycled, reused, or repurposed, minimizing waste generation and maximizing resource efficiency. Moreover, biogas facilities can create job opportunities in construction, operation, in waste collection, and maintenance, contributing to local employment and economic development. Additionally, biogas projects may generate revenue through the sale of electricity, renewable energy credits, and digestate products, further supporting economic growth.

8. Community Engagement: Biogas projects offer opportunities for community engagement and participation in sustainable waste management practices. Educating residents about the benefits of separating organic waste for biogas production can foster a sense of environmental protection and encourage active involvement in waste reduction efforts.

BARRIER IN LARGE SCALE ADOPTION OF BIOGAS

Though there are numerous benefits of Biogas, there are several challenges in its widespread adaptation. Here are some of the prominent barriers:

1. Initial Investment Costs: Setting up biogas infrastructure requires a significant initial investment. The cost of constructing biogas plants, purchasing equipment, and installing digesters can be expensive for many farmers, with limited financial resources.

2. Technical Expertise and Knowledge: Building and operating biogas systems require technical expertise and specialized knowledge. Many farmers may lack the necessary skills and training to effectively manage biogas plants, leading to inefficiencies, malfunctions, and underutilization of the technology.

3. Feedstock Availability and Quality: The availability and quality of feedstock, such as animal manure, crop residues, and organic waste, can vary depending on factors like seasonality, agricultural practices, and livestock density. In some cases, farmers may struggle to procure sufficient feedstock to sustain biogas production, while in others; the feedstock may be of inadequate quality, affecting the efficiency and performance of biogas systems.

4. Infrastructure and Access to Resources: Access to infrastructure, such as transportation networks and distribution channels, is crucial for the successful implementation of biogas projects. Remote and rural areas may lack the necessary infrastructure, making it challenging to transport feedstock or distribute biogas to end-users. Additionally, limited access to water, electricity, and other resources can hinder the operation and maintenance of biogas plants.

5. Regulatory and Policy Barriers: Inadequate or inconsistent regulatory frameworks and policies can impede the widespread adoption of biogas technology. Issues such as complex permitting processes, ambiguous regulations, and a lack of incentives or subsidies may deter farmers and investors from investing in biogas projects.

6. Social and Cultural Factors: Socio-cultural attitudes and perceptions towards biogas may also pose barriers to its adoption. Farmers may be resistant to change or skeptical about the benefits of biogas technology, particularly if they have limited awareness or understanding of its potential advantages. Cultural norms and practices related to waste management and energy use may also influence the acceptance and uptake of biogas systems.

7. Market Demand and Economic Viability: The lack of market demand for biogas products and services can hinder investment in biogas projects. Without a reliable market for biogas, digestate, or other byproducts, farmers may struggle to recoup their investment and achieve economic viability.

Conclusion

Biogas holds great promise in urban waste management by offering a sustainable solution to organic waste disposal while simultaneously providing renewable energy and contributing to environmental conservation and community well-being. There are multiple benefits of biogas production like effective waste management, low sludge production, quality improvement of organic manure, reduction of the use of inorganic fertilizer and pesticides which directly helps the stabilization, improvement of soil quality and prevent environment pollution. Environment-friendly utilization of organic pollution materials and energy production can be realized together by biogas production and utilization. Hence, Biogas has proved to be a futuristic renewable energy with huge current and future potential. For farmers, it represents more than just a source of energy; it is a catalyst for rural development, environmental stewardship, and resilience in the face of climate change. There are several challenges in widespread adoption of Biogas. However, successful implementation requires supportive policies, investments in infrastructure, and public awareness campaigns to maximize its benefits.

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MUSHROOMS: A BOWL OF NUTRITION AND MEDICINE

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Introduction

Human tendency is to taste the different foods all around available whole through the year and he is continuously in search of new dishes. As the mushrooms is gaining popularity in the present days, in context to the medicinal and also pharmaceutical industries, utilization of mushrooms. Edible mushrooms are macro-fungi that can be seen with the naked eye, i.e., fleshy fruit bodies of many species of mushrooms, and they have already been widely used in food and medicine due to their delicious taste and diverse physiological activities Global food production faces many challenges, including climate change, a water crisis, land degradation, and desertification. These challenges require research into non-traditional sources of human foods. Edible mushrooms are considered an important next-generation healthy food source. Edible mushrooms are rich in proteins, dietary fiber, vitamins, minerals, and other bioactive components (alkaloids, lactones, polysaccharides, polyphenolic compounds, sesquiterpenes, sterols, and terpenoids). Several bioactive ingredients can be extracted from edible mushrooms and incorporated into health-promoting supplements. It has been suggested that several human diseases can be treated with extracts from edible mushrooms, as these extracts have biological effects including anticancer, antidiabetic, antiviral, antioxidant, hepatoprotective, immune-potentiating, and hypocholesterolemic influences.

Key words: Mushrooms, Nutrient value, Medicinal value,

Health and Nutritional Benefits of Eating Mushrooms

- Mushrooms have very less calories and contain approximately 80 to 90 percent water. At the same time, they have low sodium, carbohydrate and fat content and high fiber content. This is the reason why mushrooms are considered good for those aiming for weight loss.
- Mushrooms are an excellent source of potassium. Infact, it is said that there is more potassium in a mushroom than a banana. Since potassium helps lower blood pressure and diminished the risk of stroke, mushrooms are recommended to people suffering from hypertension.
- Mushrooms are rich in copper, a mineral that has cardio-protective properties. A single serving of mushrooms is said to provide about 20 to 40 percent of the daily needs of copper. Mushrooms are believed to help fight against cancer. They are an excellent source of selenium, an antioxidant that works with vitamin E to protect cells from the damaging effects of free radicals.
- White button mushroom have been found to restrain the activity of aromatase, an enzyme involved in estrogen production, and 5-alpha-reductase, an enzyme that converts testosterone to DHT.
- Researchers have suggested that white button mushrooms can reduce the risk of breast cancer and prostate cancer. In fact, extract of white button mushrooms has been found to help in diminishing cell proliferation as well as tumor size.
- Shiitake mushrooms comprise of Lentinan, a beta-glucan that has been associated with stimulation of the immune system and thus, is believed to be helpful in fighting against AIDS. It also helps fight infection and exhibits anti - tumor activity.
- It has been found that mushroom extract helps stop migraine headaches and is beneficial for people suffering from mental illnesses, like obsessive-compulsive disorder

Nutritional value per 100 g (3.5 oz)	
Energy	**113 kJ (27 kcal)**
Carbohydrates	4.1 g
Fat	0.1 g
Protein	2.5 g
Thiamine (vit. B_1)	0.1 mg (9%)
Riboflavin (vit. B_2)	0.5 mg (42%)
Niacin (vit. B_3)	3.8 mg (25%)
Pantothenic acid (B5)	1.5 mg (30%)
Vitamin C	0 mg (0%)
Calcium	18 mg (2%)
Phosphorus	120 mg (17%)
Potassium	448 mg (10%)
Sodium	6 mg (0%)
Zinc	1.1 mg (12%)

Percentages are relative to US recommendations for adults.
Source: USDA Nutrient Database

- Oyster mushrooms are said to be useful in strengthening of veins and relaxation of the tendons

Types of Edible mushroom

There are more than 10,000 varieties of mushrooms. The following are some of the mushroom used in day-to-day life. *Agaricus bisporus* is probably the most widely recognized, easily found and most cultivated mushroom. Commonly known as white mushroom or crimini mushroom. They can be either white or brown in appearance.

1. White button mushrooms (*Agaricus bisporus)*

White button mushrooms are the most common and mildest-tasting mushrooms available in the Indian market.. It can be eaten raw or cooked and are best used in soups, salads and on pizzas. Despite the common belief that these mushrooms are not as healthy as others, these have some interesting health benefits. White button mushrooms are low in calories and sugar. They are rich in protein and due to their exposure to sunlight, mushrooms are a natural non-animal source of vitamin D2; it helps in the absorption of calcium in your body and helps keep your bones strong. It is also rich in vitamin B12 which is an animal-obtained vitamin and so mushrooms are a good option for vegetarians. Also, it is prebiotic and helps improve gut bacteria.

2. Portobello Mushrooms (***Agaricus bisporus***)

Portobello Mushrooms are a native to Europe and North America grasslands, these are one of the most commonly consumed mushrooms in the world. When young, portobello mushrooms are known as white button mushrooms. These mushrooms are impressive because of their size and meaty texture and earthy flavour. Similar to its other varieties, portobello is one of the natural sources of vitamin D. They are rich in copper and selenium which your bod y needs to form connective tissue, metabolize iron and to produce energy and antioxidants. It also has niacin or vitamin B6 which helps metabolize food into energy and synthesizes fatty acids. Vitamin B6 is essential for our body as it is present in more than 100 chemical actions in our body.

3. Shiitake mushrooms (*Lentinus edodes*)

Shiitake mushrooms are one of the popular mushrooms in the world and for a good reason. They are known for their rich, savoury taste and various health benefits. This mushroom is a native of Japan. In Japanese, shiitake means "oak fungus." These have a meaty texture and are chewy, and go well with almost everything. They are popular for their medicinal properties and are found in powdered supplement form in many herbal pharmacies. Shiitake has a rich flavour than most mushrooms. It is usually used in soups, steamed and simmered recipes and even stir-fried in vegetarian dishes. Low in calories, rich in fibre as well as vitamin B, Shiitake mushrooms are good for boosting the immune system, lowering blood cholesterol levels, hardening of the arteries, diabetes and as an anti-ageing agent also it has promising antibacterial and antiviral effects.

4. Oyster mushrooms (*Pleurotus ostreatus*)

Oyster mushrooms are one of the biggest types of edible mushrooms which are most common and versatile. Oysters are easy to cultivate and grow mainly on decaying wood. This edible wild mushroom is now grown commercially across the world and has a slightly sweet, anise-like smell while it has tender flesh, velvety texture and mild flavour. The mushroom gets its name due to its similar appearance to the oyster. Oyster mushrooms are mostly fat-free and a good source of essential minerals and vitamins including niacin, riboflavin, vitamin B6 and thiamin. It also has numerous health benefits such as it lowers cholesterol, boosts heart health, better immune function, and improved metabolic health.

5. Enoki mushrooms (*Flammulina filiformis*) Enoki, also known as Enokitake, winter mushrooms, winter fungus, the edible variety of these mushrooms is small, shiny white caps attached to thin stems, and is crunchy. These mushrooms are usually used in East Asian food and cooking. Enokitake mushrooms are also called golden needle mushrooms. It is known to have a mild and delicate fruity flavour. These mushrooms can be eaten raw and cooked as well as used in salads, soups, sandwiches, and pasta sauces. It has two distinct varieties, wild and

cultivated. the wild form differs in texture, colour, dampness and has dark brown colour, shorter and thicker stem while the cultivated mushrooms have long, slender stems with tiny, firm caps. This variety of mushroom is rich in several minerals and vitamins such as vitamin B3, vitamin B5, vitamin B1, vitamin B2, phosphorus, iron, selenium, thiamin, calcium and copper. The mushrooms also contain healthy amino acids and dietary fibre and are low in cholesterol which helps to improve the immunity system, reduces body fat and increases metabolism. It also improves digestion and reduces the chance of developing allergies.

6. Shimeji mushrooms (*Hypsizygus tessellatus*)

These mushrooms are also known as buna shimeji, beech brown mushroom, clamshell mushroom and they grow on dead beech trees. Native to East Asia, this variety is also found in Northern Europe. They have cracked, speckled brown caps and a white base. When eaten raw Shimeji mushrooms taste bitter and when cooked, these brown-capped clusters are crunchy and have a sweet nutty flavour. It is usually used in stir-fried foods and soups, stews and sauces. It can also be sauteed whole, including its stem. Shimeji mushrooms are a great accompaniment to noodles. It is rich in umami tasting compounds such as guanylic acid, glutamic acid, and aspartic acid. It is cholesterol and sodium-free, low in fat and high in dietary fibre. Also, it is a good source of protein, zinc, B vitamins and copper. It lowers cholesterol, aids weight loss, manages diabetes and is natural anti-cancer food. It is also anti-inflammatory, antimicrobial and anti-parasitic.

7. Porcini mushrooms (*Boletus edulis*)

Porcini mushrooms are one of the most popular mushrooms in Italian Cuisine. These are large mushrooms with a cap that can grow up to 12 inches in diameter. Porcini mushrooms have a few different varieties, are slightly reddish-brown, have a thick stem and are a little sticky to touch. It has an aromatic, woodsy and nutty flavour which makes it a gourmet mushroom and it is loved for its smooth texture. Porcini mushrooms can be used to make meat dishes, sauces, broth, eggs, pasta and vegetarian dishes. Similar to other varieties of mushrooms, Porcini has its own set of health benefits.

8. Paddy straw mushrooms

It is one of the easiest mushrooms to cultivate. Paddy straw mushrooms were first cultivated in India in the year 1940. It is equally popular as white button mushroom for its flavour, aroma, delicacy and nutrients. These straw mushrooms are cold and good for the summer season. They are rich with protein, fibre, iron, vitamin B and vitamin C, also has mineral extra folic acid, potassium and copper. Paddy straw mushroom's health benefits include reduced cholesterol in the digestive system. It has natural insulin which is good for diabetics, the beta-glucan prevents the growth of cancer cells and vitamin D strengthens bones. It also prevents anaemia and is good for heart health.

9. Milky Mushrooms (*Calocybe indica*)

Calocybe indica, commonly known as the milky white mushroom, is a species of edible mushroom native to India. The sturdy all-white mushrooms appear in summer after rainfall in fields and on road verges. Traditionally eaten in West Bengal, it is being grown commercially in several Indian states and other tropical countries. This is the first indigenous mushroom to be commercialized in the country. Mushrooms white in color, gills and stalks white. Mushrooms large with long, thick fibrous stalk. It can be grown on pasteurized or sterilized wheat or paddy straw. Spawn running period 24-28 days. Cropping requires an optimum temperature of 35-38°C, humidity of 85-90%, diffused light and ventilation. Mushrooms can be harvested in 2 flushes after which the entire cycle is repeated. It can be marketed as fresh, dry or as mushroom powder.

Conclusion

In conclusion, edible mushrooms contain essential food supplements and versatile food sources that provide numerous health benefits. Effective management of edible mushroom production is crucial to ensure their continued availability, quality, and sustainability. The study of edible mushrooms and their health benefits continues to be an area of active research, and additional benefits will likely be further discovered. Spent mushroom substrate (SMS) can also be used as an excellent organic manure or for vermicomposting. It is an excellent edible mushroom with high fiber.

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IMPORTANCE AND CONSERVATION OF MANGROVE IN COASTAL ECOSYSTEM

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Abstract

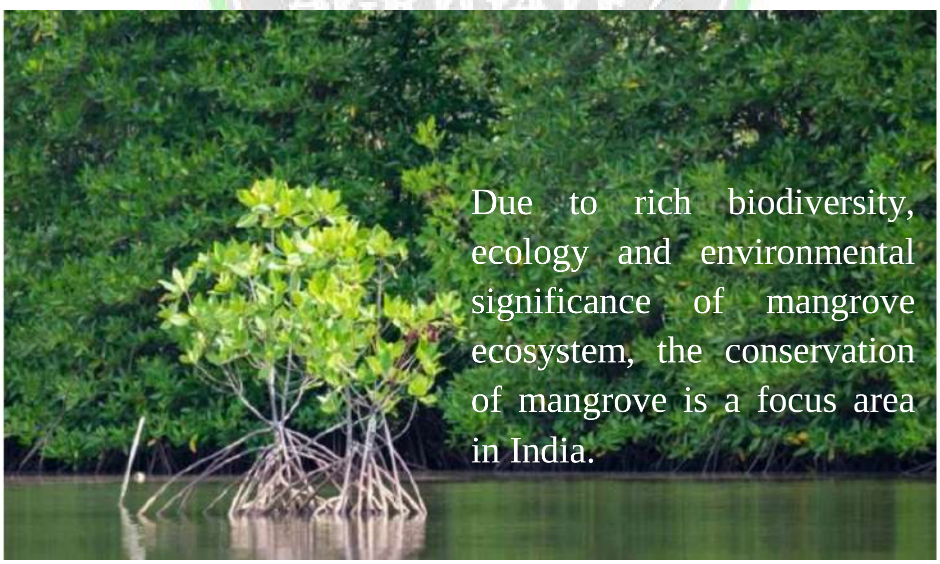
Mangroves serve as nutrient sources, sinks and sediment traps, all of which are essential for coastal ecosystems. They preserve marine systems, nourish fish and other species and sustain food webs. Because they support forestry, fishing and ecotourism, mangroves are economically significant. They may be used for bioprospecting to find beneficial products, compounds and genes resistant to salt. Monitoring mangroves and other coastal ecosystems is crucial for tracking the development of coastal disaster management plans as well as increasing issues of climate change and sea level rise. This abstract emphasizes the need for creative thinking and sustainable management in order to protect mangroves and their ecosystems.

Keywords: Coastal, conservation, mangrove

Introduction

Mangroves are a diversified group of arboreal, blooming plants that can withstand salt and are mainly found in tropical and subtropical areas along coasts in the intertidal zones. The term "mangrove" refers to any tree, shrub, palm or ground fern that is typically taller than half a meter and typically grows in the intertidal zones of marine coastal habitats or estuary borders above mean sea level. They belong to the most productive ecological niches. Mangroves are an important living resource that are rich in diversity and beneficial to the economy and the preservation of coastal areas. Mangroves are sometimes referred to as "inter-tidal forest" or "coastal woodland." Mangrove forests serve multiple ecological functions, including producing woody trees, providing habitat for fin-fish and shellfish, providing habitat for birds and protecting coastlines. They have high biological productivity and resilience, restoring after heavy damage. Mangrove resources offer economic benefits like firewood, fishery resources, honey collection and tourism. They are classified into true mangroves and mangrove associates, with associated flora and fauna including invertebrates, molluscs, crustaceans and vertebrates.

Temperature and moisture have an extremely big impact on the density and diversity of mangroves. Both heat stress and a rise in ocean salinity are brought on by rising temperatures. Sea level rise is not the only element contributing to the problem of salinity in water; additional reasons include variations in river flow of fresh water and the rise in human activities like shrimp farming and the development of salt pans along the coast. In addition to maintaining biodiversity and ecological integrity, protecting mangroves is crucial for ensuring the livelihoods and general well-being of coastal people, reducing the effects of climate change and building resilience in the face of environmental change. Therefore, supporting mangrove protection is not just a moral duty but also an economically responsible choice for the long-term viability and health of coastal ecosystems and the millions of people who depend on them for their livelihood.



Mangrove Cover in India

About 0.1% of the Earth's surface is comprised of mangrove forests, with 15 nations holding approximately 75% of the world's total mangrove forest area. India contains around 3 percent of South Asia's total mangrove cover; the most diverse areas are the Sundarbans in West

Bengal and the Bhitarkanika mangroves in Odisha. The Sundarbans are among the world's most biodiverse mangrove ecosystems. The Bengal tiger, fisher cat, mangrove snakes, goliath heron, saltwater crocodile, and water monitor lizard are among the many species of wildlife that call it home. The mangrove forest cover of the nation has grown by 930 square kilometers since 1987, according to the India State of Forest report. The nation's overall mangrove cover is 4,992 sq km, according to the Forest Survey Report 2021. Coastal states tend to be the most industrialized; in these states, the destruction and degradation of mangrove health and cover is primarily caused by aquaculture, industrial effluent discharge, reclamation of mangrove areas for human settlements and other major factors. The majority of coastal states that continue to lose mangrove cover are those that are most susceptible to the negative effects of climate change, including Tamil Nadu, West Bengal and the Andaman and Nicobar Islands.

Biodiversity Conservation

Hundreds of plant and animal species, such as fish, crabs, birds, and mammals, depend on mangroves as their home. For many economically and ecologically significant species, they serve as breeding grounds, feeding places and nurseries, adding to the overall diversity and resilience of coastal ecosystems.

Nursery grounds

A significant number of the world's fish, shrimp, crabs, and other shellfish find perfect nesting habitats in mangroves. Numerous fish species, including snook, tarpon, and barracuda, take refuge in the mangrove roots as young, mature into adults, and then go out into the open ocean to feed on the seagrass beds. 75 percent of fish that are harvested for commercial purposes are thought to have spent some time in mangroves or to have depended on food webs that originate in these coastal forests.

Home to many species

Thousands of species at various levels of the marine and forest food webs, including bacteria, barnacles, and Bengal tigers, find home in mangrove forests. Insect species find refuge in the trees, drawing in birds that hide in the thick twigs. For hundreds of shorebirds and migratory bird species, such as kingfishers, herons, and egrets, these coastal woodlands are ideal places to nest and rest. Among the mangroves hunt crab-eating macaque monkeys, fishing cats, and enormous monitor lizards, as well as endangered species like olive Ridley turtles, white-breasted sea eagles, tree-climbing fish, proboscis monkeys and dugongs. Furthermore, animals that burrow, such clams and snails, can lay in wait due to the soft soil found beneath mangrove roots. In the rich mud, other species like shrimp and crabs feed.

Coastal Protection

The safeguarding of coastlines is one of mangroves' most important roles. Mangrove trees' extensive root systems maintain shorelines and lessen the effects of erosion brought on by storms, waves, and currents. Mangroves serve as organic barriers that lessen the chance of storm surges and coastal floods by absorbing wave energy. Additionally, they shield inland regions from the eroding effects of currents and tides.

A stable coastline

The silt and sediment carried by rivers and tides that go out to sea are gathered by mangrove roots. The trees prevent shorelines from eroding by stabilizing the earth. Eventually, tiny islands may be formed by seedlings that take root on sandbars and stabilize them over time.

Carbon Sequestration

The storage of carbon dioxide from the atmosphere in the biomass and sediments of mangroves is crucial for mitigating climate change since it contributes to a slower rate of global warming. Because of their remarkable capacity to absorb and retain carbon, mangrove ecosystems are important resources in the fight against climate change on a worldwide scale. Global carbon sequestration and climatic resilience are other benefits of mangrove forest protection and restoration, in addition to protecting biodiversity and providing assistance to coastal communities. To optimize the sequestration of carbon dioxide and maintain the long-term biological integrity of mangroves, it is necessary to safeguard their habitats and adopt sustainable management approaches.

Resources for humans

Many of the materials needed by coastal communities for basic needs are found in mangrove forests. People can pick clams, shellfish and shrimp by walking over the tidal flats during low tide. Fish enter the marshy area at high tide to feed in the sheltering mangrove roots, transforming it into productive fishing territory. The mangrove trees themselves yield timber for constructing homes and boats, as well as fuel, medications and tannins.

Conservation of Mangroves

In India, mangrove forests have been somewhat restored, but considering the rate at which mangroves have been disappearing over the past several decades, this is by no means sufficient. The relationship between climate change, human activity, and coastal ecosystems has to be understood, predicted, and managed using a far more inclusive approach. At the most fundamental level, community training programs must be established in order to provide the necessary knowledge and skills for the preservation and restoration of mangrove ecosystems, as well as public awareness campaigns stressing the importance of mangroves. Mangrove forests have been managed and restored in part in recent years because to various conservation initiatives and policies from the Indian government, non-governmental organizations, and local people. Creating balanced coastal land-use plans that uphold sustainable restrictions on logging and other harvesting operations can improve mangrove conservation. Mangroves should be protected and preserved for the sentimental, religious, and cultural significance they have for the surrounding community. It is essential that the local population takes part in the preservation of mangrove regions and works to stop illegal removal and encroachment. Resource-dependent communities have taken up arms against illegal activity in a few incidents.

Protection of mangroves against climate change receives far less attention than conservation of mangroves in the context of pollution and anthropogenic activity, which is mentioned at least often, if not frequently enough. The health, development, survival, and production of mangroves are significantly impacted by the increase in soil salinity, as already mentioned. The whole mangrove ecosystem is under imminent risk due to extreme climate change. Because a variety of factors contribute to the degradation of the mangrove ecosystem and cannot be addressed separately, it is imperative to use an integrated management approach that involves all stakeholders and takes into account factors like sea level rise, extreme weather, and human exploitation in order to protect and conserve mangroves.

Conclusion

For coastal ecosystems to provide biodiversity, protection and livelihoods, mangroves are essential. However, pollution, habitat loss, deforestation and climate change are hazards to them. Mangroves may be managed sustainably with the use of creative conservation techniques, frameworks for legislation and methods for involving the community. Conservation initiatives can be encouraged by strong laws, strict enforcement procedures and rewards. Including indigenous peoples and local communities in decision-making promotes stewardship and ownership. By acknowledging the interdependence of mangroves with nearby ecosystems, ecosystem-based management strategies might improve resilience. The preservation and rehabilitation of mangrove ecosystems are essential for the health of coastal communities and ecosystems. In order to ensure that mangroves stay healthy, sustainable management techniques and social responsibilities support environmental sustainability and resilience.

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SPACE BREEDING: SPACE INDUCED MUTATION BREEDING FOR CROP IMPROVEMENT

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Abstract

Space research has gained widespread attention and there have been considerable advances in in-depth space exploration. Spaceflight-induced mutation technique or "space breeding," is a technique that uses the genetic variations produced in plant seeds by the space environment that can be reached by recoverable spacecraft (such as recoverable satellites and space shuttles) and high-altitude balloons to identify novel germplasm on the ground from which to develop new crop varieties. The main factors in the aerospace environment are strong Strong cosmic radiation, weak geomagnetic fields, microgravity, hyper clean and super vacuum environment. The seeds are mutated due to high charge and high energy radiations and are evaluated for mutation. This article discusses the detailed mechanism of mutagenesis, effect of cosmic rays on the phenotypic, genotypic and molecular changes observed in the cosmic crop.

Key words: Space mutation, spacecraft, cosmic crops, microgravity

Introduction

Space research has gained widespread attention and there have been considerable advances in in-depth space exploration. Spaceflight-induced mutation technique or "space breeding," is a technique that uses the genetic variations produced in plant seeds by the space environment that can be reached by recoverable spacecraft (such as recoverable satellites and space shuttles) and high-altitude balloons to identify novel germplasm on the ground from which to develop new crop varieties. In other words, it refers to sending seeds to space 200-400 km above the earth's surface using recoverable satellites or recoverable spacecrafts and upon return screening the seeds for induced mutations with highly desirable traits. The crops which are raised from those seeds called as “cosmic crops”.

Main factors of aerospace environment

- Strong cosmic radiation
- Weak geomagnetic fields
- Microgravity
- Hyper clean and super vacuum environment

Mechanism of space mutagenesis

Space environments induce random mutation in plants. The high-charge and high-energy (HEZ) particles of cosmic radiation in space causing multiple chromosomal aberrations. The aberrations were different if HZE particles hit different parts of seeds. The frequency of aberration was the highest when the root meristem or hypocotyl was hit. However, many experimental results show that an increased frequency of aberrations can also be observed in seeds not hit by cosmic particles during space flight.

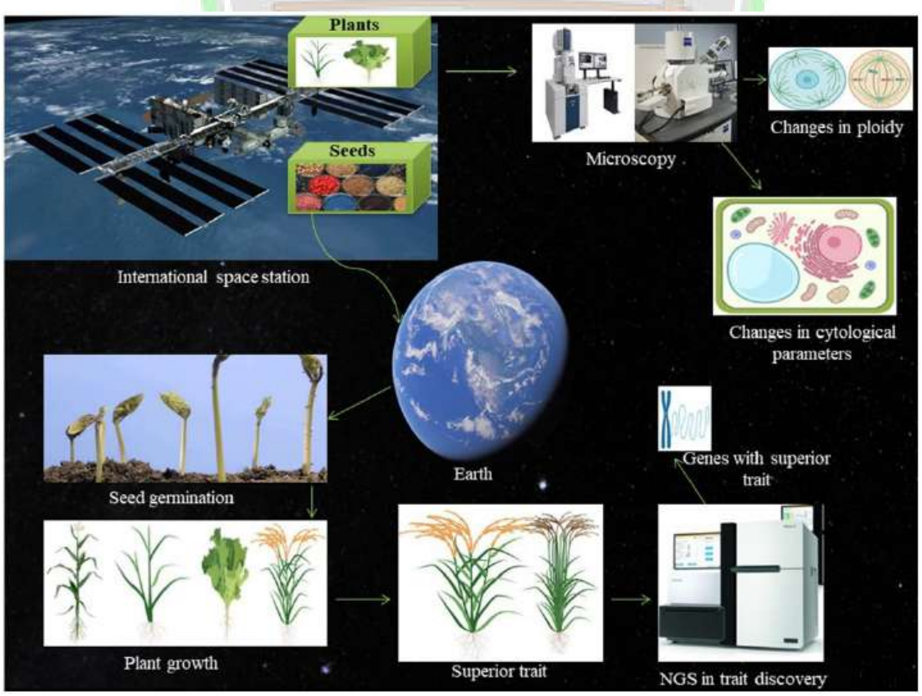

Figure showing a schematic presentation of the space breeding platform

Source credit: Mohanta *et al.*,2021.

The longer the seeds were kept in space, the higher the frequency of aberration, suggesting that microgravity might also have a mutagenic effect on seeds. It is evident that the combined effects of both cosmic radiation and microgravity are the main causes of the genetic changes in plants induced by space conditions. Once the seeds of plants that have evolved under the effects of earth gravity were put in the microgravity environment of space and were affected by various physical radiation factors at the same time, their genomes were inevitably strongly affected. In addition, the strong vibration and blast force associated with spacecraft launch and landing cannot be neglected as causal agents contributing to the increased frequency of chromosomal aberrations during space flight. Space environments does not induce mutations in every seed. Therefore, screening for mutated seed is crucial. Thes seeds were assessed for phenotypic and genotypic characteristics. Numerous molecular markers can be used to confirm the mutations. Luo *et al*., 2007 identified 30.2% polymorphism in rice using RAPD analysis

Understanding the effect of plants on exposure to space environments:

Cell size and differentiation

The structure of a cell can undergo significant changes when exposed to the external environment of space. Under microgravity conditions the structure of the cells may be changed along with changes in starch granules and chloroplast structures due to increased surface tension and reduced mechanical pressure. Space mutation resulted in increased cell elongation. Merkys *et al.*,1975 observed elongated cells in the roots of peas. The changes were observed in the cell differentiation also. A large cell differentiation was observed by Il'ne and Parfenov, 1979 in carrot somatic embryos resulting in longer roots.

Cell division

Space environment induces mutations in the seeds due to high energy high charge cosmic radiation that hits the seeds. The space environment affects the seed germination and plant growth with a decrease in mitotic cell division and an increase in chromosomal aberrations. Mitotic disturbances, such as abnormal migration of the nucleus and unseparated chromatids, have been observed in microspores and root cells of various plant species. Additionally, anomalies in spindle organization and chromosome segregation have been noted, potentially leading to aneuploidy and other genetic abnormalities. Multiple nuclei and fused embryo sac were also reported. (Saunders, 1971). The reduced cell division were seen in anaphase and telophase stage in mung bean (Halster and Dutcher, 1987), telophase stage in lettuce (Merkys and Laurinavichius 1983) and it was reported in the pea seedlings also (Merkys *et al.*, 1976). Even the use of radioprotectants such as 5-methoxytryptamine, aminoethylisothiourea, and cysteine, have not been able to reduce space-induced chromosomal aberrations.

Arabidopsis and Sorghum seeds send to International Space Station as a part of CRS2 NG-18 mission for a period of three months.

Source credit: Sivasankar, 2023

Subcellular changes

Weightlessness and microgravity have profound effects on subcellular organelles within plant cells. Studies have significant reduction in cellulose and lignin content in the cell walls. Halstead and Dutcher, 1987 observed 54% and 18% reduction in the cellulose and lignin content respectively in mung bean plants when grown in space. Furthermore, space-grown seedlings display lower levels of protein and enzymes compared to their Earth-grown counterparts. Changes in other organelles such as reduction in the density of cisternae in endoplasmic reticulum (ER) and swollen mitochondria were reported. The reduction of starch and mucilage content in pea seedings were also reported.

Phenological changes

The seeds which were induced mutation in space and grown in Earth undergo several phenological changes.

Seed germination

Space induced mutation imparts changes in seed germination. However, the sensitivity of the plant to seed germination differs between species and between the varieties of the same species. The seed germination was increased in case of wheat, triticale, barley, maize, cotton, sunflower, soybean, cucumber and tomato. There was no significant difference in germination rate in seeds of rice, millet, pea, sweet pepper, lettuce and tobacco, while seed germination rate decreased in seeds of sorghum, watermelon, eggplant, radish and towel gourd.

Reproductive organs

The plants were treated in space and bought back to Earth completed flowering; however their fertility was reduced, the frequency of recessive mutants increased, and germination success was reduced. The androecium and gynoecium of the space treated plants were degenerated and sterile. The sterility was caused due to unsuitable illumination.

Plant stature

The plant produced fewer leaves, smaller hypocotyl and cotyledonary leaves, smaller and fewer siliques. The plants appeared to be shorter than normal plants. The changes were observed between the F1 and F2 plants also. When the F1 seeds obtained from the flight were planted in the ground, 42% of the seeds biologically completed their life cycle and produced fertile plants. No significant changes in developmental morphology was observed in the F2 plants.

Physiological changes

The micro and macro elemental composition of the cell may change when exposed to space environments. For example, pea plants grown on the Salyut space station showed problems with mineral balance, resulting in an increase in phosphorus and potassium levels in the shoots, but a sharp decrease in calcium, iron, magnesium, manganese, and zinc levels. The mineral imbalance may be due to the inhibition of ATPase activity due to microgravity. From this report, it is clear that the free cellular calcium is more likely to be membrane-bound under hypogravity. Changes in Ca^{2+} levels also trigger the activation of membrane phospholipases leading to changes in the plant metabolism (Palladina et al., 1984)

Genetics and polymorphism

The space environment induces mutations in crop genomes. Molecular markers like random amplified polymorphic DNA (RAPD) markers were used to confirm the polymorphic variations in these plants. A study conducted by Luo *et al.*, 2007 identified 30.2% genetic polymorphism in the rice germplasm containing 201 rice individuals. Studying 24 random primers led to the detection of 189 loci being detected with 4–15 loci per primer. Fragments of the amplicon were between 400 and 2,000 base pairs. Studies using molecular markers can lead to the detection of single nucleotide polymorphisms (SNPs). Luo *et al.*,2007 identified 12 SNP using OPS-19 as a primer in the rice seeds of I-B11.

Mutant varieties developed by space breeding

China is the leader of space-induced mutagenesis experiments. Since 1987, China has conducted experiments of space-induced mutagenesis using recoverable satellites, spacecrafts and high-altitude balloons to carry plant seeds into space. Shijian-8, the breeding satellite specially designed for the space-breeding programme, was launched on September 9, 2006. It carried over 2,000 accessions of plant seeds belonging to 133 species. So far, China has officially approved 66 new varieties of crops including rice, wheat, cotton, rapeseed, sesame, pepper, tomato and alfalfa developed by the space-breeding programme. These new varieties have characters of high yield, good quality and multiple resistances. Some useful rare mutations (high biomass, increased fruit size, less irrigation, disease resistant and temperature resistant) that might make a great breakthrough in crop yield were also obtained. Chinese scientists have discovered “Space rice” or “rice from heaven” variants that are having resistant to pest and climate change.

Conclusion

So far, only three countries China, Russia and United Stated only have achieved the technological mastery. This program requires major investment and technological support. To encourage space borne mutations on Earth breeding with “space stimulation” is now on trend. Liu *et al.*,2009 identified three new techniques of mutation breeding by simulating the space environment. They are Magnetic field-free space (magnetic strength is 20 nT, which is 4×10^{-4} of the magnetic strength of the earth’s magnetic field), single high-energy ion beam implantation (^{7}Li ion beam generated by a tandem accelerator at an energy level of 42.3 Mev), and mixed high-energy particles (E2 beam lines from Beijing Electron Positron Collider). Thus, this technology is highly useful in decreasing cost, improving efficiency, boosting productivity and supporting traditional industry transformation.

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CHALLENGES, OPPORTUNITIES AND POTENTIALS OF ECOTOURISM IN LAKSHADWEEP

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Abstract

Ecotourism is a burgeoning travel trend, lauded for its educational, resource-conserving, and cultural showcasing attributes. It serves as a vital tool for rejuvenating environmentally degraded regions through agricultural endeavours. Developing nations actively seek to expand ecotourism destinations, proven to enhance biodiversity conservation and foster sustainable development, particularly in areas strained by human activities. Lakshadweep, an Indian archipelago, emerges as an ecotourism hotspot, drawing attention for its untapped potential. Despite challenges, including population pressure, inadequate infrastructure, and livelihood concerns, Lakshadweep's ecotourism promises global allure. A comprehensive analysis highlights these hurdles, emphasizing the need for government intervention and strategic initiatives to unlock the region's potential. In the current landscape, with proper policies, Lakshadweep can transform into a sought-after global tourist destination, showcasing the harmonious coexistence of nature, culture, and responsible travel practices

Keywords: Ecotourism, Challenges, Opportunities, Lakshadweep

Introduction

Globally, ecotourism has been proclaimed as the solution to all challenges: a means of financing scientific research, conservation, safeguarding fragile ecosystems, assisting rural communities, fostering development in developing nations, enhancing ecological and cultural sensibilities, establishing environmental consciousness and social responsibility in the travel industry, and fostering world peace. It is often pitched as a substitute for mass tourism, although there has been much ambiguity around the concept's interpretation and use. It is seen as counterintuitive to strike the perfect balance between development and conservation at the same time, not only for ecotourism but also for associated concepts like sustainability and enhancing natural conservation (Bhavani, 2016). In recent times it was found that ecotourism has not achieved the objective of integrating the conservation of biodiversity and the socioeconomic development of adjacent communities; one reason for the existing implementation problems has been the concept itself and how it has been operationalized. Moreover, problems with ecotourism in developing countries include inadequate or non-existent development frameworks, ineffective administration and management, and failure to realise the advantages that have been promised. In recent times after the visit of the Indian Prime minister, the tourism potential of Lakshadweep has been discussed across the country. Hence the present article comprises the potential opportunities and challenges of Ecotourism in Lakshadweep

About Lakshadweep

Lakshadweep, a 36-island group, renowned for its sun-kissed beaches, translates to "a hundred thousand islands" in Malayalam and Sanskrit. As the smallest Union Territory in India, it spans 32 sq km, comprising 10 inhabited islands, three reefs, five submerged banks, and twelve atolls. Kavaratti is both the capital and main town. Situated in the Arabian Sea, 220-440 km from Kochi, these islands offer natural beauty, sandy beaches, rich flora and fauna, and a relaxed lifestyle. With a tropical climate, temperatures range from 27 to 32°C. The warmest months are April and May. Monsoon season halts ship-based tourism, making October to March the ideal visiting period. The South West Monsoon, active from June to October, brings 10–40 mm rainfall, with 70–75% humidity. Light to moderate winds prevail from October to March.

Challenges of Ecotourism in Lakshadweep

A. Environmental Impact

1. Fragile Ecosystems

The islands, which are experiencing the effects of climate change, may bear the burden of increased tourism, with significant financial costs to the local population associated with such plans. The group of islands is already dealing with swift erosion, a rough sea, and warming waters. However, the extensive human meddling may put the islands, which are made up of beaches, sand dunes, lagoons, and reefs in even greater jeopardy.

2. Coral Reefs and Marine Life

Lakshadweep, known as the coral paradise of Arabian sea, constitutes a group of islands lying scattered, at a distance of 220 to 460 kms. away from the Kerala coast. The alarming loss of coral reefs has already turned fatal for all the atolls in the island cluster. A research found that coral mining, pollution, dredging of navigational channels, and damaging activities like blast fishing pose a threat to Lakshadweep's coral reefs. The beaches and sand dunes of the archipelago are being severely impacted by the sea level rise brought on by global warming.

B. Cultural and Social Impacts

The cultural disparity between the tourists and the islanders is yet another factor of discontentment. The type and magnitude of tourism development should be compatible with the environment and socio cultural characteristics of the local residents. The inhabited islands have limited carrying capacities and further expansion possibilities in terms of creation of land based facilities are limited. Availability of vacant land is scarce and most of the inhabited islands have very high population density. The traditions and cultural habits of the islanders vary widely with that of the visitors. Guard against negative impact of tourism on the society at large (Social disharmony, cultural tensions, undesirable exploitation) is much needed.

C. Infrastructural and Logistical Challenges

Transportation challenges between the island and mainland, along with port issues, deter positive experiences for tourists. The absence of an international or sizable airport nearby discourages foreign visitors despite the attractiveness of destinations. Notably, Male Island in the Maldives, despite its small size, boasts a significant international airport, facilitating progress in tourism on deserted islands. However, insufficient inter-island ferry services impede transport infrastructure. While the islands offer beaches and water sports, the absence of land-based attractions like theme parks hinders visitor satisfaction. The lack of such features leads to short average visitor stays, highlighting the need for diverse attractions and improved transportation.

D. Institutional constraints are too many operating in the way of tourism growth.

- The existing CRZ Act when strictly enforced does not provide adequate space for development in certain narrow strips of islands.
- Restriction on entry of foreign visitors (International tourists are allowed only in selected islands) automatically brings down the number of high-spending tourists.

- Need for entry permits to all visitors and special permits for foreign tourists. Enforcement of prohibition in all inhabited islands.
- Lack of policy initiatives for private sector participation in critical sectors like transportation, accommodation, etc.

Opportunities for Ecotourism in Lakshadweep

The most outstanding strength of the islands is their immensely attractive seascape and the marine wealth. (The blue water lagoon, corals, coral reefs).

A. Sustainable Tourism Practices

Sustainable tourism practices are essential for minimizing the negative impacts of tourism on the environment, local communities, and cultures. Here are some key points on sustainable tourism practices:

1. **Eco-friendly Accommodations**
   - Utilize renewable energy sources, such as solar or wind power, to reduce the carbon footprint of accommodations.
   - Implement water conservation measures, like water-saving devices and reuse/recycling of water.
   - Design and construct buildings with minimal impact on the local ecosystem.
2. **Responsible Tourist Behavior**
   - Encourage tourists to follow ethical guidelines, such as respecting local customs and traditions.
   - Promote the "Leave No Trace" principle, emphasizing the importance of minimizing impact on natural areas.
   - Educate visitors about the fragility of ecosystems and the importance of preserving local biodiversity.

B. Biodiversity Conservation

1. **Rich Marine Biodiversity**
   - Lakshadweep is renowned for its diverse marine ecosystems, including coral reefs, lagoons, and extensive underwater flora and fauna.
   - The region hosts a variety of species, including various types of fish, crustaceans, molluscs, and coral species.

2. **Coral Reef Protection**
   - Coral reefs in Lakshadweep are vital for marine biodiversity and act as breeding grounds for numerous marine species.
   - Conservation efforts focus on protecting coral reefs from threats such as coral bleaching, overfishing, and physical damage.
3. **Marine Conservation Programs**
   - Implementation of marine conservation initiatives and programs to monitor and safeguard marine life.
   - Research projects to understand the ecology of the marine environment and identify key conservation areas.
4. **Protected Marine Areas**
   - Designation of marine protected areas (MPAs) to restrict human activities and provide safe havens for marine life.
   - Balancing tourism activities with the need for protected zones to ensure sustainable biodiversity.
5. **Endangered Species Protection**
   - Conservation efforts targeted at endangered marine species, such as sea turtles and certain species of fish.
   - Rehabilitation and protection of nesting sites for endangered species.

C. Community Involvement

1. **Community Engagement**
   - Foster partnerships with local communities to ensure they benefit economically from tourism.
   - Involve local residents in decision-making processes related to tourism development. Support community-based tourism initiatives that empower local businesses and individuals.
2. **Cultural Sensitivity**
   - Develop cultural awareness programs for tourists, promoting respect for local customs and traditions.
   - Encourage tour operators to offer culturally immersive experiences that contribute positively to local heritage.

- Ensure that tourism activities do not disrupt or exploit indigenous cultures.

Potentials of Ecotourism in Lakshadweep

A. Economic Benefits

1. **Revenue Generation:** Ecotourism attracts visitors who are willing to pay for unique and sustainable experiences in natural environments. This generates revenue for local businesses, including accommodations, tour operators, guides, and local artisans.
2. **Job Creation:** The growth of ecotourism often leads to the creation of new jobs, ranging from tour guides and park rangers to hospitality and transportation services.
3. **Diversification of Income:** Many communities that engage in ecotourism find that it provides an alternative and sustainable source of income. This diversification is crucial, especially in areas where traditional industries may be vulnerable to economic downturns.
4. **Infrastructure Development:** Investments in infrastructure like roads, airports, and communication networks for ecotourism not only benefit tourists but also improve the overall quality of life for local residents and communities

B. Conservation and Preservation

1. **Conservation Funding:** Ecotourism can serve as a source of funding for conservation initiatives. Entrance fees to natural reserves and parks, for example, can be reinvested into habitat protection, wildlife conservation, and environmental education programs.
2. **Cultural Preservation:** Ecotourism often emphasizes the preservation of local cultures and traditions. This can lead to the development of cultural tourism, providing economic incentives for communities to maintain and showcase their unique heritage.

C. Global Recognition

1. **Unique Natural Attractions:** Travelers seeking unique and untouched natural environments are drawn to destinations that prioritize conservation and sustainable practices.
2. **Cultural Heritage:** Ecotourism often integrates cultural elements, highlighting the significance of indigenous communities and their traditional practices..
3. **International Media Coverage:** Successful ecotourism initiatives often attract attention from international media outlets.

4. **Social Media Impact**: In the age of social media, travellers share their experiences instantly with a global audience.
5. **Collaboration with Global Conservation Organizations:** Partnerships with renowned global conservation organizations can enhance a destination's credibility and recognition.

Government Initiatives and Policies

A. Policy initiatives

1. Spread awareness among locals as well as visiting tourists on the ecological sustainability of the tourism promotion (Formation of 'Green Army'– voluntary group).
2. Selective approach on CRZ laws.
3. Explore possibilities of relaxation on entry permits rules. (Initially for domestic tourists). This needs to be done strictly within the carrying capacity of the islands.
4. Selective relaxation on prohibition rules.
5. Tourism policy declaration with importance of 'high priority' industry status.
6. Policy on privatisation for support services as well as tourism projects.
7. Close co-ordination among all key departments (Tourism, Port, PWD, Electricity, Environment and others)

B. Government initiatives

1. A full-fledged Government Tourism Department under a Government Secretary with independent charge.
2. Full time Director for Department of Tourism, Information and Publicity.
3. Reorganization of SPORTS into Lakshadweep Tourism Development Corporation with heavy dose of professionalism at all managerial levels.
4. Segregation of entire group of islands into 4 separate groups
5. The SPORTS office at these centres will look after the entire gamut of developmental programmes in the respective islands.
6. Upgrading the aqua sports centre into a 'centre of excellence' in Kadmat island
7. Constant vigil on upgrading the standards and its propagation in aqua sports markets of Europe is an extreme necessity.

Conclusion

At present, in order to sustain these ecotourism places as key hubs for expanding traveller numbers, the heart of varied nature's landscapes and biodiversity serves as key draws. Therefore, the main goal of the stakeholders is to minimize such threats and problems. Finally, with careful planning and management, the negative effects can be minimized and the ecotourism site can be strengthened for future growth.

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CITRUS BY PRODUCT UTILIZATION: "FROM TRASH TO TREASURE IN THE FOOD INDUSTRY"

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Abstract

Citrus fruits are globally renowned as one of the most cultivated fruit crops, often utilized in the production of various value-added products such as juices, jams, and jellies. However, this leads to the generation of significant agro-waste, including peels, pomace, and seeds. The accumulation of such by-products presents substantial challenges concerning environmental impact, health concerns, and economic losses. Recognizing these challenges, there has been a noticeable shift towards unlocking the untapped potential within citrus by-products. Innovative approaches are emerging, aiming to transform what was once considered waste into valuable resources. This transformation is gaining attraction as industries increasingly acknowledge the versatility and value of citrus by-products, prompting the development of novel methods and applications for their utilization. These initiatives are aimed towards harnessing citrus waste to create valuable resources with diverse applications, particularly within the food industry. This article explores the significance of utilizing citrus waste and its potential impact on various sectors.

Global Production

Citrus fruits are among the most extensively cultivated fruits globally, found in both the Southern and Northern Hemispheres. Originating in the Himalayan region of southwestern China, northeastern India, and northern Burma, citrus cultivation has spread to over 140 countries (Sharma et al., 2019). According to the Food and Agriculture Organization (FAO), global citrus production reached approximately 144 million tons in 2019, covering 9.89 million hectares. By 2021, citrus fruits became the second largest fruits produced globally, with over 161.8 million tons, grown across more than 10.2 million hectares. China, Brazil, and India are among the largest citrus-producing countries. China's high productivity is attributed to production of tangerines and other citrus fruits. Brazil on the other hand leads in orange production and is the top exporter of orange juice.

India holds the title of the world's largest producer of lemons and limes. The substantial production and consumption of citrus fruits stems from their exceptional sensory qualities, including flavor, taste, and aroma, coupled with their nutritional richness (Suri et al., 2022). Oranges, lemons, grapefruits, mandarins, kumquat, lemons and limes are the most prevalent citrus varieties cultivated worldwide (Liu et al., 2022). Currently, citrus fruit production exceeds demand, leading to the generation of approximately 10 million metric tons per year of processing waste thus raising a global environmental concern (FAO, 2021). While the handling and management of fruit waste pose substantial challenges in waste management practices, there lies a significant opportunity for sustainability and resource optimization through its utilization. Reutilization of fruit waste, holds vast untapped potential for a multitude of purposes. This will mitigate environmental impact and simultaneously enhance the value of the agricultural sector (Borges and Pimentel, 2020). This underscores the importance of exploring innovative strategies to harness the latent value within fruit waste, thereby contributing to both environmental conservation and economic development.

Components

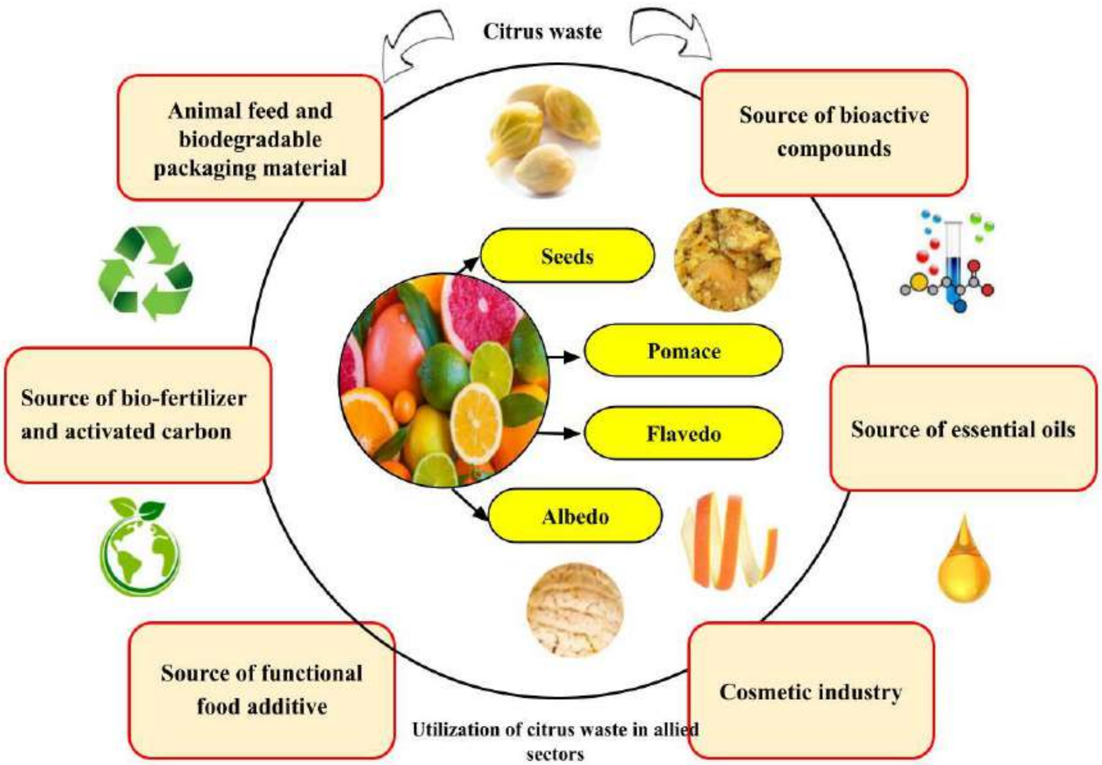
Citrus fruit waste encompasses various residual components, including peels, pulp, and seeds, which are often discarded. Peels consist of two main parts: the flavedo, rich in essential oils, carotenoids, phenols, and flavonoids, and the albedo, which is abundant in pectin, cellulose, hemicellulose, lignin, and dietary fibers (Suri et al., 2022). Pulp waste, known for its fiber content such as cellulose, hemicellulose, and lignin, also contains citrate sugar, pectin, essential oils, limonene, and polyphenols like flavonoids and natural antioxidants (Suri et al., 2022). Conversely, citrus seed waste serves as a reservoir of essential oils and limonoids (Dubey et al., 2023).

Valorization

The valorization of citrus fruit waste is vital for mitigating adverse environmental impact caused by the substantial quantities of waste generated. Sustainable valorization techniques are essential for leveraging citrus processing waste-derived products to contribute to the bio-economy. For instance, fruit pomace, the solid residue remaining after juice extraction, is rich in dietary fiber, antioxidants, and bioactive compounds. The pomace is used as animal feed, dietary supplements, or functional food ingredient. It not only reduces waste but also enhances nutrition and health outcomes (Dubey et al., 2023).

Citrus peels are rich source of essential oils. These oils, derived from the peel's outer layer (flavedo), contain aromatic compounds such as limonene, which impart the characteristic citrus flavor and fragrance to various culinary delights. Widely used as natural flavoring agents in bakery items, citrus essential oils offer a spectrum of flavors, colors, and functional properties that enhance the taste, appearance, and flavour profile of food products. Moreover, citrus peels are rich sources of bioactive compounds, including flavonoids and phenolic acids, known for their antioxidant and antimicrobial properties, which inhibit oxidation and microbial growth, thereby extending shelf life. Additionally, citrus peel extracts can be incorporated into functional foods and dietary supplements to promote health and well-being (Liu et al., 2022).

Often overlooked as waste, citrus seeds harbor untapped potential for utilization in the food industry. These seeds, abundant in essential oils and limonoids, can enhance various sensory attributes of food products. The oil extracted from citrus seeds adds a distinct citrus aroma and flavor profile to a wide range of products. Citrus seed flour, containing protein, dietary fiber, and bioactive compounds, serves as a valuable addition. Moreover, citrus seeds contain antioxidants such as flavonoids and vitamin C, contributing to their potential health benefits when incorporated into food products (Suri et al., 2022). Furthermore, fruit pomace serves as a rich source of bioactive ingredients, including dietary fibers, carbohydrates, phenolics, and natural antioxidants, with potential applications in both food and pharmaceuticals. Thus, the utilization of citrus by-products underscores their invaluable role in enhancing the functionality and nutritional value of various food products. Thus the valorization of citrus fruit waste not only reduces waste but also contributes to improving nutrition and health outcomes through the utilization of its bioactive compounds and antioxidants, ultimately promoting overall well-being.



Valorization of Citrus Waste				
Application	**Citrus waste**	**Usage**	**Function**	**Outcome**
Flavoring Agent	Citrus peels and essential oils	Baked goods, confectionery, beverages, and savory dishes	Enhance flavor and aroma	Enhancing sensory appeal
Functional Food Ingredients	Citrus peel extracts	Functional foods and dietary supplements	Bioactive compounds like flavonoids and phenolic acids	Antioxidant, antimicrobial properties, contributing to the health-promoting benefits
Dietary Fiber Enrichment	Citrus pomace	Enriched food products with high fiber content,	Dietary fiber	Improve nutritional profile and promote digestive health
Food Preservatives	Citrus peel extracts	Extended shelf life of perishable products	Bioactive compounds, antioxidants	Inhibit oxidation and microbial growth Maintains shelf stability

Nutrient-Rich Ingredients	Citrus seed flour	Nutrient-rich formulations	Rich in protein, dietary fiber, and essential nutrients	Improving nutritional index
Natural Food Colorants	Citrus peel extracts	Imparting vibrant hues to food products-fruit flavored beverages, desserts, and candies.	Antioxidants, pigments	Natural colorants are protective and healthy
Infused Beverages	Citrus peel extracts and essential oils	To enhance flavor and the nutritional value - Fruit juices, flavored water, teas, and cocktails	Volatile components, bioactives	Add a refreshing citrus twist and provide additional health benefits
Snack Foods	Citrus peel powders or extracts	Enhance flavor profile- snack foods, such as chips, crackers, and popcorn	Flavoring compounds	To create unique flavor profiles and improve appeal
Dairy Products	Citrus peel extracts	Introduce citrus flavor variations	Yogurt, ice cream and cheese	Contribute to the overall nutritional value and antioxidant content of these products
Concentrated Ingredients	Citrus peel powders, oils, and extracts	Incorporate into various recipes and formulations	Bakery, conectionary	For food manufacturers ensuring consistent flavor and quality

Conclusion

The utilization of citrus waste emerges as a crucial strategy in mitigating the challenges posed by the substantial volumes of waste generated during processing. Despite the exceptional sensory properties and nutritional richness of citrus fruits, their by-products have traditionally been discarded. However, through innovative valorization techniques, a wealth of valuable resources hidden within citrus waste has been unearthed, contributing significantly to sustainability and resource optimization in the agricultural sector. The global significance of citrus production underscores the urgency of harnessing the potential of citrus waste. With citrus fruits ranking among the most produced and economically important crops worldwide, effective management and utilization of their by-products are imperative. By using citrus waste into essential oils, pectin, animal feed, biodiesel, and antioxidants, we not only reduce environmental pollution and waste disposal costs but also foster economic growth and innovation. Through collaborative endeavors across industries and sectors, we can fully unlock the potential of citrus waste and usher in a brighter, more sustainable future for generations to come.

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DESMODIUM- A VALUABLE LEGUME FODDER CROP

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Introduction

Desmodium, botanically called *Desmodium intortum* (2n: 22) belonging to plant family Fabaceae and subfamily Papilionoideae is a summer growing perennial forage legume, highly palatable protein supplementary feed during summer and autumn. It is grown throughout the tropics and well established in high rainfall areas of subtropics and elevated hilly areas. It is also called Beggar lice, Beggar's Lice, Hitch Hikers, Linear-leaf Tick clover, Tick's Clover, Tick-trefoil. It is a nitrogen-fixing fodder crop, it has been introduced to the rest of the world's tropics, including Africa, India, Australia, New Guinea and Taiwan

BOTANICAL DESCRIPTION OF DESMODIUM

Habitat

Desmodium grows well in subtropical areas receiving atleast 1200 mm rainfall with warm season and late season rainfall for seed setting. It can tolerate light frost and come up well even in acid soil with a pH range of 4.5 to 5, but not in salaine soil.

Habit

A large trailing and scrambling perennial (pluri-annual) legume.

Root: A strong taproot with root nodules.

Stems:

Grooved, hairy and reddish-brown in colour, branching freely, climbing pubescent stem that is rooting at the nodes.

The stems are green or sometimes red, 1.5 to 7.5 m long and about 7 mm in diameter.

Leaves:

Trifoliately compound. Upper leaf surface is lighter in colour and covered with fine hairs. leaflets, each commonly about 4cm long and 3cm wide. reddish brown to purple in colour. Pulvinus present only on the middle leaflet. Lateral veins curving inside the blade margins but not forming loops. Underside of the leaflet blades clothed in pale straight hairs held at an angle of 30-45.

Inflorescence:

The flowers are borne on terminal compact racemes.

Flowers:

Small (less than 1cm long), deep lilac to deep pink in colour., borne in groups at the ends of the stems.

Calyx:

About 5 mm long, sparsely hairy on the outer surface. Two calyx lobes fused almost to the tip.

Corolla:

About 8 mm long, glabrous. deep lilac to deep pink in colour.

Androecium:

Stamens 10, the filaments of nine stamens fused to form a tube. Free part of the filaments alternately long and short. One stamen free. Anthers less than 1 mm long.

Gynoecium:

Ovary clothed in pale prostrate hairs. Ovules about ten. Style and stigma glabrous. Style about 10 mm long.

Fruit:

Narrow segmented pods to 5 cm long, each holding 8 - 12 seeds. The segments break up when mature and, being covered with short hooked hairs, will stick to hair or clothing.

Seeds: Flattish, yellow-brown, oval-kidney shaped seeds about 1.5 mm long; about 595,000 seeds per kg.

Pollination:

It is an often cross pollinated forage legume with out-crossing ranging from 8 to 30 per cent. Flowers may require tripping by bees or other insects for pollination and for good seed.

Center of Origin:

Native of central America or Mexico.

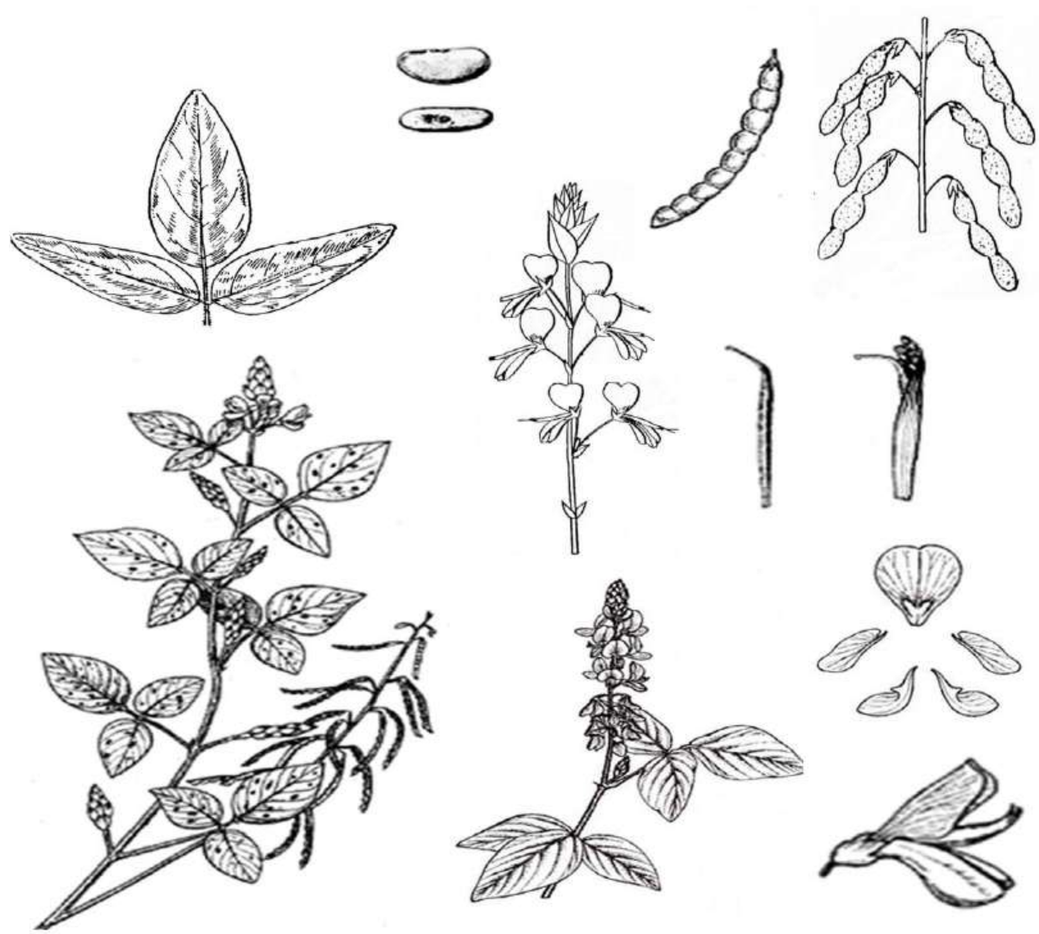

Fig. 1. Desmodium intortum- Botanical illustration

Related species:

1. *Desmodium uncinatum*
2. *Desmodium adscendens*
3. *Desmodium wynaadense*
4. *Desmodium sessilifolium*
5. *Desmodium rotundifolium*
6. *Desmodium grans-hi-res*

7. *Desmodium gangeticum*
8. *Desmodium incanum*
9. *Desmodium perplexum*
10. *Desmodium acanthoclada*

CULTURAL MANAGEMENT

Desmodium has very small seeds and requires a well prepared seedbed for establishment. It can be sown from spring to mid-summer or later in frost-free areas. It is possible to propagate desmodium by rooted cuttings. Once established, Desmodium grows vigorously and spreads rapidly into ungrazed areas because of its stolons. Desmodium is usually sown in association with a grass or another legume. It grows well with a wide range of forage grasses. Desmodium is a N-fixing legume that has been reported to fix 213-300 kg N/ha/year in the soil, but it transfers only 5% of this nitrogen to its companion grasses. Desmodium is generally introduced into natural pastures to increase the DM yield. In Brazil, 3 years after its introduction, Desmodium still represented 38 to 53% of the pasture (Silva et al., 1993). Desmodium may be grown in association with Napier grass (*Pennisetum purpureum*) in order to increase the protein content of the stand (from 11% in a pure Napier stand to 15% in mixed sward). The *in vitro* OM digestibility of Napier/greenleaf forage decreased with maturity, from 70 to 56%. Yield was favoured by late cuttings (120 days), with quality (protein up to 18% DM) favoured by early cuttings (60 days). It has moderate needs for added fertilizers, only P, S, K and Mo being required. It is susceptible to pests such as the Pyralidae caterpillars *Hedylepta dnopheralis* Mab. and *Hedylepta indicata* F., that can cause heavy losses at the end of the hot season.

USES OF DESMODIUM

1. It is cultivated as a long term irrigated pasture legume
2. It is also grown for cut-and-carry forage legume.
3. Produces good quality silage when mixed with 8 per cent molasess on fresh matter basis.
4. It is used as a good stanover feed during autumn and winter in frost free areas.
5. It fixes admospheric nitrogen to the tune of 12 to 19 tonnes of N per hectare per annum and therby improve the soil fertility.
6. Grown as a cover crop in coffee plantations.

7. Increases the organic carbon content of the soil where it is cultivated.
8. It is grown as a cover crop in Agroforestry system to prevent soil errosion.

FODDER VALUE OF DESMODIUM

Green fodder:

Desmodium get well established after 3 to 12 weeks based on growing conditions. Once established, for cut and carry system, longer cutting intervals of 30 to 85 days shall be given to get higher yield. Desmodium yields 12 to 19 t/ha/year.

Pasture:

It is also suitable for pasture legumes. Initial grazing should be very light and after a period of establishment (3 to 12 weeks) moderate to heavy grazing can be allowed on rotational basis.

Hay and Silage:

Desmodium act as a good standover hay feed during autunm and winter in frost free areas. Good quality silage can be made with mixing green matter with 8 per cent molasses on fresh weight basis.

Nutritive value:

Nutrients present based on dry weight basis includes Crude protein 15%, crude fiber 30%, Neutral digestible fiber 51%, Acid digestibile fiber 37%, Lignin 9% and ash 7.5 %. This forage is rich in Calcium, poatassium, manganese and Copper.

Palatability:

Palatable and eaten well by cattle and sheep, but not as that of Siratro.

Toxicity:

Desmodium contains high levels of condensed tannins that may limit the digestibility of the feed to 55 to 60 per cent. But no undesiarable reports have been observed in animals.

ADVANTAGES OF DESMODIUM

1. Fixes admospheric nitrogen to the tune of 213 to 300 kg/ha/year.
2. Has good early and late season vigour and hence act as a standover feed during autumn and winter.
3. It is shade tolerant and can be grown as a cover crop in coffee plantations.
4. As a companion crop it can be grown with tussock grasses such as Guinea grass and Napier grass.

5. It is tolerant to waterlogging and flooded conditions.

6. It spreads vegetatively along the trailing stems.

LIMITATIONS OF DESMODIUM

1. Desmodium has low seedling vigour.
2. It cannot tolerate heavy grazing and has poor persistence
3. It is susceptible to Pyralidae caterpillars.
4. Poor tolerance to drought and salinity.
5. Considered as an invasive weed due to its shade tolerance and ability to climb over other plants and tree species.
6. Because of its high condensed tannin content, its digestibility is reduced to 60 per cent in cattles.

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EDGE LUCERN- MULTIPURPOSE FORAGE LEGUME CROP

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Introduction

Hedge lucern, botanically called *Desmanthus virgatus* (2n: 28), belonging to plant family Fabaceae and Sub family Mimosoideae is an highly variable perennial forage legume adapted to tropical and subtropical regions with a wide range of temperature including frost condition and rainfall ranging from 250 to 2000 mm. It is mostly found in the coastal thickets, roadsides and heavily disturbed areas from sea level to altitude of 2000 m, but most commonly found below 500 m. Hedge lucern as its name indicate can be grown as an hedge or fence as a forage crop as well as ornamental crop in gardens and recreation centers. Hedge Lucern is also called as dwarf koa, desmanthus, bundle flower, ground tamarind, and virgate mimosa.

Botanical Description of Hedge Lucern

Habitat:

It can grow in a wide range of temperatures including frost condition and rainfall regimes ranging between 250 and 2000 mm rainfall. It can grow in neutral to alkaline soils, but not in acid soils.

Habit: It is a highly variable erect or decumbent perennial woody sub-shrub that grows up to 2.5 to 3 m.

Root:

It has a deep tap root with a strong branching that produces root nodules.

Stem:

The stem is sparsely branched, rather angular, often hollow, glabrous or slightly pubescent at the top. The stems are slender, pithy in the center, angular, green turning brown.

Leaf:

The leaves are alternate, compound bipinnate. They are held by a small petiole of 3 to 7 mm long. The stipules are linear, slightly membranous at the base and consist mainly of the central rib, 3 to 6 mm long. There is a discoid gland, of red colour, 1 to 2.5 mm, present at the top of the petiole. The leaves are bipinnate, with 1 to 4 pairs of opposite pinnae, on which 6 to 15 pairs of opposite leaflets are inserted. The latter are oblong to narrowly obovate, slightly asymmetrical at the base and with rounded top. They are 4 to 12 mm long and 1.5 to 3 mm wide. The margin is entire, cilliated and venation is not clear.

Inflorescence:

The inflorescence is a spherical to ovoid powder buff like head or capitulum, consisting of 6 to 10 flowers. It is held by a peduncle, The inflorescence bears perfect, male, and sterile flowers.Sterile flowers zero to eight numbers at the base of the head; one or few male flowers towards the base of the head above the sterile flowers, and below the perfect flowers; perfect flowers 3–14 in apical position.

Flower:

Flowers are perfect or staminate or staminodal, incomplete or complete and actinomorphic. Sterile flowers are smaller than the perfect and male flowers and have white or pink staminode.

Calyx:

Five sepals fused to form a tube.

Corolla:

Five greenish fused petals forming a tube, twice the length of the calyx (long of 3 to 4 mm).

Androecium:

There can be 10 white stamens or 10 staminodes that are 7 to 10 times the length of the corolla. Ten stamens in two whorls of five each, maturing in different times. Anthers caducous, dorsifixed, oblong; connective broader and darker than the thecae.

Gynoecium:

Ovary superior with a single locule.; ovary 1.5 to 2.4 mm long, linear and glabrous. Style 1.9 to 4.4 mm long, not exserted beyond the stamens.

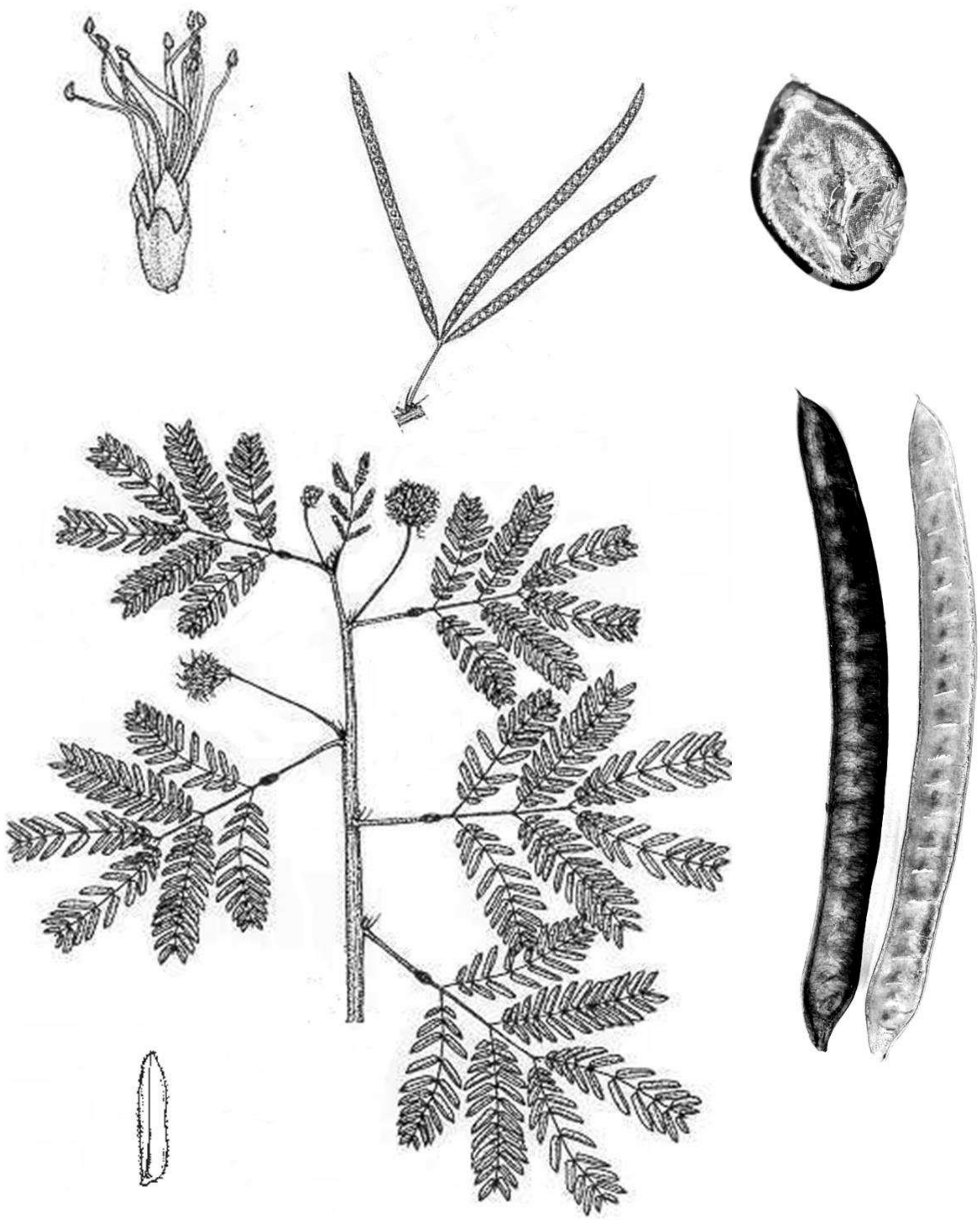

Fig. 1. *Desmanthus virgatus*- Botanical illustration

Fruit:

The fruit is a shortly pedicellate or sessile pod. The pods are in bundles of 2 to 6 at the top of the peduncle. The pod is linear, dorsi-ventrally flattened; have a woody, coriaceous pericarp. Fruit dehiscence along both the sutures, rarely along one suture or indehiscent.

Seed:

The seed is oblique or elliptical or roughly rhombic; it measures 2.5 to 3 mm long. The tegument is smooth, dark brown, dotted with small white scales.

Pollination:

It is basically a self-pollinated species and sefl-compatible in nature. But cross-pollination by insect vectors increases the seed set.

Origin: Mexico

Related species:

1. *Desmathus leptophyllus*
2. *Desmathus pubescens*
3. *Desmathus reticulatus*
4. *Desmathus pumilus*
5. *Desmathus obtusus*
6. *Desmathus oligospermus*
7. *Desmathus acuminatus*
8. *Desmathus hexappetalus*
9. *Desmathus glandulosus*

CULTIVATED FORMS OF DESMANTHUS

1. *Desmanthus virgatus* var. *virgatus:* Erect plant type suitable for pasture and grow well in fertile clay soils.

2. *Desmanthus virgatus* var. *glandulosus:* Erect plant type suitable for rocky hillsides, plains and roadsides associated with limestones.

3. *Desmanthus virgatus* var. *depressus:* Prostrate plant type, widespread as weed of lawns and dry pastures, disturbed ground and roadsides. Great soil tolerance.

CULTURAL MANAGEMENT

Hedge lucerne is very adaptive and can grow under a wide range of temperatures (including frost conditions) and rainfall conditions (from 250 to 2000 mm). Hedge lucerne prefers neutral to alkaline clay or clay-loam soils but is also known to do better than *Leucaena* on acid infertile soils. It is also tolerant of sodic soils. Hedge lucerne is a very drought-tolerant legume. It withstands frost and fire (which may suppress buried seed dormancy) since it can regrow from the crown. Hedge lucerne tolerates severe competition from grasses and herbs but disappears when overtopped by trees since it does not withstand shaded conditions.

Yields of hedge lucerne range from 7.6 t DM/ha in the humid tropics (2000 mm rainfall) to 2-2.4 t DM/ha in low rainfall (600-750 mm) areas. It can withstands regular cutting, and plantations can be cut for feed 4or 6 times a year. In drought-prone areas, hedge lucerne is one of the most resistant legumes and was able to persist under grazing over a 14 year period. It was found less suitable than *Leucaena leucocephala* (lower protein and *in vitro* OMD) for grass-legume forage production. The contribution of *Desmanthus virgatus* to pasture yield is higher in harsh environments than in more favourable ones, so that it is relatively more valuable on soils of moderate fertility in environments with a marked dry season.

USES OF DESMANTHUS

1. Grazed by herbivores in the native range.
2. Component of improved permanent pastures in the dry tropics.
3. Can be used for hay, but requires rapid drying to avoid significant leaf drop.
4. Desmanthus helps to put weight on cows
5. It helps to control soil erosion, especially on slopes.
6. It is grown as an hedge species of garden as a protective fencing vegetation.
7. Hedge lucerne, provided it is inoculated with adequate rhizobium strains, is a good N-fixing legume.
8. Hedge lucerne is an efficient nursery-stage host for highly priced sandalwood

FODDER VALUE OF DESMANTHUS

Green fodder:

This is a fodder crop suitable for harsh dry environment than favourable environment. *Desmanthus virgatus* withstands regular cutting, and plantations can be cut for feed 4 or 6 times a year. In drought-prone areas, hedge lucerne is one of the most resistant legumes and was able to persist under grazing over a 14 year period. Hedge Lucern is very tolerant to regular cutting. The yield of green fodder is about 7.6 t Dry matter/ha/year.It is one of the low yielding forage legume.

Nutritive value:

Crude protein 21%, Neutral digestibile fiber 42%, Acid digestibile fiber 35%, tannin 2-3%.

Palatability:

Hedge lucern is palatable to grazing animals and grazed by beef cattle throughout the growing season. It is less palatable than *Leucana*, and more readily eaten by livestock than Stylosanthus.

oxicity:

No toxicity has been reported for Hedge Lucern and it contains less amount of codensed tannins only.

Pasture:

Hedge Lucern is very tolerant to grazing by ruminants. It combines well with grass pasture in sub-humid moderately fertile environment. In more testing environments, its relative contribution to pasture yield can be significant, whereas in highly favourable environments, other legume species may make a greater contribution to yield.

Hey and Silage:

Hedge lucerne hay can be successfully included in compound feeds.It has very low protein digestibility, in relation with a non-enzymatic browning during drying. When used with a concentrate, the nutritive value of fresh hedge lucerne leaves can be estimated as 9.0 mg/kg DM and protein digestibility as 57.7%.

ADVANTAGES OF HEDGE LUCERN

1. Combines well with grass pasture in sub-humid moderately fertile environment.
2. It is tolerant to alkaline, sodic, saline and heavy clay soils.
3. It is a very drought tolarant legume fodder.
4. Can tolerate severe competitions from grasses and herbs.
5. It can persist in dry cracking clay soils.
6. It can perform well in harsh environment, while other forage legumes do not.
7. It has high rate of seed production.
8. Very tolerant to regular cuttings as well as heavy grazing.
9. It regrows from left out crown after a moderate fire event.
10. It is a very persistent forage legume in low rainfall environment.

LIMITATIONS OF HEDGE LUCERN

1. Establishment in first year is very slow
2. Relatively low dry matter production along with vigorous grass pasture
3. Limited scope of hay and silage due to low dry matter production.
4. Seed may need inoculation with effective Rhizobium strain for inducing growth.
5. It cannot tolerate shade condition and hence it gives low productivity if shaded by tree crops.

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BEREEM- A WINTER SEASON LEGUME FODDER CROP

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Introduction

Berseem or Egyptian Clover, botanically called *Trifolium alexandrinum* (2n: 16), belonging to plant family Fabaceae and Sub famil Papilionoideae is an important long duration rabi legume fodder in India. It is one of the most important fodder crops and has been rightly described as the king of fodders. It is highly esteemed fodder which has a special place in animal husbandry programmes throughout the country. It is cultivated from 35°N to the Tropics, from sea level up to 750 m and up to 1500 m in North West Himalaya. It is cultivated in Egypt, Pakistan, Turkey and the Mediterranean region, where it is the principle green fodder for animals.

Botanical Description of Berseem

Habitat:

Berseem grows well in mild winter and recovers strongly after cutting. It does not grow well under hot summer conditions. Berseem has some frost tolerance, with annual rainfall ranging between 550 mm and 750 mm. It can withstand some drought and short periods of waterlogging. It does better than alfalfa in high moisture soils and is very productive under irrigation. It is moderately tolerant of salinity with a pH range of 6.5-8.

Habit:

Small, erect shallow rooted, sparsely hairy, shruby annual growing up to a height of 80 cm.

Root:

Shallow tap root that grows up to 50 cm depth with root nodules.

Stem:

Stem is hollow and succulent, but becomes fibrous after flowering.

Leaves:

Leaves trifoliate, alternate arrangement; tender, slightly hairy on upper surface and lamina is membranous with green veins; leaflets 4-5 cm long and 2-3 cm width; oblong-elliptical to oblong-lanceolate, tapering at both ends, mucronate at apex, denticulate in upper part

Inflorescence:

The inflorescence is a compact umbel like raceme with sessile and pedicillate flowers attached to the main stem in involcured manner.

Flower: Flowers are round yellowish white in colour.

Calyx:

Gamosepalous (with five united sepals), calyx tube obconical to campanulate with ten prominent nerves.

Corolla:

Modified papilionaceous corolla with two standard petals fused together, two free wing petals and single keel petal; standard considerably longer than wing petals; colour varying from yellow, cream to white.

Androecium:

Stamens in diadelphous (9+1) condition

Gynoecium:

Monocarpellary, unilocular ovary with globular stigma.

Fruit:

The fruit is a pod containing one single seed.

Seed: White to purplish-red seed

Pollination:

Berseem is a cross-pollinated crop. The extent of cross-pollination is up to 82 per cent and tripping by bee is essential for cross-pollination. Berseem has a simple valver mechanism in which the stamens and stigma are forced out of keel due to the pressure exerted by the insect and return to the original position as soon as the pressure is released. The bee species involved in tripping of Berseem include *Apis dorsata*, *A. mellifera* and *A. florea*.

Fig. 1. *Trifolium alexandrinum*-Berseem- Botanical illustration

Center of Origin: Asia Minor

Related species:

1. *Trifolium repens*- tetraploid
2. *Trifolium nigrescens* - self-incompatible
3. *Trifolium occidentale* - self-compatible perennial
4. *Trifolium uniflorum* - Self-incompatible autotetraploid perennial
5. *Trifolium echinatum* - gene source for late flowering
6. *Trifolium pratense* - drought and winter hardiness

CULTIVATED TYPES OF BERSEEM

1. Single-cut cultivars- *Trifolium alexandrinum* var. *alexandrinum*: Unbranched or slightly branched with slender, solid stem; Fahl group of cultivars which are late maturing and grown for single cut forrage crop. These are culltivars with high growing points and easily get damaged by close grazing. It is suitable for hay making.

2. Multi-cut cultivars- *Trifolium alexandrinum* var. *serotinum*: Branched from the base; stems thick,but fistulose; early maturing Mescawi cultivars cultivated for multi-cut forage crop. These are cultivars with low growing points and suitable for multicut and carry as well as for grazing and hay making.

CULTURAL MANAGEMENT

Berseem is only propagated by seeds and is usually sown in early autumn. It can be sown on a conventional seedbed or be direct drilled. Berseem can be sown alone or in combination with other species. It is mixed with grass (ryegrass) or with a winter cereal crop such as oats to make high quality silage. Berseem can be integrated into a rice-wheat cropping system, as a winter and spring feed: it is then sown before or just after rice harvest. In Australia, berseem is sown with other legumes such as arrowleaf clover (*Trifolium vesiculosum*), Persian clover (*Trifolium resupinatum*) or balansa clover (*Trifolium michelianum*). In some areas, berseem is sown with vegetables such as sarson (*Brassica juncea*) or turnips. Under irrigation, berseem must be sown earlier and irrigated on a weekly basis at the beginning. Ten to 15 irrigations are generally necessary for fodder production. Berseem should be cut when basal buds are short (about 2-4 cm high) so that they escape cutting, which would hamper regrowth and forage yield.

USES OF BERSEEM

1. Berseem is a high quality, protein rich green forage suitable for cut and carry especially for the winter season.
2. It is also grown as a green manure crop that increases the soil nitrogen and organic carbon content.
3. When grown in crop rotation with rice or wheat, it benefits the yield performance of the principle crop.
4. It establishes quickly and protect the soil against soil erosion.
5. It suppresses weeds when grown as a companion crop with other cereals and forage grasses.
6. Berseem is also cultivated for foraging honey bees.
7. Berseem act as feed for wild life animals such as Deer and rabbits.
8. Leaf meal can be used as feed for aqua fish culture.
9. Berseem is highly suitable as green fodder feed for horses.
10. Fresh green berseem, at 15% of the diet DM, improved the growth and feed intake of broilers.

FODDER VALUE OF BERSEEM

Green fodder:

Berseem is a high quality green fodder, mainly cultivated for cut and carry fodder for cattles, especially for milch animals. It is often comparable to Lucern for its feed value but unlike Lucern, it does not cause bloating in ruminants. It can be integrated with rice or wheat cropping system as winter and spring season feed. Berseem should be cut when the basal nodes are at lower levels. Green fodder yield ranges from 80 to 90 tonnes per ha per year.

Nutritive value:

On dry weight basis crude protein 19%, crude fiber 22%, Neutral digestable fiber 44%, Acid digestable fiber 27%, lignin 5% and ash 15.4%. Berseem is rich in Calcium, potassium and Zinc. The digestibility per cent of Berseem feed is about 70 per cent.

Palatability:

Berseem clover is a non-bloating highly palatable forage legume that is highly liked by cattles, horses, sheep and donkey.

Toxicity:

Berseem contains Saponins which when fed to animals in high quantity would impare digestion and cause bloat.

Pasture:

Berseem is not much suitable for grazing. The livestock may damage its upper growing points. Grazing should be started before the sward becomes erect. Quick grazing rotation is required with resting period of 30-40 days for regrowth rather than set stocking or prolonged grazing.

Hay and Silage:

Due to the presence of secculent stem, berseem is not fairly suitable for hay making. When berseem is intended for hay, only the last spring cut must be used as it is drier. For good quality hay making the crop should be cut before flowering. For hay making cut crop is allowed to wilt in the field and then let to dry on the roof tops and made into hay. For silage preparation berseem is mixed with 20 per cent ground maize. For quality silage 5 per cent molasses can be mixed with fodder on wet weight basis.

ADVANTAGES OF BERSEEM

1. Berseem is moderately tolerant to salinity.
2. It can tolerate poor drainage and brief period of water logging.
3. It can tolerate moderate level of cold or frost
4. It produces abundant quantity of seeds and hence easy to establish through seeding.
5. It is non-bloating unlike Lucern.
6. It increases the yield of principle crops, when grown as acompanion crop like rice or wheat.
7. It quickly establishes and cover the soil and prevent soil errosion and suppress the weed growth.
8. Berseem is a good for honey bee forage.
9. It enriches the soil nitrogen as well as organic carbon of the soil where it is cultivated.
10. It can be grown as a green manure crop.

LIMITATIONS OF BERSEEM

1. Berseem does not tolerate shade.
2. Forage quality declines with maturity
3. It contains saponins that may cause bloat when excessively fed.
4. Not much suited for pasture as well as for hay making.
5. Regenerations problem arise if close grazing occur.

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WEED MANAGEMENT IN SUGARCANE

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Abstract

Most common weeds of sugarcane are *Cyperus rotundus (sedge), Cyanodon dactylon, Digitaria sanguinalis, Dinebra retroflexa, Eleusine indica, Panicum spp., Dactyloctenium aegyptium (among grasses), Trianthema portulacastrum, convolvulus arvensis, Amaranthus viridis*, (among broad leaved weeds) etc. If these weeds are not controlled from very beginning the reduction in sugarcane yield may be severe. The most critical period for the week competition in sugarcane is up to 4-5 months after planting beyond which the crop smoothers the weed flora by itself. Weed removes 4 times of N and P and 2.5times of K in sugarcane. pre emergence application of atrazine @ 1.0 kg a.i. ha-1 on 3 DAP followed by post emergence directed application of glyphosate @ 1.0 lit ha-1on 45 DAP with hood+ one hand weeding on 90 DAP registered the maximum cane yield.

Introduction

In Agriculture sector, sugarcane share is about 7% of total agriculture production and occupied 2.6% of India's gross cropped area with functioning of 527 sugar factories. India occupies an important place among the sugarcane producing country and has a neck to neck race with Brazil. Sugarcane is cultivated in an area of 4.44 mha in India with the annual production of 306.07 lakh tonnes and cane productivity of around 69.0 t/ha with an average sugar recovery of approximately 10% (ISMA, 2019). Weed loss is to the tune of 12%- 72% in sugarcane. Unlike other crops, wider spacing, slow growth and one year for harvest favours the weed infestation. During the initial 100-120 days period much of the soil, space, sunlight etc. are left unutilized by the sugarcane crop. Taking advantage , weeds grow luxuriantly and cause serious damage. Most common weeds of sugarcane are *Cyperus rotundus (sedge), Cynodon dactylon, Digitaria sanguinalis, Dinebra retroflexa, Eleusine indica, Panicum spp., Dactyloctenium aegyptium (among grasses), Trianthema portulacastrum, convolvulus arvensis, Amaranthus viridis, A blitum, Digera arvensis, Portulaca oleracea, Lactuca runcinata, Euphorbia hirta, Euphorbia geniculata, Eclipta alba, Commelina benghalensis, Digera arvensis, Phyllanthus niruri* and *Ipomoea spp*. (among broad leaved weeds) etc.

If these weeds are not controlled from very beginning the reduction in sugarcane yield may be severe. The most critical period for the week competition in sugarcane is up to 4-5 months after planting beyond which the crop smoothers the weed flora by itself. Weed removes 4 times of N and P and 2.5times of K in sugarcane. Physical methods work out to be costly. Because of this, farmers face lot of problems in attending to the important operation of timely weeding. Herbicides can be very usefully employed to supplement physical control of weeds in sugarcane to achieve higher yield targets and to lower the labour requirement and cost involved. Effective weed control in sugarcane can be achieved by adopting various known approaches of weed management.

The weed management module for the main crop includes the following recommendation for Main crop

1. The pre emergence application of atrazine @ 1.0 kg a.i. ha-1 on 3 DAP followed by post emergence directed application of glyphosate @ 1.0 lit ha-1on 45 DAP with hood+ one hand weeding on 90 DAP registered the maximum cane yield.
2. If pre-emergence spray is not carried out, apply post-emergence spray of Grammaxone 1.0 litre + 2,4-D sodium salt 2.5 kg/ha in 600 liter of water on 21st day of planting.
3. Hand weeding and partial and full earthing up for ratoon weed management.

Finally the crop earthed up, just before it enters its grand growth period. By this time a healthy crop of cane should close in sufficiently to smother any new weed seedling, *Ipomoea spp*., *Convolvulus arvensis* and the like trailing weed species, may however still survive by climbing the cane plants. These trailing weeds are severe in ratoon and disturb the harvesting.

Hericide

Atrazine is applied as a premergence herbicide effectively manages the weeds up to 20 DAHS (Days after Herbicide spraying). After which early post emergence (EPOE) application of either metribuzin (for having a broad spectrum of weed control at early stage) or halosufuron methyl (for controlling sedges) should be done. Now the ready formulation of halosulfuronmethyl +metribuzin is available. Besides that power operated weeder or minitractor weeding (120cm width) can also be done. After Atrazine application power operated weeders or minitractor weeding can be done. Normally for sugarcane thrice we have to operate the mechanical weeder to manage the weeds effectively up to 120 DAP (the critical **crop weed competition period)**

Table 1. List of herbicides used in sugarcane with reason for selection

SI.No	Herbicide	Mode of action	Time of application	Classification	Reason for selection	Trade name
1	Atrazine	by binding to the plastoquinone-binding protein in photosystem II. Plant death results from starvation and oxidative damage caused by breakdown in the electron transport process.	Pre –mergence 3DAP	Systemic	Pre - emergence is necessary to manage the early weed growth and the initial depletion of weed seed bank	Atrataf
2.	Halosulfuron methyl	ALS inhibiting	25 DAP EPOE	Systemic	To manage the escaped and germinated weed after application of Pre emergence Selective for sugarcane	ra
3.	Metribuzin	inhibiting photosystem II of photosynthesis by disrupting electron transfer	25 DAP EPOE	Systemic	Selective for sugarcane	Tata metri Sencor

4.	Glufosinate ammonium	Glufosinate controls weeds by inhibiting glutamine synthetase	150 DAP POE	Systemic	Non – Selective Systemic using hood the initial 120 DAP should be weed free.	Sweep power
5..	2,4-D	Synthetic Auxin - Uncontrolled and Unsustainable growth	150 DAP POE	Systemic	To kill broad leaved weeds in sugarcane	Weedar 64
6.	Carfentrazone ethyl	controls weeds through the process of membrane disruption which is initiated by the inhibition of the enzyme protoporphyrinogen oxidase	150 DAP POE	Contact	Reported that Ipomoea was effectively controlled	Affinity

Conclusion

Weeeds are the major constraint in sugarcane Production. Weed removes 4 times of N and P and 2.5times of K in sugarcane. For Integrated Weed Management, Atrazine is applied as a premergence herbicide effectively manages the weeds up to 20 DAHS (Days after Herbicide spraying). After which early post emergence (EPOE) application of either metribuzin (for having a broad spectrum of weed control at early stage) or halosufuron methyl (for controlling sedges) should be done. Now the ready formulation of halosulfuronmethyl +metribuzin is available. Besides that weeding power operated weeder or minitractor weeding (120cm width) can also be done. After Atrazine application power operated weeders or minitractor weeding can be done. Normally for sugarcane thrice (three times) we have to operate the mechanical weeder to manage the weeds effectively up to 120 DAP (the critical crop weed competition period). Later Sugarcane Suppresses the weed flora.

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CITRUS UNDER PROTECTED CULTIVATION: AN APPROACH OF PRODUCTION ADVANCEMENT

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Abstract

Citrus is the third most important fruit crops in India. Several biotic and abiotic factors affect the Indian citriculture which leads to low productivity and poor quality fruits. Export is hampered due to low quality fruits. Use of improved production technologies could enhance the yield and quality; however, preventing the insect vectors which could transmit viral and bacterial diseases is often difficult in open field conditions. Further, the control of Phytophthora disease is challenging. In this scenario, an alternative technology is required to produce the higher yield with better quality fruits. Advanced citrus production technology or citrus under protective cover could provide ideal solution to achieve more productivity and high quality produce.

Introduction

Citrus (*Citrus spp*.) is one of the important fruits crops in India and occupies the third position next only to mango and banana. Mandarin (*C. reticulata*), sweet orange (*C. sinensis*) and acid limes (*C. aurantifolia*) are the commercial citrus species in India which are widely grown in tropical and sub-tropical parts of the country. Besides these three species, lemons (*C. limon*), pummelos (*C. maxima*) and grapefruits (*C. paradisi*) are cultivated in limited scale. Madhya Pradesh, Maharashtra, Andhra Pradesh, Punjab and Telangana are the leading citrus producing states in India. Currently in India, citrus fruits are cultivated in an area of about 1.09 million hectares with the production of 14.26 mt with the productivity of 12.66 t/ha during 2020-21 (3rd advance estimate published by Ministry of Agriculture and Farmers Welfare, Govt. of

India). Globally, India ranks third in citrus production, however, the productivity is low when compared to Brazil, China, USA, Turkey, Spain, etc.

Low planting density, lack of disease free planting materials, poor nutrient and water management, and lack of knowledge on canopy management lead to the lower productivity. Besides these, pest and diseases particularly, psyllids, fruit fly, fruit sucking moth, Phytophthora, viruses, and citrus greening disease are also affects the productivity and quality of the fruits. On an average, in Indian citrus orchards, only 10-15 % fruits are “A” grade. Because of which, India could not compete in International market. Disease free quality planting materials, improved production packages and better pest and disease management, we can improve the production and quality of citrus fruits. However, Indian citrus orchards are fragmented, and often face difficulties in managing the pests and diseases, particularly, psyllids, fruit flies, fruit sucking moth, Phytophthora, and greening. Under these circumstances, a novel alternative system is required to improve the productivity and quality.

Advanced citrus production system is an alternative to achieve higher productivity and quality produce in shorter time. In this system, citrus is cultivated under protective structures. The planting design (plant density), canopy management for altering the crop physiology, and root growth manipulation for increased water and nutrient efficiency are the fundamental concepts in the protective cultivation of citrus. The protected structures also prevents the entry of insect vectors, thereby, provides the disease free environment.

1. **Citrus Under Protective Structures (CUPS)**

Citrus under protected cultivation makes Indian citrus industry more efficient and economically competitive. Higher production and high quality blemishless fruits can be achieved in a shorter period of time. This system needs intensive water and nutrient management, training and pruning to optimize the production.

***a.Planting density*:**

High density planting system revolutionized the temperate fruits. Steadily, this system is adopted and become highly successful in most of the fruit trees. In India, high density planting system is mostly followed in apple, mango, banana, and guava. Recently, ICAR-Central Citrus Research Institute, Nagpur standardized high density planting system for Nagpur mandarin for Vidarbha region under conventional open field conditions and six times higher yield was achieved. Studies from Spain and Florida proved that highest yield can be achieved in mandarins and grapefruit by adopting high density planting coupled with advanced citrus production system or open field hydroponics system (Table 1). The open field hydroponic system for citrus was developed in Spain and it was commercialized in South Africa and Australia.

Table 1. Yield of mandarin under high density planting system (open field vs open field hydroponics)

S.No	Country	Crop	System	Plant density/ha	Yield (t/ha)	Reference
1	India	Nagpur mandarin	Conventional open field	2500	36.2	Ladaniya et al., 2021
2	Spain	Nova, Marisol and Dalite mandarin	Open field hydroponics	1000	60-75	Martinez-Valero and Fernandez, 2004
3	USA	Grapefruit	Citrus under protected structures	2177	44.6	Schumann et al., 2020

Recently, ICAR-CCRI has initiated trail on the advanced citrus production system for Nagpur mandarin suitable for Vidarbha conditions. The Nagpur mandarin has been grown under pots using soilless media using cocopeat and perlite under insect proof protective structure with the density of 1600 plants/ha.

Fig. Nagpur mandarin cultivation under protected cultivation

***b. Canopy management*:**

Under protected cultivation, the citrus trees are forced to grow into restricted growth. Therefore, canopy management is highly essential and training of the young trees is important. The trees tend to grow vertically under high density planting, particularly in protected structures. The young trees should be trained in open centre system in order to develop more horizontal branches. Once the canopy meets the desired shape, annual pruning of trees help the canopy growth at manageable volume and it allows more uniform light penetration. It enables higher fruit set, fruit development and better peel color. Further, it is desirable to keep the fruits close to the main trunk so that the fruits receive more nutrients and water effectively, thus enhances the fruit size and quality.

***c.* Water and nutrient management**

Intensive water and nutrient management for citrus is required to get early production. The drip irrigation and fertigation should be scheduled during maximum transpiration time of the day; thereby the water and nutrient use efficiency can be enhanced. Further, the scheduling should consider the soil characteristics and evapo-transpiration of the locality. In advanced citrus production system, the soil moisture level should be kept near field capacity. Limited quantities of nutrients through daily pulse-fertigation technique directly at the active root zone during the active photoperiodic time according to the crop phenology facilitate the rapid uptake of nutrients by the roots.

***d.* Insect management under ACPS**

Use of physical barriers to prevent the insect-pests is one of the key strategies in the protected cultivation. Selection of appropriate mesh size and adequate air flow are crucial for excluding insects and successful cultivation of crops in the protected structures. Citrus under protected structures approach relies mainly upon physically preventing young trees from coming into contact with the Asian citrus psyllid (ACP), the insect that transmits the bacterial pathogen (*Candidatus* Liberibacter asiaticus, *C*Las) associated with citrus greening and other insects like leaf miner, thrips, aphids, white flies, fruit flies and fruit sucking moth. The size of the mesh in the screen house is crucial for preventing the entry of citrus insects. In citrus, use of 50 mesh screen house could successfully prevent the entry of insect pests, especially like Asian citrus psyllids thus preventing the citrus greening disease under protected citrus cultivation. However, high temperature and high humidity inside the protected structures favour the multiplication of pests. Mites and thrips can penetrate the 50 mesh screen, hence, continuous monitoring and chemical control is must for the control of mites and thrips.

2. Individual Protective Covers

Cultivation of citrus like Nagpur mandarin, Mosambi, etc. under protective structures is effective for providing pest and disease free environment and achieving the healthy growth and production of early and quality fruits. However, for large scale commercial production, it is economically not feasible because of high initial establishment cost and annual maintenance cost. Recently, an alternative method of advanced production system is identified in Florida. In this system, after planting, the young plants will be covered with individual protective covers (IPCs). This system is cost effective and east to adapt because it uses only the insect proof covers which is very less cost compared to the protective structures.

Conclusion

Protected cultivation in perennial fruit crops is slowly but steadily increasing in India and day by day it becomes cost effective and profitable for the farmers. Papaya, pomegranate, banana and strawberry are being commercially cultivated in India for the production of high quality fruits for export. In citrus, it offers great scope to minimize the pest and disease incidences, particularly citrus greening, thereby it ensures the higher production and high quality fruits. Standardizing the protected cultivation technology for different citrus species is important. ICAR-CCCRI has already initiated the research on developing advanced citrus production technology for Nagpur mandarin suitable for central India conditions. Further, the studies should concentrate on physiology of the citrus under protected conditions. Also, there is urgent need to develop cost effective protected structures so that this technique can be well adopted by the farmers.

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AFLATOXINS IN CHILLI: DETECTION AND MANAGEMENT

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Abstract

Mycotoxins are low molecular weight toxic metabolites primarily produced by fungal species like *Aspergillus*, *Alternaria*, *Fusarium*, and *Penicillium*, pose significant threats to food safety. Aflatoxins, difuranocoumarin derivatives synthesized by toxigenic strains of *Aspergillus*, are among the most hazardous mycotoxins. *Aspergillus* produces four types of aflatoxins (B1, B2, G1, G2) and among them aflatoxin B1 (AFB1) stands out as the most toxic. Aflatoxin contamination is a major concern in the global trade of chillies, especially in regions like India where high moisture content and temperature provide ideal conditions for fungal growth. Regulatory standards set by entities like the European Union and the Food Safety and Standards Authority of India restrict aflatoxin levels in chillies to ensure consumer safety. This article discuss about the aflatoxin effect in chilli, their detection methods, analytical procedures and their management to ensure food safety.

Key words: Aflatoxin, mycotoxin, chilli, management

Introduction

Mycotoxins are low molecular weight (300–700 Da) toxic metabolites produced by various fungal species, primarily Aspergillus, Alternaria, Fusarium, and Penicillium (Iqbal, 2021). The word “mycotoxin” is derived from the Greek words “mycos” and “toxin,” which mean “fungus” and “poison”. Aflatoxins are a class of mycotoxins, difuranocoumarin derivatives synthesized by toxigenic strains of *Aspergillus parasiticus* and *Aspergillus flavus* via the polyketide pathway (Singh & Mehta, 2020). The four significant aflatoxins (AFs) identified are Aflatoxin B1 (AFB1), Aflatoxin B2 (AFB2), Aflatoxin G1 (AFG1), and Aflatoxin G2 (AFG2). Both *A. flavus* and *A. parasiticus* produce AFB1 and AFB2, whereas AFG1 and AFG2 are produced solely by *A. parasiticus* (Muaz et al., 2022). Among the four AFB1 is the most toxic mycotoxin (AFB1> AFG1> AFB2> AFG2).

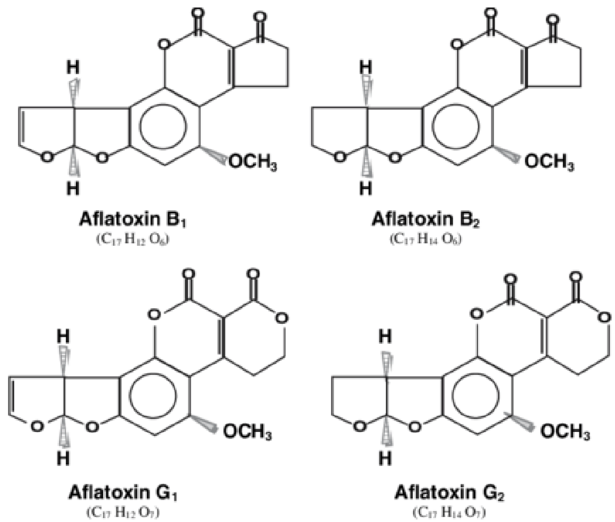

Figure showing the chemical structure of the four aflatoxins (B1, B2, G1 and G2) (Source credit: Nejad *et al.*, 2014)

Aflatoxins in chilli

Aflatoxin contamination and pesticide residues are the twin problems faced by Indian chillies in the global market trade. *Aspergillus flavus*, *A.niger* and *A. parasiticus* are the most common pathogens producing aflatoxins in chilli. High moisture content (24– 35 °C) and relative humidity (60–85%) are the most favourable conditions for the development of the fungus. They are most common under tropics and sub-tropic conditions.

Causes

- High temperature (25–42 °C)
- Contact of red chilli fruit with soil
- Improper drying
- Poor transport
- Poor storage condition
- High soil moisture

Aspergillus infected fruit

Rules and regulations

Aflatoxins are the major limitations in the export of dry chillies. Regulations by European Union (EU) permit the presence of 5 µg/ kg of aflatoxin B1 and 10 µg kg of total aflatoxins (European Commission, 2006). The Food Safety and Standards Authority of India, permit the presence of 30 µg/ kg (FSSAI, 2011)

Detection

- High performance liquid chromatography (HPLC),
- thin layer chromatography (TLC),
- high performance thin layer chromatography (HPTLC),
- liquid chromatography–mass spectrometry (LC– MS),
- gas chromatography (GC)
- Enzyme Linked Immunosorbent Assay (ELISA) test

Procedure for the detection of mycotoxins in chillies under analytical methods

Mycotoxin testing in chilli and paprika peppers generally consists of five steps: sampling, sample preparation, extraction, clean-up and determination.

Sampling

When sampling, it is necessary to take a representative sample of the lot because mycotoxins are not homogeneously distributed. The purpose of sample preparation of Capsicum fruits is to reduce the particle size using mills or blenders, and to homogenize the sample

Extraction

Extraction in paprika and chilli is usually done by organic solvents, such as methanol (MeOH), chichlor-omethane (CH_2Cl_2), chloroform ($CHCl_3$), acetone-n-hexane or organic solvents mixed with water, such as MeOH-water, acetonitrile-water. The MeOH-water extractant is less toxic than acetonitrile-water or $CHCl_3$

Purification

The major problem associated with most analytical methods used for the determination of mycotoxins is the presence of co-extracted interfering substances in samples. For example, the co-existence of mycotoxins with large amount of pigments and lipids in chilli. These substance must be removed by multiple extraction and subsequent clean up procedure. Purification steps include solvent extraction followed by liquid-liquid extraction, solid-phase extraction (SPE), strong anion exchange (SAX) cartridges, immune-affinity columns (IAC) or multifunctional columns.

Clean up

Samples can be cleaned manually but the main drawback is that they are time consuming and labour intensive. There are few clean-up equipment and techniques are available such as

Solid phase extraction (SPE)

In Solid phase extraction (SPE) the column is made up of silica gel, florisil or charcoal. The introduction of commercially available 'mini-column' based SPE cartridges, significantly reduced the time and labor investment

Immune-affinity column (IAC)

An immune-affinity column (IAC) is a type of SPE filled with antibodies that target mycotoxins, making it better at removing impurities. Immunological methods enable faster and more dependable mycotoxin analysis, particularly for paprika. They speed up the purification process and reduce the use of harmful solvents, simplifying clean-up. Chromatograms from purified extracts used in IAC are cleaner, enhancing assay sensitivity. Compared to traditional solid-phase clean-up methods, IACs are considered more versatile across different sample types and require fewer adjustments. IACs can concentrate large sample volumes for higher sensitivity and are less demanding on the analyst's expertise.

Multifunctional columns methods

Multifunctional column methods like MultiSep #226 (Romer Laboratories) are rapid (within 2 h), simple steps that have proven to produce reproducible results for the analyses of AFs in red pepper. In some analyses, the sample purification is carried out as a part of the assay, and a separate sample clean-up step is not required. The absence of sample extraction and clean-up reduces the cost and labor involved in analysis.

Gel permeation chromatography (GPC)

Gel permeation chromatography (GPC) is a simple, rapid and reliable clean-up method and can be considered an alternative to IAC and multifunctional column clean-up.

Clean-up tandem immunoassay column

A clean-up tandem immunoassay column set-up can be used for OTA detection in Capsicum spp. samples applying a column with bottom detection immune-layer. This method is a rapid cost-effective on-site field assay, universal for all target spices, which minimizes matrix interference and reduces the assay steps. Additional advantages for the preparation or the execution of the immunoassay procedure are that no special equipment, expensive components or components that are not commercially available are needed.

Matrix solid-phase dispersion (MSP)

The matrix solid-phase dispersion (MSP) method combines the extraction and clean-up in a single step, thus reducing solvent consumption and sample treatment time.

Quantification

Quantification can be done using thin-layer chromatography (TLC), high performance thin-layer chromatography (HPTLC), high performance liquid chromatography (HPLC), gas chromatography (GC) and mass spectrometry (MS). Reversed-phase HPLC coupled with fluorescence detection and combined with an IAC clean-up is increasingly used as the method of choice in the determination of Afs. Aflatoxins are intensely fluorescent in ultraviolet light.

Aflatoxins	Fluorescence under ultraviolet light
Aflatoxins B1 and B1	Blue fluorescence
Aflatoxins G1 and G1	Yellow-green fluorescence
Aflatoxin M	Blue-violet fluorescence

ELISA test

Although several methods have been described for determination of aflatoxin, enzyme-linked immunosorbent assay (ELISA) is well suited for the rapid, routine diagnostic application of aflatoxin detection. ELISA uses and enzyme to detect the binding of antigen (Ag) and antibody (Ab). The enzyme converts the colourless (Chromogen) substrate into coloured product indicating the presence of Ag:Ab binding.

Management

1. **Good Agriculture Practices (GAP)**
   - Aspergillus fungus grow in soil. Implementing proper irrigation practices to avoid excess moisture, which can promote mold growth.
   - Use certified seeds that are less susceptible to aflatoxin-producing molds.
   - Monitor fields for signs of mold growth and pest infestations.
   - Implement crop rotation practices to reduce the buildup of mold spores in the soil.
   - Environmental stresses like drought reduces the natural defense mechanism making the plants more prone to *Aspergillus* attack.
2. **Harvesting Practices**:
   - Harvesting at the right stage of maturity when they are fully mature but before they become overripe or damaged.
   - Good handling practices (GHP) to minimize bruising and damage, which can provide entry points for mold growth.
3. **Drying Techniques**:
   - Drying chilli pods to a proper moisture content of 9-12% so as to prevent mold growth
   - Use proper drying methods such as sun drying, mechanical drying, or artificial drying with appropriate temperature control.
   - Ensure that chilli peppers are dried thoroughly and evenly to prevent the development of mold hotspots.
   - Drying chilli pods over a protective layer such as Plastic covers, tarpaulins *etc.*, to avoid mold infestation.
4. **Storage Conditions**:
   - Store dried chilli peppers in clean, dry, and well-ventilated facilities.
   - Avoid gunny bags for storage as they may retain high moisture content favoring mold growth.
   - Regularly inspect stored chilli peppers for signs of mold growth or moisture accumulation.
5. **Physical treatment**
   - Drying of seeds to optimum moisture content (9-12%) to prevent mold growth
   - Maintenance of temperature and humidity.

- Irradiation with gamma (62.5, 125.0 and 500.0 krad) or beta beams is effective to control the microbial contamination and preserves organoleptic characteristics of the product.
- Cooking soda at 5% and salt at 10% were equally effective in reducing the fungal growth on fruits of chilli.
- Hot water treatment at 52°C for 15 min also showed 100% inhibition of growth of Aspergillus spp. on Capsicum fruits.

6. Chemical treatment

- Apply non-systemic fungicides like 0.3% mancozeb, 0.2% captan, 0.15% carbendazim to inhibit radial mycelial growth.
- Apply 0.5% of Neem Seed Kernal Extract (NSKE), nimbicidin and pongamia oil for inhibition of the fungus
- Apply bioagents like *Trichoderma viride* and *Pseudomonas fluorescence* against *A.flavus*
- A combined pre-harvest spray of NSKE (5%) or mancozeb (0.3%) or P. fluorescens (1×108 cfu/ml) 10 days before harvest of chilli is recommended for field level management of aflatoxin producing fungus

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FARMER SCIENTIST TAKES BANANA WASTE INTO VALUE ADDITION: A SUCCESS STORY

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Introduction

Banana is one of the most important fruit crops grown in India. In India, the area under banana has increased from 1.49 lakh ha during 1956-57 to 8.83 lakh ha during 2017-18 with the production 113.28 million tonnes of which Tamil Nadu accounts 5007.81 MT in production. After the harvest of fruits, huge quantity of waste biomass from Pseudo stem, leaves and suckers were generated which are dumped on roadside or burnt or left *in situ* causing detrimental impact on environment. Though, the technologies for extraction of fibers and paper making from Pseudo stem are available, not being adopted by the industries mainly due to lack of awareness. However, a vast potential of extracting fibers from pseudo stem which is need to exploited besides other uses.

The quantity and quality of fibers show wide variability with cultivars which is also needs to be standardized and improvement on its physio-chemical properties of the fiber to be worked out by adopting various by cultural methods. The fiber extracted from banana pseudostem appears to be good scope of profitable use in textile and paper industries on commercial scale. Besides, value added products like fabrics, bags, various types of mats, interior decoration items, window blinds, cushion covers, bolster covers, table lamps and folders can also be developed from banana pseudostem. Due to high cost of synthetic fibers, this banana fibers are eco -friendly and chemical free Banana fiber which is grease proof, water and fire resistant and totally bio-degradable.

P.M. Murgessan from Melakkal Village, Madurai District, Tamil Nadu a basically a banana farmer and cultivating different varieties of banana at his village named Melakkal around 8 acres. After the harvesting the bunch of banana, the Pseudo stem wasted and dumped into soil without any usage. The Murugesan decided to utilize these waste into value added one for which he contacted Krishi Vigyan Kendra, Madurai and received training to waste utilization of horticultural produces.

Fig: 1.Different value added products from Banana Pseudo stem

	
Flower Vase	Fruit Basket
	
Floor Mat	Decorative Ball
	
Pooja Bakket	Women's employed in value addition

	
Evaluation of products by TNAU Scientists	Customer receiving value added products

S.No.	Name of the Award	Award From	Year
1.	Grass Root Innovation and Inclusive Development Award	National Innovation Foundation-India	2023
2	Certificate of Appreciation	3rd ASEAN-India Grass root Innovation Forum Penh Cambodia	2022
3	Letter of Appreciation	From Honorable Prime Minister of India	2022
4	Letter of Appreciation	From Honorable Governor of Tamil Nadu	2021
5	District Award	Tamil Nadu Handicraft Development	2018
6	Maditssia AIMO Industrial Award	MSME	2015
7	Best Farmer Award	Madurai District Colelctor	2014
8.	National Award Best PMEGP Award	MSME KVIC, New Delhi	2013

He has been collected the entire waste of banana Pseudo stem after the harvest in his field and around Madurai District, processed and made rope with his invented Banana fibre processing machine (Patent No.326662). This fibre and rope will be utilized for different product making. At present he has been developed nearly 200 value added products and distributed both domestic and international markets.

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BIOFORTIFICATION: A STRATEGY FOR NUTRIENT ENRICHMENT IN HORTICULTURAL CROPS

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Abstract

Fruits and vegetables, being rich sources of fibre, beneficial phytochemicals, and minerals, have long been considered the basis of a healthy diet. The biofortification is a promising strategy to increase the concentration of these compounds. The term "biofortification" describes the development and cultivation of food crops that are more bioavailable to human population and have higher levels of nutritional value. These crops are produced by agronomic approaches, conventional plant breeding, current biotechnology techniques and genome editing. Biofortification works have been practiced in most of the horticultural crops like banana, cassava, tomato, beans, potato, sweet potato, cowpea, pomegranate, pumpkin, yam etc. Several conventional and transgenic varieties have been released, while additional varieties are in the consideration. The biofortified food crops, especially cereals, legumes, vegetables, and fruits, are providing sufficient levels of micronutrients to targeted populations. Biofortified crops have a promising future in tackling the issue of malnutrition.

Key words: Biofortification, Malnutrition, Conventional breeding, Genetic Engineering, Genome editing.

Introduction

By 2030 and 2050, the world's population is predicted to rise from 8.10 billion in 2024 to 8.50 and 9.70 billion, respectively. Consequently, agriculture is susceptible to current global crises like climate change (De Pascale and Rouphael, 2021; Zandalinas *et al.*, 2020] and pandemics (Inglese and Sabatino, 2022). Pandemics intimidate comprehensive human lifecycles and fitness, which will be supplementary deteriorated by increasing hunger and undernourishment caused by a disorder in the food supply chain, mostly in emerging countries. This situation is intensifying the challenges for international food security (Vinoth and Ravindhran, 2017). Human malnutrition has a serious negative socioeconomic impact, especially in emerging and poor nations where individuals are unable to eat a balanced diet. Despite the fact that many studies have been done, a sizable portion of the population still lacks access to or the means to purchase a high-quality diet that is necessary to diagnose malnourishment and/or undernutrition. The term "bio-fortification" describes the process of genetically boosting food crops' bioavailable mineral content. Creating biofortified crops also increases the crops' growth efficiency in soils with scarce or depleted mineral content. The ultimate goal of biofortification is to sufficiently and sustainably produce safe, nutrient-dense food.

Currently, agronomic, conventional, and transgenic biofortification are three common approaches. Agronomic biofortification can provide temporary micronutrient increases through fertilizers. In view of the disadvantages of transgenic/GM crops, genome editing (GE) technology offers distinct advantages. Thus, with few off-target effects and no external gene sequence integration, the genome editing results in predictable and inheritable mutations in targeted regions of the genome (Kumar *et al*., 2022). Numerous horticulture crops have been subjected to biofortification methods. Biofortification method is a potential tool for providing naturally fortified food to those who have limited access to commercially promoted fortified foods, which are more easily accessible in cities. In the future, mineral and vitamin shortages are projected to be more dangerous. Biofortified crops hold a very bright future as these have the potential to remove micronutrient malnutrition among billions of poor people across the globe.

Strategies for Biofortification

1. Agronomic Biofortification:

The success of agronomic biofortification mainly depends upon the mobility of mineral elements in the soil and in plants. Zinc, (foliar applications of $ZnSO_4$), Iodine (Soil application of iodide or iodate), Selenium **(**as selenate) are the most suitable micronutrients for agronomic biofortification. Foliar application is the quick and easy method of nutrient application to fortification of micro nutrients (Fe, Zn, Cu etc.) in plants. Several studies have found that the mycorrhizal associations increase Fe, Se, Zn and Cu concentrations in crop plants. AM-fungi increase the uptake and efficiency of micronutrients like Zn, Cu, and Fe etc. Sulphur oxidising bacteria increases the sulphur content in onion (Prasad *et al*., 2015).

2. Conventional plant breeding:

Over the past forty years, traditional breeding has prioritised resistance and yield traits over nutritional factors, which has resulted in a decline in the amount of nutrients available in the varieties that are currently in use. Recent developments in conventional plant breeding have increased interest in fortification with critical vitamins, antioxidants, and micronutrients. Important vitamins, antioxidants, and minerals have been fortified in traditional plant breeding as a result of recent advancements. Enough genetic variation in the concentrations of β-carotene, other functional carotenoids, iron, zinc, and other minerals exists among cultivars to enable the selection of nutritionally appropriate breeding materials, which is necessary for the potential to increase the micronutrient density of staple foods through conventional breeding. (Yadav *et al*., 2022).

3. Genetic engineering:

In situations where there is insufficient variation among genotypes for the desired character/trait within the species, or when the crop itself is not suitable for conventional plant breeding (due to lack of sexuality; for example, bananas), genetic engineering offers a viable alternative for improving the concentration and bioavailability of micronutrients in the edible crop tissues. Golden rice was one of the first crops to be biofortified; it was created to produce provitamin A or beta-carotene in the edible portion of the grain. Genetically modified (GM) crops, also known as transgenic crops, allow plant breeders to introduce advantageous genes into elite cultivars that were previously unavailable, greatly increasing their value and providing special opportunities for managing viruses, insects, and other pathogens in addition to providing high-quality nutrition and health benefits. (Garg *et al*., 2018)

4. CRISPR-based Genome Editing:

Current biotechnology advancements have introduced biofortification into a number of food crops in an effort to combat hunger. But these approaches have a number of drawbacks and are not sustainable; these issues are being addressed by the genome editing system based on CRISPR-Cas. Crop development programmes have made considerable use of the CRISPR-Cas genome-editing technique because of its simpler design, low methodological cost, high efficiency, strong reproducibility, and short cycle time. Using the genome editing approach, biofortified crops such as Golden Banana and Golden Tomato have been developed (Kumar *et al*., 2022) and regenerated by plant tissue culture technique (Singh and Singh, 2023) .

Table 1: Biofortification in horicultural crops

Crops	**Biofortified mineral/vitamin**
Carrot	Calcium
Radish	Selenium
Lettuce	Iron
Potato	Amin acid, protein, anthocyanin, starch,
Broccoli	Selenium
Spinach	Iodine
Beans	Iron
Pumpkin	Carotenoids
Onion	Selenium
Sweet potato	Protein, Carotene, Provitamin-A & Anthocyanin
Tomato	Flavonoids, anthocyanin ,Folate, phytoen, lycopene β-carotene, provitamin A
Cauliflower	Provitamin-A
Banana	B-carotene
Pomegranate	Iron, Zinc & Vitamin-C
Greater yam	Anthocyanin, Protein, Iron, Zinc & Calcium

Conclusion

Biofortification is a viable and economical agricultural technique for enhancing the nutritional condition of undernourished communities worldwide. Human mineral deficiency may be greatly reduced by using biofortification techniques based on crop breeding, targeted genetic modification, and/or the use of mineral fertilizers. An advanced biotechnology technique CRISPR-Cas has been used to modify a number of vital crops to improve output, quality, and nutrition. However, more research is required to explore a wider range of crops in terms of productivity enrichment, quality, and nutrition in order to pinpoint useful biofortification targets and enhance CRISPR delivery strategies. Traditional farming methods can improve the nutritional content of plant meals to some extent, but biofortification is the process of adding nutrients to food crops by traditional, agronomic, and transgenic breeding techniques in order to give a long-term, sustainable solution.

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BEE FENCING- A NEW TECHNOLOGY TO PREVENT ELEPHANTS

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Introduction

The social insects known as honeybees (species belonging to the subgenus Apis) reside in colonies. A single queen, a few hundred drones, and thousands of worker bees make up the hive population. They are flying insects that are closely related to ants and wasps. With the exception of Antarctica, they are present on every continent. In addition to its ecological benefits, beehives have various economic advantages. However, it's now known that it can be utilized in agricultural fields as a fence tool. These days, enclosing farms with "beehive fences" is one of the best methods for stopping elephant crop raiding behavior. One way for farmers living beside elephants to reduce violence is by installing a beehive fence. Dr. Lucy E. King created this technique after seeing that elephants instinctively shy away from bees—just think of the potential danger if bees were to fly inside an elephant's trunk!

History

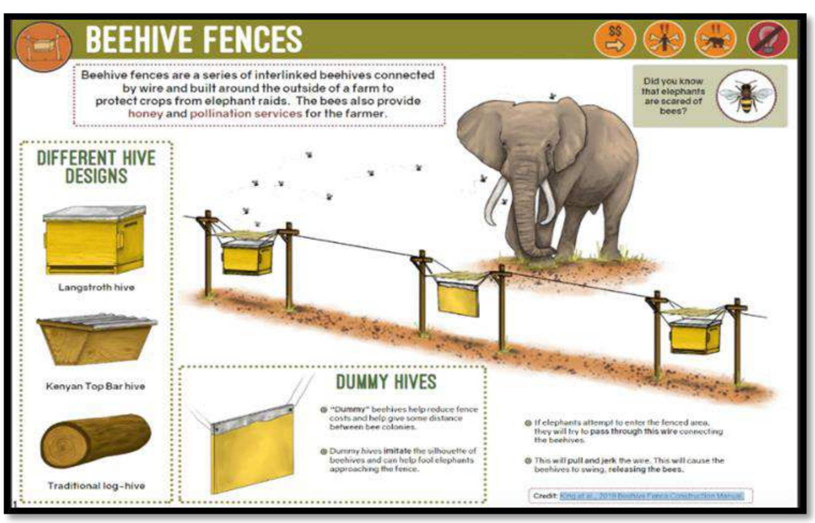
Small-scale subsistence farmers always worry that elephants would raid their crops if they venture outside the farm's boundaries. Elephant crop raids can cause significant losses for nearby farmers, and because these creatures are seen as a danger to their livelihoods, people become extremely hostile against them. Therefore, developing or locating a method or instrument that can lessen hostilities and elephant raids was imperative. Then, a study in Kenya, Africa, was carried out by the research team of Dr. Lucy. The use of passive (immovable) barriers like flashing solar lights, fences strung with rags soaked in chili oil, ditches, watch towers, walls, buffer crops (like chilies), and active (movable) deterrents like fire or firecrackers, chili powder bombs, guard dogs, human patrols and so on are tried and tested techniques. However, they had a relatively poor success rate. Finally, the scientists presented the farmers with the "beehive fence," a natural instrument, and two years of testing were conducted. Using this information, rural farmers are preventing crop-raiding elephants from entering their farms with the help of The Elephants and Bees Project. The goal of this research has been to better understand how farmers are adjusting to new technologies and to track the effectiveness of beehive fences in discouraging crop-raiding elephants. Elephants have not been able to breach the barriers and access the crops thus far thanks to the beehive fences.

Reason for avoiding bees by Elephant

Elephants flee when they hear honey bees being disturbed. The elephants' distinctive low-frequency "bee alarm rumble" vocalization, which they release while they flee, alerts other elephants nearby to take cover as well. According to these behavioral findings, elephants seem to have a bad memory of honey bees, which makes them "scare" away from certain areas. Elephants can get stung behind their thinner skin at the ears, up their trunk, and around their eyes. Locals who have seen swarms of bees sting elephants report that the agony is intense enough to make the elephants avoid getting stung by the insects in the future.

Methodology

Beehive barriers can be constructed from any kind of beehive to prevent elephants from accessing specific farms.



Modern hives come in three primary varieties that are widely used across the globe.

- The Langstroth Hive
- The Top-bar Hive
- The ware Hive

In addition to them, there are Kenyan Top Bar Hives (KTBH) and Traditional Log Hives. The beehive fence can be constructed from any kind of hive. The conventional log hive is the most affordable method.

Beehive fences using Traditional Log Hives

1. The hives can be placed eight meters apart because the bee house supports are set six meters apart.

2. Only securely fastened fencing wire to the top of the poles should allow the beehives to swing freely.

3. Sturdy, taut fencing wire that hooks onto the permanent wire of each hive should be used to connect them all. It is important that the fence's upright posts be behind the hives on the crop side.

An elephant that tries to approach the field will be diverted between the bee huts and avoid the bee huts' intricate, strong structure. The linked beehives swing fiercely as the elephant tries to push through the thigh-high wire, upsetting and releasing the bees to sting or annoy the elephant.

Beehive fences using Kenyan Top Bar Hives (KTBH)

1. The "bee hut" and the connecting wire that connects one beehive to the next, with a 7-meter space between each bee hut's post, make up this beehive fence.

2. The apiary has an 80cm-long Kenyan Top Bar Hive, which is made of 9mm plywood and engineered to create three apiaries from a single, substantial 2.4 x 1.8m industrial plywood sheet.

3. There is a flat thatched roof to shield the rain-proof corrugated iron sheet roof from the sun.

4. A thin binding wire suspends the ceiling, making it impossible for honey badgers to descend if they manage to cross the 70cm iron sheets that are fastened to the posts for protection.

5. To keep termites away, a low-cost oil-based insecticide needs to be applied to the nine-foot posts.

6. The hive is suspended by punching tiny holes in its side walls and allowing food to pass through a more robust plain wire. After passing through the hive, the ends can be fastened to the roof by drilling a tiny hole the size of a nail. This loops around the top of the upright posts with ease.

7. One beehive can be connected to the next beehive ten meters away using a sturdy length of plain wire by simply twisting the hive's hanging wire on the farm side of the bee hut.

An elephant will naturally try to get between the bee huts in order to approach the farm. As the wire stretches, the strain on the beehives causes them to swing irregularly and, if they are occupied, releases the bees. To prevent an elephant from pulling down the hive due to extreme pressure, the wire is just wrapped through the hoop and not securely twisted back onto itself.

Beehive fences using Langstroth Hive

1. Rectangular or square boxes that nestle snugly on top of one another are used to construct Langstroth beehives.

2. A series of frames with a thin foundation strip of beeswax, secured in place with tiny wire strips, are found in the bigger brood chamber at the bottom.

3. A second "super" box should be positioned on top of the brood chamber once the bees have taken up residence there and constructed the foundation combs with brood and beeswax.

4. A queen excluder wire mesh rests between the two boxes, covering the tops of the brood chamber combs in a horizontal sheet. By doing this, the worker bees are able to fill the super with pure wax comb and honey stores, preventing the queen from ascending into the super box. You harvest this part for honey, leaving the brood chamber unattended.

5. There should be a 7-meter space between each bee hut's posts. Three meters should separate the second post where the hive will be hung.

6. The 8 or 9-foot-long wooden posts should ideally be sprayed from top to bottom with an insecticide and allowed to completely dry before being inserted into the ground.

7. The bees will remain dry in the rain thanks to the iron sheet roof, but if the hive is left in the sun, it will warm, drive the bees out, and they will become hostile.

8. To ensure that the beehives swing in the event that an elephant tries to breach the fence, each beehive in the fence should be connected to the others with a sturdy piece of plain wire that loops through the wire that hangs the hive. This wire must, most importantly, be on the inside of the farm.

Application

Other researchers in Tanzania later replicated the experiment following its enormous success rate in Africa. Next, the initiative is started in India as well. Every year in India, some 400 people lose their lives defending their crops from elephants. An innovative project was initiated by the Agricultural Technology Management Agency (ATMA, Wayanad) in collaboration with the State Forest and Wildlife Department, NABARD, Khadi and Village Industries Board, with the goal of preventing elephant raids by installing beehive fencing. As a trial project, ATMA installed a 700-meter bee fence in December 2012 at Mathamangalam, a small village in Poothadi grama panchayat. They did not initially receive enough support from the local population, which contributed to its failure.

Then, in January 2016, a local farmers' group launched a second project at Mayilattumpara at a cost of Rs 5,00,000, with the support of the federal government's Agriculture Technology Management Agency, or ATMA. No one in Mayilattumpara was able to get a good night's sleep two years ago. The people living in the village at the foot of the hills in the Thrissur district of Kerala state, southwest India, were afraid of wild elephant incursions. But in the last 12 months, things have changed for the better. Today, a 2.5 km (1.5 mile) wire fence adorned with beehives encircles 18 village farms.

Italian honey bees reared in Kerala inhabit the hives that are spaced every ten meters along the wire. It turns out that bees, with their loud buzzing and powerful stings, terrify elephants. Angry bees swarm out when elephants attempt to cross the wire fence, causing the elephants to swiftly retreat. With the bees' protection, farmers may resume tending to their crops. Additionally, some people are starting to grow honey for a new harvest. However, the work is starting to pay off now. Every one of the 260 beehives arranged along the fence might provide up to 30 kg of honey during the December through March honey season. Even with the expenses of keeping the hives, each farmer might profit significantly from this, with the potential to earn up to Rs 65,000.

Case studies in Karnataka:

As a response to HEC, the Wildlife Research Conservation Society (WRCS) has presented the idea of Community Based Conflict Management (CBCM), which gives the local communities in Karnataka's North Canara District the authority to take charge by employing efficient guarding techniques to minimize crop loss and preserve the wild elephants that remain.

Many farmers in Karnataka, India's North Canara District have been inspired to install bee-hive fences by Mr. Ravi Bandekar, the Program Officer with WRCS. The project was started in 2009 and is being funded by the Asian Elephant Conservation Fund (AECF) of the US Fish and Wildlife Service. It uses bee-hive fences, trip alarms, chilly-based obstacles, and night guards. To protect their crops, about 75 farmers have erected watch towers. They have also employed rotating fire balls, drums, torches, and catapult explosives to scare away the elephants. By positioning them in the most vulnerable regions, chilled smoke is another extensively utilized, low-cost method of keeping the elephants away from the fields.

Pre-recorded Apis mellifera (bee) noises were broadcast during crop raiding episodes, sparked by Dr. Lucy King's investigation, and the results indicated an immediate elephant retreat from the crop fields. Owing to their success, low-cost beehives made of bamboo, logs, and clay pots are being built in order to keep elephants away and give farmers financial advantages. The farmers and employees of the forest department have discovered that the recommended actions work well to keep elephants from damaging crops.

Conclusion

Beehive barriers have not only lessened human-elephant conflict but also safeguarded human life and crops. It is a more affordable and organic method. Thus, anyone can attempt this method. In addition to using it as a fence, farmers can extract a significant quantity of honey from the beehives. Even with the expenses of keeping the hives, it can earn each farmer as much as Rs 65,000, which would still leave them with a healthy profit. Therefore, farmers benefit from it as well. To conserve the elephants and lessen the conflict between humans and elephants by embracing the "elephants and bees project," all we need to do is implement this technique through a few trial projects and with the cooperation of the government's agriculture and forest agencies.

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NANOTECHNOLOGY: HARNESSING NANOPARTICLES TO ALLEVIATE ABIOTIC STRESS IN PLANTS

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Abstract

Abiotic stress, stemming from environmental factors like extreme temperatures, water scarcity, and salinity, presents significant challenges to global agriculture and ecosystem sustainability. With the exacerbation of these stressors due to climate change, there is an urgent need for innovative solutions to mitigate their adverse effects on plant growth and productivity. Nanotechnology, through the manipulation of materials at the nanoscale, holds immense promise in addressing these challenges. This paper explores the potential of nanoparticles in alleviating various forms of abiotic stress in plants, including heat, cold, drought, flood, and salinity stress. The effectiveness of nanoparticles such as titanium dioxide (TiO_2), cerium oxide (CeO_2), silver nanoparticles (AgNPs), carbon nanotubes (CNTs), silica nanoparticles (SiNPs), zinc oxide nanoparticles (ZnO NPs), iron oxide nanoparticles (Fe3O4 NPs), chitosan nanoparticles (CS NPs), and graphene oxide nanoparticles (GO NPs) is examined in mitigating specific stressors. Mechanisms underlying nanoparticle-mediated stress mitigation, including regulation of gene expression, enhancement of antioxidant defense mechanisms, and improvement of membrane stability, are discussed. While nanotechnology presents promising opportunities, it also poses challenges such as nanoparticle toxicity, environmental persistence, and regulatory concerns. Addressing these challenges requires interdisciplinary collaboration among scientists, policymakers, and stakeholders to ensure the safe and sustainable application of nanotechnology in agriculture and environmental management. Further research is warranted to optimize nanoparticle properties, elucidate underlying mechanisms, and develop cost-effective and eco-

friendly nanoparticle-based strategies. By harnessing the potential of nanotechnology, we can pave the way towards resilient and sustainable agricultural practices in the face of escalating abiotic stressors.

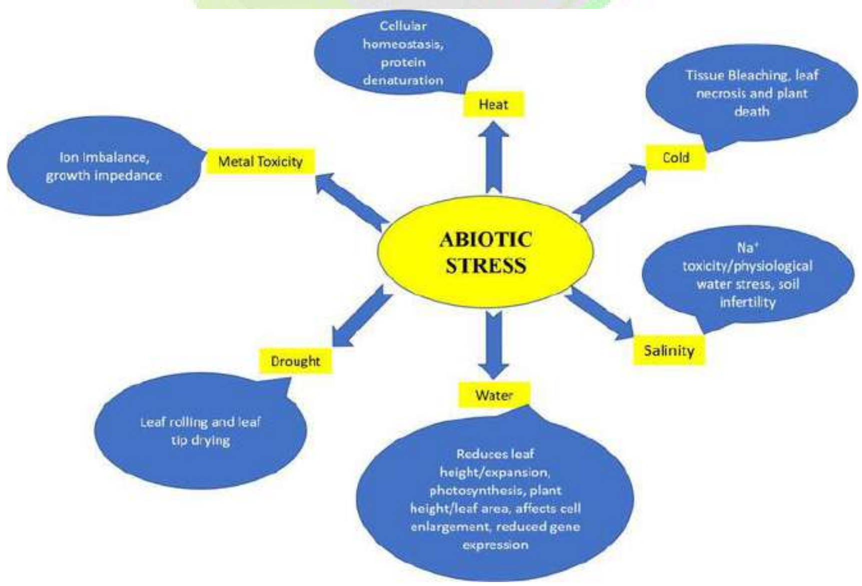
Keywords: Nanotechnology, nanoparticles, abiotic stress, heat stress, cold stress, drought stress, flood stress, salinity, stress tolerance, remediation.

Introduction

Abiotic stress, resulting from various environmental factors such as temperature extremes, water scarcity, flooding, and salinity, poses significant threats to ecosystems, agriculture, and human welfare. Climate change exacerbates the frequency and intensity of abiotic stressors, emphasizing the urgent need for innovative solutions to mitigate their adverse effects. Nanotechnology, the manipulation of materials at the nanoscale, offers promising opportunities to address abiotic stress challenges by harnessing the unique properties of nanoparticles.

Abiotic stress in crops

Plants are constantly exposed to various stress factors throughout their life span. As per the data available, the relative decreases in potential maximum yields associated with abiotic stress factors vary between 54 and 82%. Crops confront various types of abiotic stress and it has been well documented as well that among stresses, extreme temperatures (freezing, cold, heat), water availability (drought, flooding), and ion toxicity (salinity, heavy metals) are the major causes which adversely affect the plant growth and productivity worldwide



Types of abiotic stress with their effects on growth of plants.

Nanoparticles for Mitigating Abiotic Stress

1.Heat Stress

Heat stress adversely affects plant growth and productivity by disrupting cellular processes and inducing oxidative damage. Nanoparticles such as titanium dioxide (TiO_2) and cerium oxide (CeO_2) have been shown to enhance heat tolerance in plants by regulating heat shock proteins, scavenging ROS, and improving photosynthetic efficiency (Gurunathan *et al*., 2016; Singh *et al*., 2019).

2.Cold Stress

Cold stress inhibits plant growth and development by causing cellular damage and impairing metabolic processes. Silver nanoparticles (AgNPs) and carbon nanotubes (CNTs) have demonstrated potential in mitigating cold stress by enhancing membrane stability, modulating gene expression, and promoting antioxidant defense mechanisms (Mahakham *et al*., 2017; Tripathi *et al*., 2017).

3.Drought Stress

Drought stress reduces water availability to plants, leading to wilting, stomatal closure, and decreased photosynthesis. Nanoparticles such as silica nanoparticles (SiNPs) and zinc oxide nanoparticles (ZnO NPs) have been reported to alleviate drought stress by improving water use efficiency, enhancing root growth, and modulating osmotic adjustment mechanisms (Siddiqui *et al*., 2018; Tripathi *et al*., 2020).

4.Flood Stress

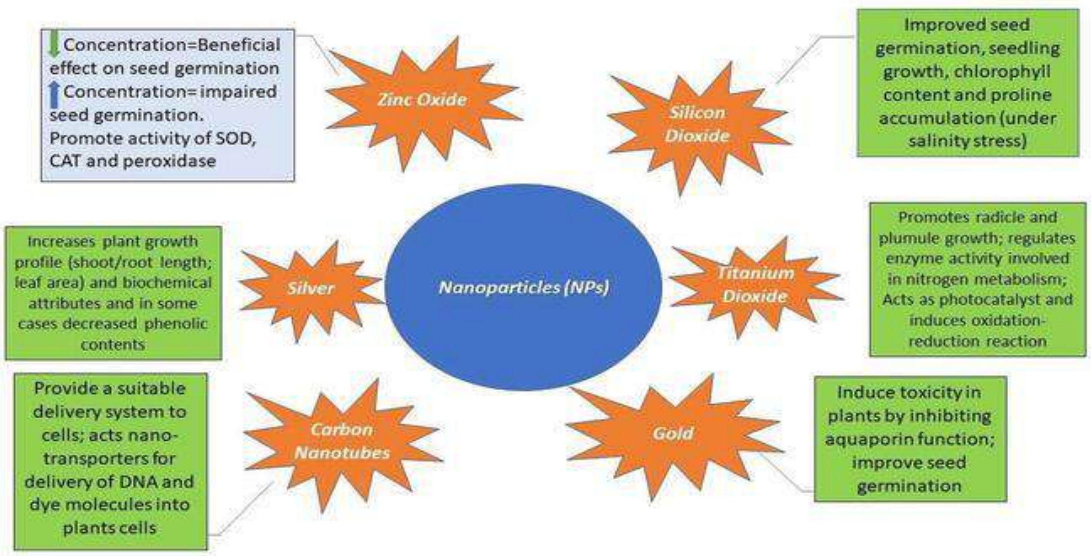
Flood stress results in oxygen deprivation and waterlogging, impeding nutrient uptake and causing root damage in plants. Iron oxide nanoparticles (Fe_3O_4 NPs) and magnetic nanoparticles have shown promise in mitigating flood stress by enhancing soil aeration, promoting root growth, and facilitating nutrient absorption (Yadav *et al*., 2017; Kaur *et al*., 2020).

5.Salinity Stress

Salinity stress disrupts ion balance and osmotic regulation in plants, inhibiting growth and reducing crop yield. Nanoparticles such as chitosan nanoparticles (CS NPs) and graphene oxide nanoparticles (GO NPs) have been explored for alleviating salinity stress by enhancing ion homeostasis, promoting osmotic adjustment, and reducing ion toxicity (Raliya *et al*., 2015; Tripathi *et al*., 2018).

Mechanisms and Challenges

The mechanisms underlying the effects of nanoparticles on abiotic stress involve complex interactions between nanoparticles and biological systems, including nanoparticle uptake, translocation, and physiological responses. However, challenges such as nanoparticle toxicity, environmental persistence, and regulatory concerns need to be addressed to ensure the safe and sustainable application of nanotechnology in mitigating abiotic stress.



Various nanoparticles with their effect on plant growth.

Conclusion and Future Perspectives

Nanotechnology holds immense potential for mitigating abiotic stress in various applications, including agriculture, environmental remediation, and materials science..

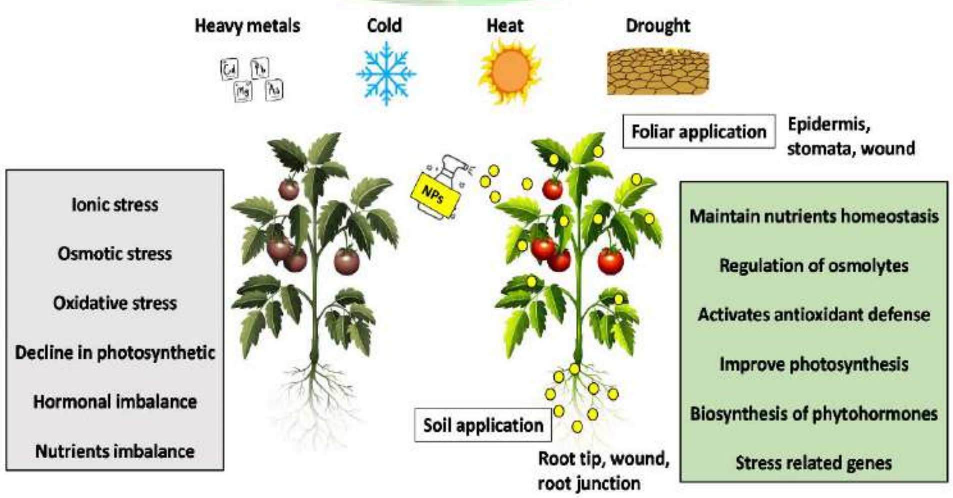


Figure 1. Mechanisms of NPs mitigate abiotic stresses in plants.

Further research is warranted to elucidate the underlying mechanisms, optimize nanoparticle properties, and develop eco-friendly and cost-effective nanoparticle-based strategies. Collaboration among scientists, policymakers, and stakeholders is essential to realize the full benefits of nanotechnology while addressing potential risks and ensuring environmental sustainability

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IMPACT OF INTERLINKING OF RIVERS IN INDIA - SHORT NOTES

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Introduction

India's water shortage is anticipated to worsen significantly in the next generations due to the current worldwide situation. Additionally, due to a lack of water for both satisfaction and the use of basic necessities like crop protection, aquaculture operations, etc., these drought circumstances may cause climate variability, which can affect humans and cause misery in many parts of the country. Freshwater has become scarce in many places of India due to the tremendous rise in demand for it brought on by population and economic expansion. As a result, the disparity between the population and the available water resources is getting worse every day. A significant project has been undertaken by the National Water Development Agency (NWDA), and over 30 linkages have been planned to connect the major rivers. (Fig. 1). An MOU has been signed between the states of Uttar Pradesh and Madhya Pradesh and the Union Government, and the Government of India has approved the nation's first river interlinking project on the Ken-Betwa (Mehta and Mehta, 2018).

Large-scale inter-basin transfers are normally very expensive, which makes them economically risky. They also frequently have considerable social and environmental consequences, typically for both the river basin supplying and receiving the water (Joshi et al., 2017). According to the current level of knowledge, there are both good and negative effects on the freshwater aquatic ecosystem caused by big dams, inter-basin transfers, and water withdrawal from rivers. There may be both positive and negative effects on fish and aquatic biodiversity, both of which will be covered here

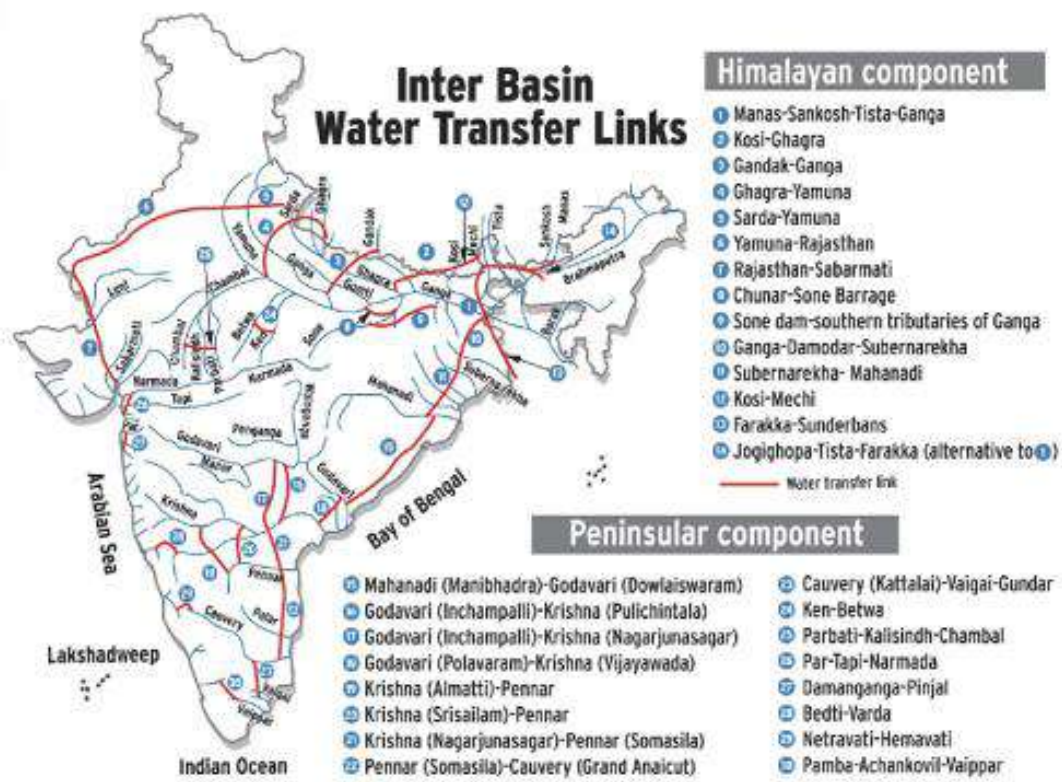

Fig.1 Interlinking of rivers in India

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Background of the interlinking proposal in India

• 1972 - Ganga Cauvery link proposed by Union Minister Dr. K.L. Rao.

• 1974 - Garland Canal proposal by Captain Dinshaw J Dastur, a pilot. Both plans were rejected due to technical infeasibility and huge costs.

• 1980 - Ministry of Water Resources frames the National Perspective Plan (NPP) envisaging inter-basin transfer.

• 1982 - The National Water Development Agency (NWDA) was set up to carry out pre-feasibility studies. These form the basis of the ILR plan.

• 1999 - A national commission (NCIWRDP) set up to review NWDA reports concluded that it saw ‘no imperative necessity for massive water transfers in the peninsular component’ and that the Himalayan Component would require more detailed study.

•August 15, 2002 - President Abdul Kalam mentions the need for river-linking in his Independence Day speech; based on which senior advocate Ranjit Kumar filed a PIL in Supreme Court.

• October 2002 - Supreme Court recommends that the government formulate a plan to link the major Indian rivers by the year 2012.

• December 2002 - Govt. appointed a Task Force (TF) on Interlinking of rivers (ILR) led by Mr. Suresh Prabhu. The deadline was revised to 2016 **(**Bandyopadhyay and Perveen, 2004)

Effects over fish environment (Alla and Liu, 2021)

1. As a physical barrier:

The dam impedes the flow of species, changing the species composition in the upstream and downstream areas and even causing species extinction. By dividing river systems and obstructing the transit of species and their use of diverse types of habitats, the obstruction limits migration.

2. Loss of habitat

In India the construction of the Farakka barrage on river Ganga has grossly affected (Hilsa, *Tenualosa ilisha*), Indian major carps (*Catla catla*, *Labeo rohita*, and *Cirrhinus mrigala*), catfishes, freshwater prawns, and many more fishes leading to detrimental effects on physical attributes and destruction of feeding, spawning, and migration routes of fishes.

3. Alteration in spawning and breeding grounds

The nursery areas are impacted by a drop in freshwater flow and nutrients as a result of water channelization, dam construction, and water diversion. These changes result in salinity increases, the invasion of predatory fish, and a decrease in the amount of food that is available.

4. Effect of changed temperature

The chemical and thermal properties of river water can be altered by dams. This may have an impact on fish populations and species downstream. Changes in water temperature have frequently been implicated as a factor in native species decline.

5. Increased exposure to predation

The construction of a dam may alter normal predation behavior; it appears that fish or other predators are more aggressive toward migrating species in the area of an installation.

6. Impact on fish production

The proposed interlinking of rivers will include 30 canal linkages and more than 36 large dams. Barrages and irrigation canals will also increase significantly. These significant reservoirs, canals, and other water-gathering infrastructure will increase the nation's potential fisheries resources.

7. River siltation and dredging

Due to interlinking, the siltation pattern in the donor and reception rivers may change. In the Himalayan region, heavy siltation of rivers, canals, and lakes is already a serious issue. The effectiveness of river bed dredging for enhancing river ecology and fish output must be evaluated immediately.

Other environmental aspects

1. Salinity

The Himalayan Mountain ranges, where there is typically heavy precipitation, are the source of the majority of the rivers that flow through the Ganga Plains and Northeast India. Most rivers flow through arid or semiarid areas of Ganga Plain, where the concentration of total soluble solids is often low. In such circumstances, the concentration of salt through evaporation increases steadily with downstream distance, especially in their lower reaches.

2. Water supply

The picture of water supply of the whole country is going to change by transferring the 'surplus water' to water 'deficit area'. The concept of 'surplus water' is itself faulty, as a reduction of surplus/flood water will affect the surface water supply in terms of quantity and quality as well.

Conclusion

India's proposed river-linking project is a very ambitious idea. It goes without saying that water resources are necessary for supporting life on Earth and all types of socioeconomic development activities. Since India already faces a growing population and a lack of all kinds of natural resources, including water, proper planning and management of aquatic resources are crucial. Many pertinent aspects concerning the sustainable protection of aquatic biodiversity must be visualized.

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A COMPREHENSIVE STARTUP AND STRATEGIC PLANNING FOR BACKYARD POULTRY FARMING VENTURE

Article ID: AG-VO4-I03-57

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Abstract

An overview of the rising demand for fresh, organic poultry products and the growing interest in backyard farming. It emphasizes the need for a well-structured startup plan to navigate the complexities of the backyard-poultry farming industry. This abstract describes a thorough start-up strategies that takes into account all the important elements needed to create a profitable backyard poultry farm, including operational strategies, infrastructure construction, market research, and sustainable practises. Infrastructure development outlines the physical and technological infrastructure required for a backyard poultry farm. It covers aspects such as choosing suitable chicken breeds, designing brooder house for optimal comfort and safety, implementing biosecurity measures for monitoring and management. Efficient operational strategy discusses key considerations such as feed management, health monitoring, waste disposal, and biosecurity protocols. It also explores the implementation of sustainable practices to reduce environmental impact. The target demographics, local demand, and customer preferences are all determined through market research. The analysis encompasses an examination of rival companies, their pricing tactics, and possible avenues for distribution in order to facilitate efficient market entry. Backyard poultry farming has a significant positive impact on the economic and nutritional status of low-income and malnourished people in India. Backyard poultry production accounts for 15% total poultry production and Native chicken

varieties raised in backyards produce around 11% of total egg production in India. Improved chicken breeds appropriate for backyard farming must be introduced, and farmers' knowledge of general management, housing, feeding, and disease control must be developed for sustained production. This article highlights on emphasizing the holistic nature of the startup plan and importance of a realistic budget to ensure financial sustainability and growth

Keywords: *Backyard poultry, Biosecurity, Profitable business, Disease control.*

Introduction

According to the most recent (20th) livestock census, there are 851.81 million chickens in India as of 2019, an increase of 16.8% over the previous census. Accordingly, the number of backyard chickens in the nation increased by 45.8% from the previous Census to 317.07 million in 2019. On the other hand, commercial poultry production climbed by 4.5% from the previous census, reaching 534.74 million birds in 2019. The statistics data by itself indicates that the backyard poultry industry is expanding tremendously. It is growing at a much faster rate as compared to commercial poultry production. This article explores the peculiarities of backyard poultry farming in India, rearing and managemental practices along with project report proposal for 1000 chicks and its contribution to farming people' livelihoods, and potential future initiatives for increasing backyard chicken output. Indigenous avian species exhibit remarkable resilience, demonstrating the ability to thrive in challenging environmental conditions.

These birds possess inherent immunity to common diseases, excel as nurturing mothers, and display exceptional foraging skills. Scavenge freely around homes, they generate high-quality animal protein through the production of eggs and meat. Their capacity to endure irregular feed and water supply, coupled with minimal healthcare, results in sustained production levels. For small and marginal farmers, as well as agricultural laborers, these birds serve as a crucial source of additional income. While backyard bird farming is primarily extensive, some supplementary feeding enhances productivity in the management of these flocks. The establishment of night shelters plays a crucial role in safeguarding birds from harsh weather conditions and potential predators. While birds scavenge for food during the day, consuming insects, pests, crop residues, and more, this scavenging alone does not ensure an optimal diet for maximum production. The nutrient intake of scavenging birds varies based on location, seasons, crops, and natural vegetation. Common feedstuffs in family poultry include maize grains, maize scrap, millet bran, food scraps, grower mash, and poultry mash, often provided in the form of mash or pellets. The manure produced by birds serves as an excellent source of organic matter, contributing to soil fertility and increased crop yields. Given the seasonal nature of agriculture, poultry farming offers the potential for year-round employment opportunities for many individuals.

Optimal Returns with Minimal Investment: Launching a poultry unit requires as few as two chickens, scaling up to a large flock. The feed cost is negligible, thanks to efficient use of agricultural by-products and leftover feed. With a burgeoning local market demand for high-quality desi chicken meat and eggs, selling at premium prices is viable. This venture not only enhances family income but also provides opportunities for family members unable to engage in other agricultural activities, such as older family members or children. Backyard poultry farming serves as a flexible income source, akin to an 'ATM,' allowing the sale of birds and eggs at any time and place for immediate cash. Furthermore, the organic farming approach ensures superior quality chicken and eggs, as the birds thrive in a stress-free environment with natural inputs. Optimum conditions required in poultry shed Temperature: 22-30º C (70-85ºF), Relative humidity: 30-60 per cent, Litter moisture: 15-25 per cent, Airflow: 10-30 meters per minute, Ammonia: less than 25 ppm

Materials and Methods

1 **Brooding operations**

In preparation for the imminent arrival of chicks, it is essential to set up the brooder approximately 24 hours beforehand, as illustrated in Figure 1. The housing facility should undergo thorough cleaning, including disinfection, whitewashing, and the use of a blow lamp, for proper brooder arrangements, a layer of paddy husk, reaching a height of 5 cm, should be spread, with newspaper placed over it to prevent the ingestion of husk by young chicks. Metal sheets and cardboard are employed as brooder guards, arranged in a circular fashion on the litter material, extending 1.5 feet. The diameter of the brooder guard is determined by the number of chicks, for an example with a recommended 150 cm diameter for 225 chicks and 180 cm diameter for 300 chicks. Adequate free space should be provided around waterers and feeders to allow unrestricted movement.

The lighting setup is crucial, with a requirement of 1 watt per chick. Bulbs should be turned on 1-2 hours prior to the chicks' arrival to maintain a warm environment. On the first day, continuous light for 24 hours is necessary, followed by a schedule from the 3rd day evening (4 pm) to the following morning (8 am). Maintaining optimal brooding temperature according to chicks age, at first week house temperature was maintained at 35 ºC, second week at 32.2 ºC, third week at 29.4 ºC and by fourth week at 26.6 ºC and followed by removal of brooder guard on 7th day and space was given as per standard managemental procedure 0.5 square feet/chick.

Vaccination of chicks were started by 7th day by F-strain for Raniket disease by intra-occular route followed by Georgia strain for Infectious bursal disease on 14th day and lastly by Lasota vaccine for Raniket disease (Booster dose) on 28th day

2. Summer management

Mitigating the Impact of Elevated Summer Temperatures on Poultry: Effective Strategies for Managing Growth Rate and Egg Production. Poultry farmers face substantial economic losses due to the heightened ambient temperatures during summer, leading to severe depression in growth rate and egg production. Implementing proper summer management practices can significantly overcome these challenges, focusing on shed and feed modifications.

Shed management strategies encompass the use of thatched roofing with a thickness of more than 6 inches (maintained at temperatures above 45º C), avoiding excessive stocking density, increasing floor space by 10%, incorporating ridge ventilation, limiting litter thickness to 6 cm to prevent heat generation, applying white paint to walls for heat reflection and stress reduction, covering side walls with wet curtains, enhancing air flow rate and air exchange by at least 25%, and utilizing sprinklers on the roof to operate continuously from 10-18 hours for roof cooling.

Feed modifications involve replacing 10-15% of calories (energy) in the feed with fat or oil (adding 2-3% fat without increasing the total calorie content), providing 1-2% protein with a 10% reduction in energy, adding 0.48% potassium chloride to water to lower heat stress, incorporating 0.5-1% sodium bicarbonate, and increasing water supply as intake rises by 2-4 times during the summer.

3 Debeaking Procedure

It is necessary in backyard farming to prevent feed wastage and vent pecking among birds causing self-mutilated wounds. The 1stdebeaking done at 10th -14th day. Their beaks have to be cut and cauterised by electrical cauterization, by maintaining Temperature of 550-600ºC.

Results and Discussions

The market analysis involves extensive market research revealed a growing demand for locally sourced poultry products, indicating a favorable market for the proposed venture and identified key competitors and market trends, providing crucial insights for strategic planning and differentiation. The ffinancial viability was conducted by thorough financial analysis, including startup costs, operational expenses, and revenue projections over a five-year period and developed financial models to assess profitability and return on investment, ensuring the economic sustainability of the backyard poultry farming venture. Operational framework has established a comprehensive operational plan covering breeding, feeding, health management, and waste disposal and also implemented biosecurity measures to prevent disease outbreaks, ensuring the overall health and productivity of the poultry.

The strategic planning formulated a detailed strategic plan encompassing short-term and long-term goals, market positioning, and potential expansion opportunities. The technology integration was explored by innovative technologies for poultry farming, including automated feeding systems, health monitoring, and data analytics for optimized decision-making and demonstrated how technology integration can improve efficiency, reduce costs, and enhance overall productivity. The regulatory compliance was developed by a regulatory compliance framework to guide the venture in adhering to industry standards and ethical practices. Community impact and sustainability investigated the potential environmental impact of the poultry farming venture and proposed sustainable practices. The risk assessment and mitigation involved identification of potential risks associated with the backyard poultry farming venture, such as disease outbreaks, market fluctuations, and regulatory changes and also formulated a robust risk management plan, outlining strategies to mitigate and respond to identified risks.

Conclusion

In conclusion, It asserts that a well-executed plan will not only ensure the success of the backyard poultry farming venture but also contribute to the broader goals of food security and environmental responsibility. A robust marketing strategy is essential for creating brand awareness and attracting customers. It's important to focus on converting conventional backyard chicken farming into scientific backyard poultry farming in order to draw in more farmers and make the industry more profitable or cost-effective.

The feasibility and viability of the comprehensive startup and strategic planning for the backyard poultry farming venture. The findings provide a solid foundation for the successful establishment and sustainable growth of the proposed enterprise.

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MILLETS: INDIAN SCENARIO, BENEFITS AND TYPES

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Abstract

Indian Millets are nutritionally superior to wheat and rice as they are rich in protein, vitamins and minerals. They are also gluten-free and have a low glycemic index, making them ideal for people with celiac disease or diabetes. Millet is a resilient small-seeded grass that grows well as a rain-fed crop under marginal soil fertility and moisture conditions in dry regions. The earliest domestically farmed cereal grain millets are Sorghum, Finger Millet, Foxtail Millet, Proso Millet, and Barnyard Millet. While rice and wheat require a lot of water and fertiliser, millets can thrive in dry areas since they are rain-fed crops. They are low in fat, low in glycemic index, and high in dietary fibre. According to some research, Millet may also raise your "good" cholesterol levels and lower your triglycerides. Eating millet regularly may assist in keeping your heart healthy because it lowers cholesterol levels.

Key words : Fibre, Glycemic index, Health, Millets,

Introduction

Indian millets are a group of nutritiously rich, drought tolerant and mostly grown in the arid and semi-arid regions of India. They are small-seeded grasses belonging to the botanical family Poaceae. They constitute an important source of food and fodder for millions of resource-poor farmers and play a vital role in ecological and economic security of India. These millets are also known as "coarse cereals" or "cereals of the poor". Indian Millets are nutritionally superior to wheat and rice as they are rich in protein, vitamins and minerals. They are also gluten-free and have a low glycemic index, making them ideal for people with celiac disease or diabetes. India is among the top 5 exporters of millets in world. World export of millet has increased from $400 million in 2020 to $470 million in 2021 (ITC trade map) India exported millets worth $64.28 million in the year 2021-22, against $59.75 million in 2020-21. Share of Millet based value added products is negligible.

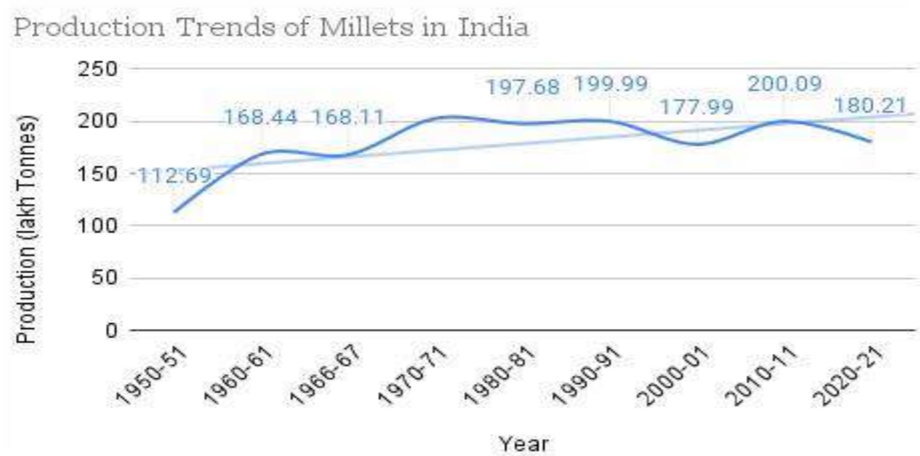
India is the largest producer as well as the largest exporter of cereal products in the world. India's export of cereals stood at Rs. 96,011.42 Crore / 12,872.64 USD Millions during the year 2021-22. Rice (including Basmati and Non-Basmati) occupy the major share in India's total cereals export with 75% (in value terms) during the same period. Whereas, other cereals including wheat represent only a 25 % share of total cereals exported from India during this period.

Indian Millet Production Scenario

Millet is a type of grain that is popular in many parts of the world, especially in Africa and Asia. It is a staple food in many parts of the world, particularly in Africa and Asia. According to the World Food Programme, there are an estimated 1.2 billion people who consume millet as a part of their diet.

Millet production has remained relatively stable over the past few years, with an estimated production of 28 million metric tons in 2020. The majority of millet is produced in Africa, followed by Asia. India is the largest producer of millet, followed by Niger and China. Other major millet-producing countries include Burkina Faso, Mali, and Senegal.While millet is not a major food crop in the developed world, it plays a vital role in the diets of many people in developing countries. Millet is a drought-tolerant crop that can be grown in dry, arid climates where other crops would fail. It is also a nutritious grain that is high in fiber and essential minerals. For these reasons, millet will continue to be an important food crop in the years to come.

In India, millet production has been on the rise in recent years. India is one of the largest producers of millets &Indian farmers have been increasingly planting millet as a drought-resistant crop. The Indian government has also been promoting millet production as part of its National Food Security Mission. As a result of these factors, millet production in India is expected to continue to grow in the coming years. The graph below depicts the production trends of millets in India.



Indian Millet Sourcing Point:

India is one of the leading producers and suppliers of millet, and there are a number of millet sourcing points located throughout the country. The main millet-growing states in India are Rajasthan, Maharashtra, Karnataka, Andhra Pradesh, and Madhya Pradesh These states have a large number of millet farmers who grow the grain for both domestic and international markets. In addition to the major millet producing states, there is also a number of smaller millet producing regions located throughout India. These regions include the states of Uttar Pradesh, Bihar, and Madhya Pradesh.

Benefits of Millets:

- Niacin, found in millet, aids the body in more than 400 enzymatic processes. Niacin is necessary for a healthy immune system and healthy skin and organs. Because it’s such a vital component, it’s typically added to processed foods as a supplement.
- Beta-carotene is abundant in millet, particularly the darker kinds. This natural pigment functions as an antioxidant and a precursor to vitamin A to protect your eyes and your body from free radicals.
- Millet is a low-glycemic index (GI) as well as a non-acid forming food because it is low in simple carbohydrates and high in complex carbohydrates. Therefore, millet flour requires more time in the digestive process. People with diabetes can better control their blood sugar levels by eating meals with a low glycemic index (GI).
- Insoluble and soluble fibre can be found in millet. As a prebiotic, millet’s insoluble fibre promotes the healthy microorganisms in your intestines.

• In addition to helping keep you regular and decreasing your chance of colon cancer, this particular form of fibre helps bulk up stools.

• Millet's soluble fibre may help lower bad cholesterol levels, which is a risk factor for the development of atherosclerosis. In the stomach, soluble fibre forms a gel that absorbs cholesterol, allowing it to exit the body safely.

• According to some research, Millet may also raise your "good" cholesterol levels and lower your triglycerides. Eating millet regularly may assist in keeping your heart healthy because it lowers cholesterol levels.

Nutrition

- Potassium, found in abundance in millet, aids kidney and heart health. Nerve signal transmission, which is how your mind and muscles communicate, also relies on potassium.
- Potassium, Phosphorus and Niacin are also found in abundance in this food, as well as Vitamins A and B. Millets are also rich sources of minerals.

Wide Capacity for Adoption

• Millet is a resilient small-seeded grass that grows well as a rain-fed crop under marginal soil fertility and moisture conditions in dry regions. The earliest domestically farmed cereal grain millets are Sorghum, Finger Millet, Foxtail Millet, Proso Millet, and Barnyard Millet. While rice and wheat require a lot of water and fertiliser, millets can thrive in dry areas since they are rain-fed crops. They are low in fat, low in glycemic index, and high in dietary fibre.

• According to agronomics, the resurgence of millet production in the southern states of Karnataka, Andhra Pradesh, and Telangana is a step toward more environmentally friendly farming methods that preserve the region's rich biodiversity. Millets have several advantages over other crops in terms of sustainability.

• When comparing the amount of water required to cultivate rice and millets, it is clear that rice requires more water. An ICRISAT study has found that a single rice plant requires approximately 2.5 times the amount of water as a single millet plant of most kinds. This global research organisation is striving to popularise millets.

• During the Kharif (April-October) season, it was a staple food in the northern and southern Karnataka regions during the Kharif (April-October) season. It was grown alongside groundnuts and other crops by farmers in Dharwad, Bagalkot and the surrounding areas. When rice and wheat arrived in the region three to four decades ago, millet was supplanted as the primary source of food for farmers in the Mandya and Tumakuru regions.

Types of millets

Jowar (Sorghum)

Sorghum is commonly known as Jowar in India. Traditionally, jowar was used as a grain to make flat breads/ rotis. Enriched with the goodness of iron, protein and fibre, jowar can help in reducing cholesterol level as it has a component called policosanols (a part of sorghum wax). It is good for people who have wheat intolerance.

Ragi (Finger Millet)

Ragi is used as a healthy substitute for rice and wheat. Ragi is undoubtedly a powerhouse of nutrition. Loaded with protein and amino acids, this gluten free millet is good for brain development in growing kids.

Foxtail millet

Foxtail millet has healthy blood sugar balancing carbohydrates, and it is popularly available in the form of semolina and rice flour. The presence of iron and calcium in this millet helps in strengthening immunity.

Bajra (Pearl millet)

This millet is known for its umpteen health benefits. Packed with the goodness of iron, protein, fibre, and minerals such as calcium and magnesium; the daily consumption or inclusion of this millet can work wonders.

Barnyard millet

This nutrient dense millet has high fiber content, which can effectively help in losing weight. It is a rich source of calicum and phosphorius, which helps in bone building and its daily caonsumption helps infighting bone diseases.

Proso millet

This millet can effectively help in balancing blood sugar level. Its low glycemic index has made it a fad among weight watchers. In India is has been a commonly bird feed.

Little millet

Packed with the goodness of B-vitamins, minerals like calcium, iron, zinc and potassium, little millets can provide essential nutrients, which further help in weight loss. It is a part of many traditional dishes in south India. What's more, more than anything its high fiber content makes it a healthy replacement for rice.

Government Measures to Increase Millets Production

- Despite its multiple advantages, Millet use is confined to traditional consumers, i.e., tribal communities. There aren't many ready-to-eat millet-based goods available to consumers.
- Millets have recently received attention, and attempts are being made to obtain easy and value-added processed products from them. Millets, such as jowar, bajra, ragi, and other varieties, are important food sources for many households in dry and hilly regions. As a result, it has been advocated that the Public Distribution System add millets to its food supply.
- Millets have been acknowledged as an important part of the food chain by the government. The NFSM's first projections for increasing food grain production by 25 million tonnes include a 2 million-ton share for millets or 8 percent of the increased food grain output.

Conclusion

It has several advantages, including low-maintenance, disease resistance, nutritional value, market demand, fodder value, and ecological benefits.

Millets, often known as C4 crops, are extremely effective at absorbing and utilising CO_2. Most millets are well-known for their toughness and ability to produce grains and fodder, even when subjected to protracted periods of drought and high heat.

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OCCURRENCE OF COCONUT BUTTON/ NUT BORER (*CYCLODES OMMA*) IN ORATHANADU BLOCK OF THANJAVUR DISTRICT

Article ID: AG-V04-I03-59

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Introduction

Coconut palm (*Cocos nucifera*) is one of the important commercial crops, cultivated as a sole crop or as an intercrop. It is in high demand for cooking, tender coconut and coconut oil. India is the largest coconut producer (19,247 million nuts) worldwide and accounted for 31. 45 % of world's total production during 2021-22. Thereby contributes approximately Rs. 307, 498 million to country's gross domestic product. In Tamil Nadu, coconut is being cultivated in 4.3 lakh's hectares with the production and productivity of 4515 million nuts and 10484 nuts ha^{-1} respectively and ranks first in coconut processing activities. It is cultivated around 95,000 acres in Thanjavur district, particularly in Pattukottai and surrounding areas such as Peravurani, Orathanadu, and Sethupavachathiram.

Different stages of caterpillar (*Cyclodes omma*)

	
Pupa	**Adult**

This crop is vulnerable to many major insect pests *viz*., rhinoceros beetle, red palm weevil, eriophyid mite, black-headed caterpillar, rugose whitefly, etc. However, scales, leaf eating caterpillar, nut borer, thrips, white grubs, red tree ants, etc. are some of the minor pests of coconut palm occurring in Tamil Nadu.

The palm coconut trees at Ampalapattu, Sivakollai, Vadacherry and Thirumangalakottai villages of Orathanadu block in Thanjavur district were observed with damages caused by coconut nut borer, *Cyclodes omma* (Lepidoptera: Noctuidae) on coconut buttons. It is a sporadic pest normally found in dwarf genotypes and also in hybrids. The excessive application of nitrogenous fertilizers is one of the factors responsible for pest outbreak. Palms subjected to assisted pollination are more susceptible to this pest attack. ..

	
Nut Borer (*Cyclodes omma*) larval feeding on coconut buttons	**Bore hole symptoms on coconut buttons**

Symptoms

- Caterpillars bore into buttons after pollination as well as immature nuts and feeds voraciously during night hours and cause button shedding.
- Later infestation destroys the entire bunch of developing nuts.
- Caterpillar excreta were also evident on the palm leaf petiole.
- The pupal stages are observed on the debris of palm crown.

Nut Borer (*Cyclodes omma*) larval feeding on coconut inflorescence

Nut Borer (*Cyclodes omma*) larval feeding on Spadix

Symptoms on Spadix due to larval feeding

Preventive and Curative measures

- Crown cleaning and removal of immature stages of the pest by hand picking and destroying is the effective management tactics.

- Judicious and need based application of nitrogenous fertilizers
- Application of the entomopathogen, *Bacillus thuringiensis* @ 20 g per litre or neem oil 0.5%
  (5 ml per litre with 10 g soap powder) using hand sprayers would reduce pest incidence.
- Pressurized spraying of neem oil @ 3 ml/ lit with 1.5 ml of spreader/ soap oil at 45 days interval which disturbs the egg masses
- As prophylactic measure, spray 1% of Bordeaux mixture to the spindle/leaf or crowns of the tree before onset of the monsoon.
- In case of severe infestation spray chlorantraniliprole 9.3% +Lamda cyhalothrin 4.6 % ZC @ 2ml/lit or spraying of Lamda cyhalothrin 5 % EC @ 2ml/ lit
- After 30 days, again spraying of neem oil @ 5ml/ lit with 2ml of teapal on all emerging newly developed inflorescence.
- Repeat the neem oil spray at 15 days interval upto 2 months.

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THE ROLE OF IOT IN ADVANCING PRECISION AGRICULTURE

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Abstract

The integration of Internet of Things (IoT) in agriculture, particularly in precision farming, has revolutionized farming practices, significantly boosting efficiency, sustainability, and productivity. Precision agriculture relies on real-time data-driven decision-making, facilitated by IoT technologies. By deploying interconnected devices, sensors, and actuators across fields, farmers access valuable data on soil health, weather conditions, and crop growth patterns. This empowers them to optimize resource usage and minimize environmental impact. A key application of IoT in precision agriculture is soil monitoring, where smart sensors provide real-time insights into soil composition, moisture levels, and nutrient content. This data guides precise irrigation and fertilization strategies, maximizing yields while minimizing resource overuse. Crop monitoring and management benefit from IoT as well, with smart devices monitoring health, detecting diseases or pests early, and optimizing agricultural inputs. This proactive approach fosters healthier crops and a more sustainable farming ecosystem. IoT extends into machinery and equipment, where smart tractors, harvesters, and drones equipped with sensors enable precise and automated farming operations. Integration of GPS technology enhances accuracy, ensuring efficient field utilization. Moreover, IoT aids in weather forecasting and predictive analytics, leveraging data from various sources to inform planting schedules and harvest timings, mitigating risks and increasing farm resilience. The role of IoT in advancing precision agriculture signifies a transformative shift, redefining farming practices for increased

precision, productivity, and sustainability. The seamless integration of IoT devices, data analytics, and smart machinery allows farmers to operate with unprecedented efficiency, maximizing yields while minimizing environmental impact. Overall, IoT in agriculture represents not just a technological advancement but a fundamental reimagining of how we cultivate the land and nourish the world.

Keywords: *Precision farming, IoT integration, Sustainable agriculture, Enhanced productivity*

Introduction

Agriculture holds the largest share in India's economy, contributing around 18% to the gross domestic product and engaging approximately 57% of the rural population. Despite a rise in overall agricultural output, the proportion of farmers has declined from 71.9% in 1951 to 45.1% in 2011 (Reddy and Dutta 2018). According to the Economic Survey 2018, the agricultural workforce is projected to decrease to 25.7% of the total workforce by 2050. In rural areas, farming families are gradually losing the next generation of farmers due to factors such as rising cultivation costs, low per capita productivity, inadequate soil maintenance, and a shift towards non-farming or more lucrative occupations. At present, the world is on the brink of a digital revolution, making it an opportune time to integrate agricultural landscapes with wireless technology, thereby introducing and facilitating digital connectivity for farmers.

The current phase of agriculture, known as Agricultural Era 4.0, integrates advanced technologies such as the Internet of Things, big data analysis, artificial intelligence, cloud computing, and remote sensing. The adoption of these new technologies has led to significant enhancements in agricultural practices through the creation of cost-effective sensor and network platforms. These platforms aim to optimize production efficiency while minimizing the usage of water resources and energy with minimal environmental impact (Ferrandez *et al*., 2016). In smart farming, big data analysis offers real-time insights into agricultural conditions, enabling farmers to make informed decisions (Wolfert *et al*., 2017). Additionally, real-time programming, utilizing concepts of artificial intelligence, is embedded in IoT devices to assist farmers in making optimal decisions (Liakos *et al*., 2018).

Precision agriculture stands as a strategic approach to farming management, leveraging technology and data to enhance both the efficiency and sustainability of agricultural production. This method revolves around the meticulous observation, measurement, and response to variations within fields and crops. By employing advanced technologies and analytical tools, farmers gain the ability to make well-informed decisions regarding the allocation of resources. This proactive strategy not only optimizes the utilization of resources but also contributes to a more sustainable and environmentally conscious approach to agriculture.

At its core, precision agriculture entails a comprehensive process of monitoring and analyzing various factors influencing crop growth, including soil conditions, weather patterns, and overall field variability. Armed with this valuable data, farmers can implement targeted interventions, adjusting their practices based on real-time information. This enables a more precise and efficient use of resources such as water, fertilizers, and pesticides, minimizing waste and environmental impact. In essence, precision agriculture transforms traditional farming by integrating cutting-edge technologies into the decision-making process. The result is a more dynamic and responsive approach to agricultural management, fostering increased productivity while concurrently promoting sustainable farming practices. Through the continual refinement of techniques and the integration of emerging technologies, precision agriculture remains at the forefront of modern farming strategies, offering a path towards a more resource-efficient and environmentally responsible future for the agricultural sector.

Fundamental Aspects

Technologically-Enhanced Framework: Utilizes contemporary instruments and employs data analysis to enhance the efficiency of agricultural methods.

Enhanced efficiency and heightened productivity*:* Aim to optimize crop yields while minimizing resource inefficiencies, resulting in increased overall production.

Environmentally Responsible Approaches: Concentrates on reducing environmental consequences through the efficient utilization of resources such as water and fertilizer.

Information-Based Decision Making: Depends on information gathered from sensors, satellites, and various tools to inform decisions regarding planting, irrigation, pest management, and harvesting strategies.

Predictive Modelling Methods*:* Utilizes diverse models such as Crop Growth Models, Digital Twins, and Machine Learning to forecast crop behaviour, optimize the distribution of resources, and detect potential issues.

Benefits of IoT

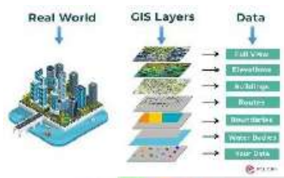
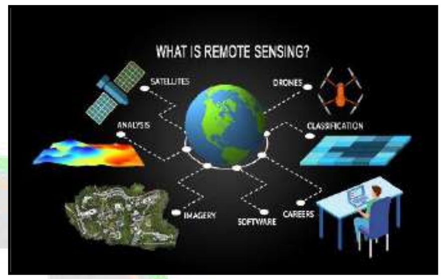
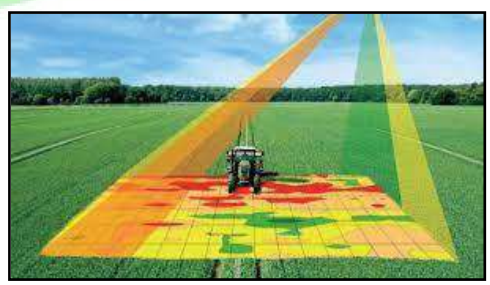
Greater Financial Prosperity: Greater financial gains result from increased yields and more efficient utilization of resources.

Superior Environmental Resilience: Reduces environmental footprint by employing responsible practices in water and chemical usage.

Better-Quality Harvest: The adoption of data-driven management practices leads to crop quality that is both healthier and more consistently maintained.

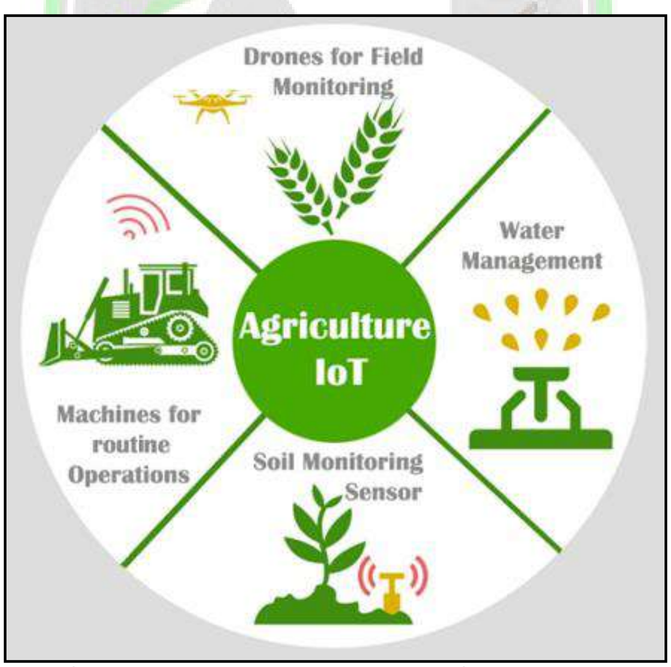
Upgraded Decision-Making Proficiency: Farmers possess the ability to make knowledgeable decisions by utilizing both real-time data and historical patterns.

Examples of Technology Used:

  Applied in field mapping, monitoring equipment location, and generating zone maps to facilitate the variable rate application (VRT) of resources.	 Satellites and drones assess the well-being of crops and analyze the conditions in the field.
GPS and GIS	**Remote Sensing**
 Measure crop yield during harvest, providing valuable data for analysis.	 Modifies the rates of input applications, such as water, fertilizer, and pesticides, according to field-specific data.
Yield Tracking Systems	**Variable Rate Technology**

	
Enhance water efficiency by providing crops with the precise amount of water needed.	Automated functionalities in tractors, planters, and additional equipment facilitate more accurate and precise operations.
Precision Irrigation Systems	**Autonomous Agricultural Equipment**

Precision agriculture marks a noteworthy progression toward a farming future characterized by sustainability and reliance on data. Through the adept use of technology and information, farmers can establish an agricultural system that is not only more effective and productive but also environmentally conscious.

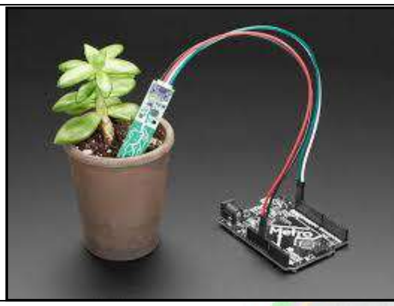


Within the realm of agriculture, IoT (Internet of Things) encompasses a network of linked devices, sensors, and actuators designed to gather, exchange, and analyze data for the enhancement of farming practices. This integral element of precision agriculture facilitates immediate monitoring, automated control, and decision-making guided by data analysis.

Components of IoT in Agriculture

1. ***Sensor:*** These components act as the mainstay, collecting information on different elements of the farm environment and crops. Instances encompass sensors for soil moisture, temperature, and humidity, along with those gauging plant health and weather conditions.

Sensor technology plays a crucial role in precision agriculture by continuously monitoring critical environmental and crop-related factors. These sensors provide real-time data on:

	
Soil Moisture: Ensures optimal irrigation practices and prevents water waste.	**Temperature:** Helps predict frost risks and adjust crop management strategies.
	
Humidity: Provides insights into disease and pest threats, allowing for preventative measures.	**Crop Health:** Monitors plant health and identifies potential problems early on.

2. *Controls:* These devices utilize data gathered by sensors to initiate physical operations in various environments. For instance, they can manage irrigation systems based on soil moisture levels, dispense fertilizer automatically, and control equipment from a distance.

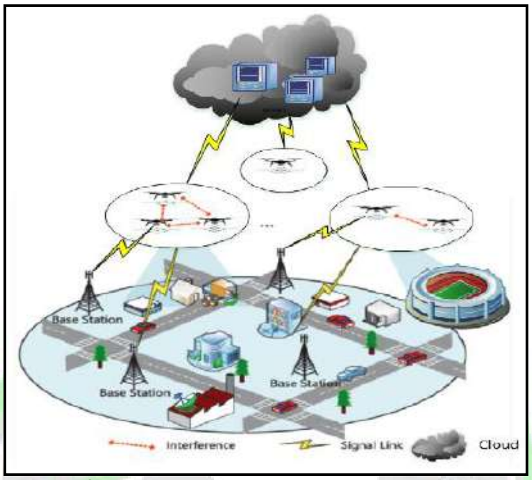
Acting Based on Data: The collected sensor data is used to control actuators, which are essentially automated mechanisms that translate data into physical actions. These controls:

1. *Regulate Irrigation Systems*: Adjust water delivery based on real-time soil moisture levels.

2. *Manage Fertilizer Dispensers*: Apply fertilizers precisely based on specific needs of different areas in the field.

3. *Control Other Farm Equipment*: Automate various farm functions for increased efficiency and precision.

3. *Linkage:* Devices establish communication with each other and a central platform through a range of technologies such as cellular networks, Wi-Fi, or satellite connections.



4 Information platform: The platform gathers, retains, and analyzes data sourced from sensors, offering farmers valuable insights to support informed decision-making.

Benefits of IoT Implementations in Agriculture Sector

- ***Optimized decision-making*:** Timely data empowers farmers to make accurate choices regarding irrigation, fertilization, pest management, and harvest, thereby optimizing resource distribution and crop output.
- ***Increased resource effectiveness*:** Through accurately directing resources according to specific requirements, IoT aids in reducing water and fertilizer wastage, promoting the adoption of more sustainable agricultural practices.
- ***Enhanced efficiency*:** Through the surveillance of crop health and early intervention in addressing issues, IoT enables farmers to attain greater yields and produce crops of superior quality.
- ***Reduced human resource expenses*:** Automation through actuators and remote monitoring can reduce the need for manual labor, allowing farmers to manage larger areas effectively.
- ***Improved monitoring*:** Collecting data from the farm to the table improves food safety and transparency for consumers.

IoT Applications in Agriculture:

- ***Smart irrigation***: Sensors monitor soil moisture and automatically adjust irrigation systems to deliver the right amount of water at the right time.
- ***Remote area observation***: Farmers can monitor crop health, weather conditions, and equipment status remotely using sensors and data platforms.
- ***Variable rate application (VRA):*** Sensors are capable of charting field discrepancies, facilitating the accurate dispensation of fertilizers and pesticides tailored to the distinct requirements of various areas.
- ***Livestock management***: Livestock necessitates consistent monitoring. Utilizing IoT-enabled smart tracking can provide farmers with direct access to stock information on their smart devices. This technology aids in identifying flu outbreaks at earlier stages, enabling the segregation of unaffected breeds from those infected.
- ***Crop Monitoring***: Field supervisors have access to diverse crop monitoring tools, including IoT devices deployed within the fields to gather data on crop health, water levels, and soil condition. Another alternative for overseeing large-scale crop conditions is satellite monitoring. These tools aid in the early detection of potential issues such as nutrient deficiencies, diseases, and water scarcity, facilitating prompt interventions.

Conclusion

The future of agriculture appears promising due to the transformative capabilities of the Internet of Things (IoT). Through interconnected sensors, data-driven analysis, and intelligent automation, IoT is facilitating the emergence of precision farming, an approach that encourages:

Improved ecological balance: IoT empowers farmers to maximize resource utilization, such as water and fertilizers, thereby reducing their environmental footprint.

Improved profitability: Precision farming results in improved yields and reduced waste by employing precise interventions, ultimately leading to increased profitability.

Richer Harvests: Data-driven decisions based on real-time insights empower farmers to maximize crop health and harvest bountiful yields.

These advantages extend well beyond individual farms. Every farmer and agricultural business owner can harness the power of IoT-driven precision farming to:

Make informed decisions: Real-time data enables proactive and accurate field management.

Manage risks: Early identification of potential issues enables prompt intervention and reduces adverse effects.

***Optimize resource utilization*:** Precise targeting ensures efficient resource use, resulting in cost savings and environmental stewardship.

For instance, envision a farmer deploying a drone equipped with imaging sensors. These sensors capture detailed crop health data, which is then analyzed by machine learning algorithms. This analysis identifies areas susceptible to pests or diseases, enabling the farmer to take precise action, reducing pesticide application and ensuring a thriving harvest.

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EMPOWERING HORTICULTURE: GENOME EDITING (CRISPR-CAS) AS A TOOL FOR VEGETABLE CROP IMPROVEMENT

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Abstract

Vegetables play a crucial role in human nutrition, providing essential nutrients like vitamins, minerals and fibre, thus promoting overall health. Many biotic and abiotic stresses threaten these crops' crop growth, yield and quality. Hence, there is an urge to develop crop plants with good agronomic traits and resistance to biotic and abiotic stresses. Nowadays, gene or genome editing technology plays an indispensable role in improving crop plants. Genome editing technology enables precise manipulation of DNA sequences in organisms facilitating targeted mutations. It offers a promising approach for improving crop varieties by altering gene functions in plants. Compared to classical mutation breeding, genome editing is simpler to use and carries a lower risk of off-target effects. Additionally, it can be applied to crops with complex genomes or those difficult to breed using traditional methods. With highly versatile tools for precise editing of plant genomes, the scope of application extends to functional genomics research and molecular crop breeding. This technology accelerates the development of new germplasm resources with improved agro-economic traits. This article provides an overview of genome editing technology, its potential applications in olericulture, challenges encountered and prospects.

Keywords: Gene editing, vegetables, resistance, applications

Introduction

Crop improvement has been an ongoing process for several thousands of years. Initially, Traditional breeding approaches mainly relied on natural variations of the gene pool, selection from related species and spontaneous mutations. Later on, the introduction of artificial hybridization by Fairchild in 1716 marked a significant development. Then, in 1930, Stadler used X-rays to induce mutation and assist in a new era of mutagenesis breeding including chemical means. Thus, plant breeding has evolved with accompanying innovations including precision breeding and molecular breeding encompassing gene editing (GE) and marker-assisted selection (MAS) has become integral to the field. In the current era, the term "New Plant Technologies" (NBTs) encompasses recent biotechnological developments aimed at crop improvement. The first green revolution in the late 1960s was a coordinated effort by various stakeholders. Subsequently, achieving self-sufficiency in food and enacting the Right to Food Act in 2013 underscored the need for continued efforts in strengthening local food ecosystems to address biotic and abiotic challenges. To sustain and increase food production, there is a growing need to incorporate advanced tools including genomics, genome editing (GE), artificial intelligence and deep learning. This multifaceted approach is crucial for addressing the evolving challenges in agriculture and ensuring food security.

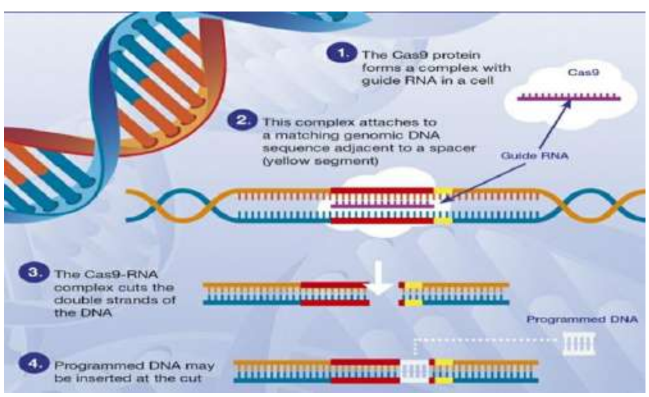
Genome or gene editing encompasses a myriad of innovative techniques empowering scientists to precisely modify the genome sequences. Utilizing genome editing to enhance agricultural and horticultural productivity becomes imperative in light of the expanding global population. Through this technology, we can strategically alter the regulation of gene expression patterns within specific regions, unlocking unprecedented insights into the functional genomics of organisms. The pivotal role of genetic diversity in enhancing traits in plants underscores the importance of creating variations in the gene pool for the development of novel plant varieties. The advent of genome editing has ignited significant enthusiasm, particularly among agricultural scientists owing to its ease of use, accuracy and effectiveness. Genome editing emerges as a powerful tool, not only for developing enhanced crops but also for unraveling the intricacies of reverse genetics. Its versatility positions it as a crucial asset in basic research, opening avenues for groundbreaking discoveries and advancements in agricultural and horticultural science. Genome-edited plants are differentiated from conventional transgenic plants as they may not incorporate foreign DNA.

Types of genome editing

There are 3 types of modifications produced by genome editing: Type I includes altering a few nucleotides; Type II involves replacing an allele with a pre-existing one and Type III allows for the insertion of new gene(s) in predetermined regions in the genome. Because most genome-editing techniques can leave behind traces of DNA alterations evident in a small number of nucleotides, crops created through gene editing could avoid the stringent regulation procedures commonly associated with GM crop development.

Mechanism of genome editing

Genome editing encompasses a wide variety of tools using either a site-specific recombinase (SSR) or a site-specific nuclease (SSN) system. Both systems require recognition of a known sequence. The SSN system generates single or double-stranded DNA breaks and activates endogenous DNA repair pathways. SSR technology, such as Cre/loxP and Flp/FRT mediated systems can knock down or knock in genes in the genome of eukaryotes, depending on the orientation of the specific sites (loxP, FLP etc.) flanking the target site. There are 5 main classes of SSN developed to cleave genomic sequences *viz*., meganucleases/homing endonucleases, zinc finger nucleases (ZFNs), oligonucleotide-directed mutagenesis (ODM), transcriptional activator-like effector nucleases (TALENs) and the CRISPR / Cas nuclease system (Clustered regularly interspaced short palindromic repeat/CRISPR-associated protein). Site-specific double-stranded breaks (DSBs) are enabled by CRISPR/Cas which further activate the cellular DNA repair systems. These DSBs can either be corrected by the non-homologous end joining (NHEJ) pathway or through the homology-directed repair (HDR) pathway. The use of first-generation technologies like ZFNs and TALENs has been limited due to their adverse mutagenic outcome, low editing efficiency, time-consuming process and the labour-intensive selection and screening process.



The second-generation genome editing technology *i.e*. CRISPR/ Cas9 is easier to design and execute and more cost-effective. The use of CRISPR/Cas9 in vegetable crops has substantially expanded gene editing technology and made it possible to create novel genotypes with desired phenotypic features and altered genomic functions at the base pair level. The recombinase-mediated genome engineering depends on the recombinase (sub-) family & target site and induces high frequencies of homologous recombination….

Genome editing relies on a DNA repair mechanism. DNA damage occurs in all living cells due to exogenous factors (UV radiation) or endogenous factors (metabolic by-products and free radicals). The most lethal type of DNA damage is the double-strand break (DSB) which must be repaired before DNA replication, which has led to either non-homologous end joining or homology-directed repair. In non-homologous end-joining (NHEJ), it can quickly and imprecisely, be repaired the break. In one way, several different proteins bind to broken DNA ends and are joined together resulting in the INDELs of nucleotides. In another way, NHEJ, 5′ ends are cut until 3′ overhangs with homology are created. DNA strands then bind at their complementary sequence, and non-homologous DNA is excised which results in NHEJ and often leads to frameshift mutations which can result in premature stop codons, resulting in non-functional genes. The second DNA repair pathway is homology-directed repair (HDR) which relies on template DNA. Homologous recombination is an important process that occurs in somatic cells to repair DSBs and in meiotically dividing cells to exchange genetic material between parental chromosomes. The most common conservative HDR mechanism in plants, which repairs almost all DSBs in somatic cells, is the synthesis-dependent strand annealing (SDSA) pathway.

Application of genome editing tools especially CRISPR CAS-9 in vegetable crops:

- ✓ Development of albino phenotypes
- ✓ Development of abiotic and biotic stress-resistant traits in crop plants
- ✓ Quality improvement (nutritional, post-harvest etc)
- ✓ Improvement of polyploidy crops like potato, okra, *etc*.
- ✓ Enhancement of yield or productivity
- ✓ Herbicide resistance
- ✓ Induction of parthenocarpy
- ✓ Enhancement of seed germination etc.,

Role of genome editing in a few vegetable crops

1. Tomato: Disrupting BRASSINAZOLE RESISTANT 1 (BZR1) through knockout inhibited the induction of RESPIRATORY BURST OXIDASE HOMOLOG1 (RBOH1) and promoted the production of H2O2, enhancing heat tolerance in tomatoes. The introduction of exogenous H2O2 restored heat tolerance in bzr1 tomato mutant plants. Furthermore, CRISPR-Cas9-induced mutations in slmapk3 increased heat stress tolerance in tomatoes. The slmapk3 mutant exhibited reduced wilting, mild membrane damage, lower reactive *oxygen* species production and enhanced antioxidant enzymatic activity under heat stress. In tomato, SlDMR6-1 orthologue Solyc03g080190.2 is up-regulated when infected due to *Pseudomonas syringae* pv. tomato and *Phytophthora capsici*. The tomato homologue genes were knocked out using CRISPR-Cas9 to cause mutations in DMR6, which resulted in broad-spectrum resistance to *Pseudomonas*, *Phytophthora* and *Xanthomonas* spp. The homology-directed repair (HDR) pathway was used to replace the allele of ALC with the alc gene, resulting in T1 homozygous tomato plants with a long shelf life.

2. Brinjal: Three polyphenol oxidase genes (SmelPPO4, SmelPPO5 and SmelPPO6) showing the highest transcript levels in the fruit after cutting were regarded to be associated with enzymatic browning of eggplants/brinjal. CRISPR-Cas9-based mutagenesis has been applied to knock out three target PPO genes simultaneously aiming to reduce fruit flesh browning.

3. Cucumber: The initial utilization of CRISPR-Cas9 in cucumber aimed to establish broad viral resistance by knocking out the eukaryotic translation initiation factor 4E (eIF4E) gene. Gynoecious inbred lines in cucumbers hold significance due to their increased yield and reduced labor costs for crossbreeding. CRISPR-Cas9 tools to create Cswip1 mutants targeting the WPP trp/pro/pro domain Interacting Protein1 (CsWIP1) gene, responsible for encoding a zinc-finger transcription factor. The resulting Cswip1 T0 mutants exhibited a gynoecious phenotype, characterized by the presence of only female flowers, indicating the gene's involvement in inhibiting cucumber carpel development.

4. Watermelon: Artificial gynoecious watermelon lines have been generated using the CRISPR-Cas9 system targeting the ClWIP1. The CRISPR-Cas9 system was used to generate the knockout mutation of the phytosulfokine1 (ClPSK1) gene responsible for the infection by *Fusarium oxysporum* f. sp. *niveum* (FON). The loss-of-function mutation of ClPSK1 rendered watermelon seedlings more resistant to infection by FON. CRISPR-Cas9-mediated mutations in the phytoene desaturase (ClPDS) gene, encoding a key enzyme of carotenoid synthesis, caused the expected albino phenotype in watermelon plants. Watermelon plants possessing C to T mutations in the

Pro 190 (CCG) codon at the ClALS gene have become resistant to all sulfonylurea herbicides without compromising fruit size, seed size and seed yield.

5. Potato: CRISPR/Cas has emerged as a substitute and effective method for the control of late blight and viral diseases of potatoes. Targeting P3, CI, Nib and CP viral genes, Cas13a protein was used to give resistance to three PVY strains (RNA viruses). Similarly, the functional knockouts of StDND1, StCHL1, DMG400000582 (StDMR6-1) and caffeoyl-CoA-O-methyltransferase gene generated potato plants with increased late blight resistance. Improved starch quality with a full knockout of granule-bound starch synthase (GBSS), starch synthase gene (SS6) and starch-branching enzymes (SBEs) genes SBE1 and SBE2 was reported in potatoes using CRISPR-mediated genome editing.

6. Lettuce: The CRISPR/Cas9 technique was employed to knock out the LsNCED4 (9-cis-EPOXYCAROTENOIDDIOXYGENASE4) gene, leading to the elimination of thermo-inhibition of lettuce seed germination. Genome editing of the upstream open reading frame (uORF) enabled the modulation of the translation of mRNA. Editing the uORF of LsGGP1 and LsGGP2, which encodes a key enzyme in vitamin C biosynthesis, increased mRNA translation, thereby elevating ascorbate content and oxidation stress tolerance.

Regulation of genome editing crops

Genome and gene editing involves precise alterations to DNA or RNA sequences in organisms ranging from single base pair changes to significant genomic reorganizations. This technique can introduce novel traits by incorporating genes not naturally present in the organism's gene pool. Due to the genetic manipulation involved, adherence to regulatory frameworks such as the Cartagena Protocol on Biosafety is essential for any country. Diverse approaches to regulating genome-edited crops exist worldwide. The United States exempts CRISPR-Cas9 edited crops from regulatory oversight, considering them akin to conventionally bred varieties. This approach streamlines testing and legislation, facilitating quicker crop development. In contrast, Canada mandates further regulatory scrutiny for novel gene editing technologies ensuring safety regarding toxicity, allergenicity and ecological impacts. Similarly, the European Court of Justice imposes strict regulations on gene-edited crops, treating them to traditional genetically modified plants. South American countries like Argentina, Chile and Brazil follow the Cartagena Protocol's guidelines for genome-edited product approval, relying on case-by-case evaluations with exemptions for transgene-free edits. Australia's regulatory framework distinguishes between different genome editing methods, with only SDN-2 and SDN-3 edits regulated as GMOs, while New Zealand regulates genetically modified plants under the Hazardous Substances and New Organisms (HSNO) Act 1996. In India, regulations are governed by the Environment (Protection) Act 1986 overseen by the Genetic Engineering Appraisal Committee (GEAC). This committee evaluates and approves permits for experimental trials and commercial release of genetically altered crops, including those modified using CRISPR/Cas9.

Overall, the regulation of genome editing technologies varies globally, reflecting differing approaches to balancing innovation with safety and environmental concerns. These regulations aim to ensure the responsible development and deployment of genetically modified organisms while safeguarding human health and the environment.

Challenges

- Undesirable site effects
- Delivery efficiency
- Ethical and regulatory concerns
- Costly and time consuming

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MARKER ASSISTED SELECTION IN CROP IMPROVEMENT

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Introduction

Marker-assisted selection (MAS) is the process of using morphological, biochemical, or DNA markers as indirect selection criteria for selecting agriculturally important traits in crop breeding. This process is used to improve the effectiveness or efficiency of selection for the traits of interest in breeding programs. MAS allows heritable traits to be linked to the DNA segments that are responsible for controlling that trait. These segments of DNA or QTLs (Quantitative Trait Loci) can be detected through specific laboratory techniques. The most commonly used method is Polymerase Chain Reaction (PCR) that amplify segments of DNA linked to heritable traits such as yield or disease resistance.

This method is useful because the DNA that we amplify is different (polymorphic) between cultivars. It is this difference that we use to determine whether the plant has the desired trait or not. The process in which the differential DNA sites (or primer sites) are explored, comes from genetic mapping techniques, i.e. RAPD, microsatellites etc. With a marker assisted selection breeding program the simpler methods are necessary since they are time and cost effective. PCR is an effective method for generating large quantities of a specific DNA sequence from a small amount of starting DNA. This technique is useful for a MAS breeding program because the results are reliable. To learn how MAS works, basic molecular biology principles need to be understood. This paper “Marker Assisted Selection in crop improvement” has been designed to provide a basic understanding with regards to use of molecular markers in crop improvement. This bulletin describes basic concepts used in marker assisted breeding programme, different applications of MAS and basic principles underlying DNA extraction, PCR, running of gel and data analysis.

Features of MAS

Pre-Requisites

There are two pre-requisites for marker assisted selection. These are: (i) a tight linkage between molecular marker and gene of interest, and (ii) high heritability of the gene of interest.

Markers Used:

- MAS makes use of various types of molecular markers. The most commonly used molecular markers include amplified fragment length polymorphisms (AFLP), restriction fragment length polymorphisms (RFLP), random amplified polymorphic DNA (RAPD), simple sequence repeats (SSR) or micro satellites, single nucleotide polymorphisms (SNP), etc.
- The use of molecular markers differs from species to species also.

Efficiency:

- The relative efficiency of MAS is greatest for characters with low heritability, if a large fraction of the additive genetic variance is associated with the marker loci. In other words, MAS is useful when the heritability of the trait is low. Moreover, MAS is more efficient than purely phenotypic selection in quite large populations.
- It has been found by some workers that MAS may become less efficient than phenotypic selection in the long term. This is because the rate of fixation of unfavourable alleles at QTLs with small effects is higher under MAS than under phenotypic selection.
- It may be a consequence of the strong selection applied to QTLs with large effects under MAS in early generation. However, such problem comes after a long period.

Accuracy:

Molecular markers have very high accuracy. They are not affected by environmental conditions. MAS is a new breeding tool which is available to make more accurate and useful selections in breeding populations. MAS allows heritable traits to be linked to the DNA which is responsible for controlling that trait.

Speed of Progress:

- MAS is a rapid method of crop improvement.
- For example, in conventional breeding when we transfer a recessive character through backcross, one selfing is required after every backcross for identification of recessive character.
- MAS permits identification of recessive alleles even in heterozygous condition and thus speeds up the progress of crop improvement work.

Traits Improved:

- MAS can be used for improvement of both oligogenic and polygenic traits.
- In the past, MAS has been mostly used for the genetic improvement of oligogenic traits and little progress has been made with polygenic traits.

Material Developed:

- MAS leads to development of non-transgenic genotypes or cultivars. In other words, MAS is used for development of non-transgenic cultivars.
- The transgenic cultivars face public resistance. On the other hand, cultivars developed by MAS are acceptable by consumers.

Cost:

- MAS is very costly as compared to phenotypic selection.
- In MAS, the costly items include equipment's, consumables, infrastructure, labour and DNA extraction process. MAS requires sophisticated and well equipped laboratory.

Applications of MAS

- MAS is very effective, efficient and rapid method of transferring resistance to biotic and abiotic stresses in crop plants.
- It is useful in gene pyramiding for disease and insect resistance.
- It is being used for transfer of male sterility and photo period insensitivity into cultivated genotypes from different sources.
- MAS is being used for improvement of quality characters in different crops such as for protein quality in maize, fatty acid (linolenic acid) content in soybean and storage quality in vegetables and fruit crops.

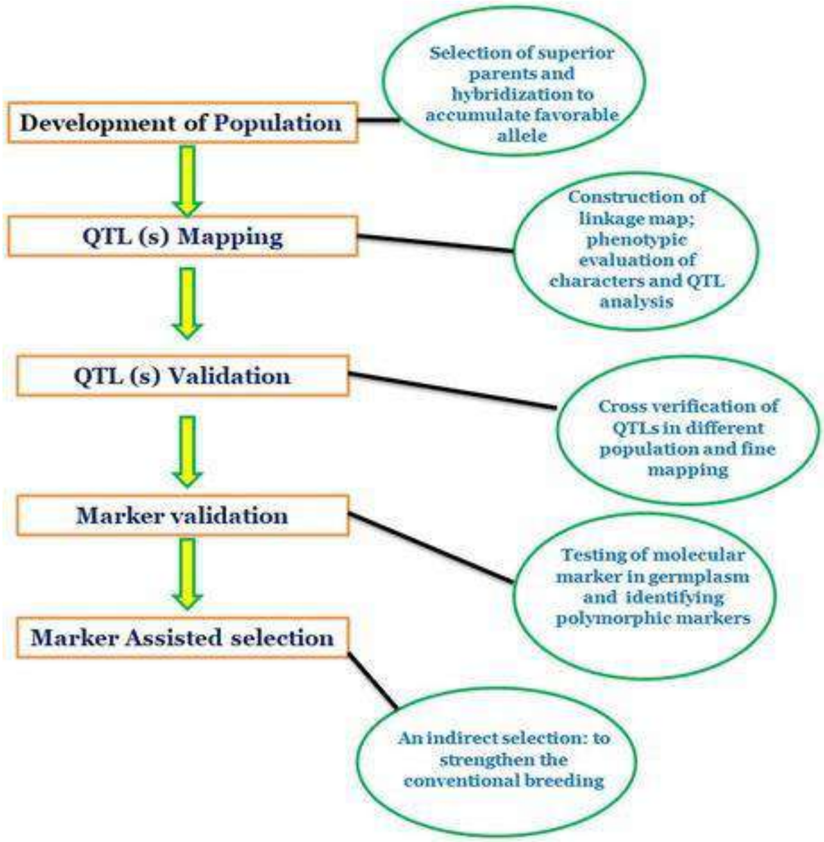
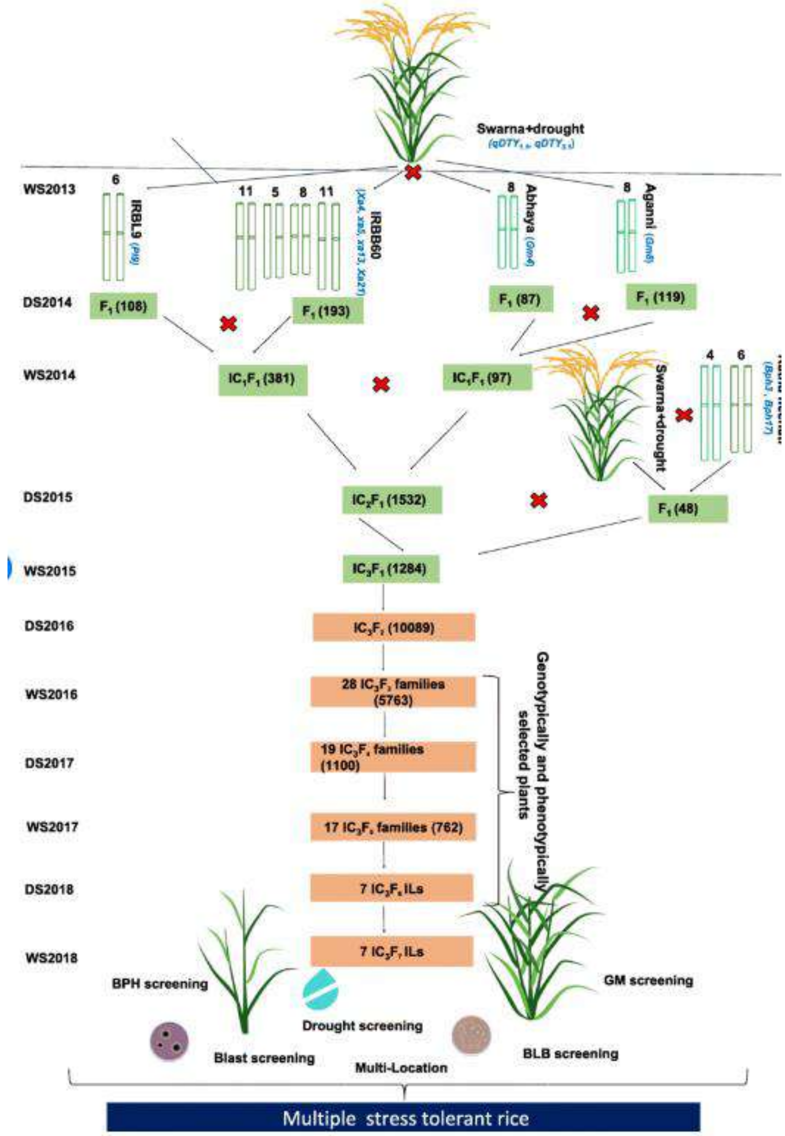


Fig 1: Steps involved in Marker Assisted Selection

- MAS can be successfully used for transferring desirable transgene (such as Bt gene) from one cultivar to another.
- MAS is very effective in introgression of desirable genes from wild into cultivated genotypes.
- MAS is equally effective in genetic improvement of plants and animals.
- MAS is useful in genetic improvement of tree species where fruiting takes very long time (say 20 years) because for application of phenotypic selection we have to wait for such a long time.
- MAS has wide application for genetic improvement of oligogenic traits as compared to polygenic traits.

Marker assisted forward breeding in rice

Marker-assisted forward breeding is a quick and effective method for combining multiple QTL and genes. Lines with 5–8 QTL and genes for drought and genes for blast and bacterial leaf blight were developed



Flow diagram depicting different steps of marker assisted forward breeding to combine multiple biotic-abiotic stress resistance/tolerance in rice Crossing program was initiated in WS2013 which involved crossing of recurrent parent (Swarna+drought, possessing drought tolerant QTLs namely (qDTY1.1, qDTY3.1) with four different donors possessing targeted genes or BB (Xa4, xa5, xa13, Xa21), blast (Pi9), BPH (Bph3 and Bph17) and GM (Gm4 and Gm8). The number over the chromosome represents the chromosome number of the respective donors. Through several rounds of inter-crossing, IC3F1 with desirable QTLs/genes combinations were obtained in WS2015. Further, MAFB approach was utilized to combine genes/QTLs for BB, blast, BPH, GM and drought tolerance

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VERTICAL FARMING: BENEFITS, OPPORTUNITIES AND CHALLENGES

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Introduction

Soil fertility is reduced by rapid urbanization, natural disasters, excessive use of chemicals and pesticides. Thereby, the productivity has declined and the availability of land to each person has also decreased. Water resources also get deteriorated due to change in climate, uncertainty in meteorological conditions. World population is expected to increase 8.9 billion by 2050 and the world has to produce 50 % more food to meet the needs. Many countries mainly rely on import of foods to meet the needs and usually have less choice for healthy food due to higher prices. So, in this scenario, we need soil-free cultivation systems. By adopting vertical farming systems, we can resist the modern challenges.

Vertical farming is a modern agriculture technique using hydroponic or aeroponic culture systems inorder to produce crops in a vertically stacked layers on a protected indoor space. Main advantage of vertical farming is that the crop yield can be increased from a smaller unit area of land. They also need less water use, less amount of pesticides and herbicides and can protect the crops from severe weather. Also, they can be established in almost anywhere, including underground, all the factors lead to meet the increase in population and the increase in requirement of food.

Types of vertical farming

Vertical can be divided into three types based on structure:

1. Hydroponics

It is the mostly used growing system in vertical farming. In this growing system, plants are grown in nutrient solutions which is free of soil. NASA researchers identifies hydroponics as a good option for growing food in outer space. Some of the vegetables which have success growing through hydroponics are onions, lettuce and raddish. It has gaining popularity nowadays over soil-based cultivation. Because, it has the potential to eliminate soil-based cultivation issues like the insect, fungi and bacteria in soil. Moreover, hydroponics is a less labor-intensive method. It is easier to control pH and nutrient levels in hydroponics. There are many factors like temperature, oxygen level as well as moisture to determine the availability of these nutrients to plants. Hydroponics can produce good yield than other methods when the plants get good even amount of nutrients.

2. Aeroponics

The innovative indoor growing technique, aeroponics, has been developed by National Aeronautical and Space Administration (NASA). Aeroponics can be defined as growing plants in an air/ mist condition, has very little amount of water and with no soil. As the system uses mist or nutrient solutions, it doesn't need containers or trays to retain water. The major advantage of aeroponics is that it has excellent aeration. Aeroponic system is the most efficient plant growing system in vertical farming as it uses upto 90% less water than the most efficient hydroponic system and aeroponics does not require replacement of growing medium and use of fertilisers and pesticides. In addition to, harvesting is easier and get higher yield than high density planting method.

3. Aquaponics

Aquaponics is the combined production of fish farming and hydroponic vegetable, flower and herb. In indoor ponds, fish are grown and the plants uses nutrient rich source produced by fishes in the vertical farm. Then, the waste water purified and filtered by the plants can be recycled to the fish ponds. Fish excrete metabolites into water after they consume the food. Inorder to act as a nutrient source to plants, fish effluent has to be treated to remove ammonia, nitrate, nitrite, phosphorous, potassium from the waste stream. In aquaponic system, lettuce, herbs and plants such as spinach, chives, basil and water cress can be grown. Aquaponics give a considerable advantage over traditional farming methods among countries where nutrient enrichment is considered.

Vertical farming can be divided into two based on designs:

1. Simple designs

- **Container vertical gardens**

In container vertical gardens, plants are grown in containers arranged vertically, mostly on walls or structures. Various container types can be used like pocket planters, hanging pots or modular systems. We get a good yield by choosing suitable containers, appropriate plants by considering growth habits and by giving proper irrigation and sunlight. We have to regularly water the plants and good amount of fertilisers for maintaining the vertical garden.

- **Trellies vertical garden**

In trellies vertical garden, trellies are used as support structures for growing climbing or vining plants and allow for vertical growth. Plants have to be placed by considering the factors like growth habit of plants and size of the trellies. Inorder to encourage vertical growth, plants have to be trained by gently tying or weaving through the trellies. Ensure proper care and attention inorder to make a beautiful trellies vertical garden.

- **Tower system vertical garden**

In tower system vertical garden, towers are made up of various metals such as plastic, metal or fabric. Planting pockets or containers are found on each level of the tower. We have to choose the plant according to the size of the planting pockets. Tower system mostly contains drip or wick irrigation system, here, water is supplied from the top and it reaches each level to give adequate moisture. Maintain the plants by providing adequate sunlight, water and fertilisers.

2.Sophisticated designs

- **Building based**

In building based vertical garden, climbing plants or modular systems like panels, pockets or grids can be used to cover the building surface with vegetation. We have to ensure whether building can support the additional weight of garden. Give good maintenance like adequate water, sunlight and fertilisers to get good yield.

- **Shipping container**

Here, a shipping container can be transformed into a self-contained, portable garden space. Firstly, interior of the shipping container has to be modified inorder to accommodate more plant growth by installing shelves, rack for placing planting pockets. LED lights can be used inorder to ensure adequate light for plant growth. The main advantage of this vertical garden is the portability of shipping containers, so containers can be relocated to different places. Environmental factors can be monitored by sensors and automated monitoring systems.

- **Deep farms**

Deep farms vertical garden is constructed on underground tunnels, abandoned mine shafts or any subterranean environment. Deep farms need only less heating energy as underground temperatures and humidity are usually remains constant. Deep farms can also use ground water near to it to reduce the water costs. Deep farms can generate 7 to 9 times more food than traditional farming.

Need of vertical farming

- **Utilize less water and space:** Vertical farming techniques need only 98% less water and 99 % less land than traditional farming methods. Vertical farms can produce 240 times more crop yields than traditional farms. Vertical farms use LED lights, so, these systems are not reliant on fossil fuels.
- **Increased production:** Vertical farms offer consistent year-round production. There are times when some fruits and vegetables were only available seasonally. But, by introducing vertical farms, all types of crops can produce year-round with less dependence of weather and climate. Vertical farming has introduced to solve the problem of increase in population and scarcity of farm land. Vertical farming can produce more food from smaller area based on a simple principle. As vertical farming is mainly an indoor farming, it is weather independent and has the ability to produce higher yields than traditional farming inorder to meet the expected food security demands.
- **Environmental impacts can be eliminated by Controlled Environment Agriculture (CEA):** Indoor vertical farming is done by CEA. CEA means providing a series of technologies which provides optimal conditions for plants. CEA controls temperature, lighting and humidity which lessens the occupational hazards caused by traditional farming. Vertical farming escapes farmers from hazards, poisonous chemicals and diseases such as malaria.
- **Reduced arable land:** As we know that arable land is depleting day by day because of erosion and pollution, we need an alternate way to produce the healthy food without using acres of land. Vertical farms can be constructed on green houses, roof tops, inside ware houses or even in depleted areas, thus by reducing the usage of arable land.

• **Free of pesticides:** As vertical farming controls the environment around crops, naturally they can resist the pests. So, there is no need of using chemical pesticides.

• **Reduced emissions:** As vertical farms are mostly constructed in urban areas, it reduces the carbon emissions by reducing the travel between farm and grocery stores. Moreover, consumer gets fresh food as the distance between producer and consumer is less.

Challenges of vertical farming

• **High startup cost:** The initial cost for starting a vertical farming is high. Because technologies and tools needed for vertical farming is very expensive. The cost of many components in vertical farms rises as the global supply chain issues emphasized by the Covid 19 pandemic. The expansion of vertical farming is both expensive and time consuming.

• **Only a limited number of crops can grown independently:** Limited number of crops can be grown in vertical farming than traditional farming. It is not only due to space constraint but also due to economic viability. Mostly, leafy greens, small vegetables are grown through vertical farming. Nowadays, potatoes, mushrooms, cucumbers and tomatoes can also be grown but most of them are not economically viable when grown in large scale systems. One of the big challenges for growing flowering plants is their pollination. As, vertical farming have controlled environment systems, the pollination by bees, birds and even wind cannot happen. So, here, pollination is done by manual, human made process, but it is not economically sustainable.

• **Risk of growing tall field crops:** Tall field crops and protein dense plants do not fit into the vertical farming systems as they are not economically viable.

• **Proper working of technology:** Vertical farming works by the use of innovative technologies and high automation systems and the proper working of those systems are itself considered as a risk. For example, irrigation system in hydroponic system has to work properly because it gets nutrients through nutrient rich water solution instead of soil. Thus, if the irrigation system doesn't work properly, growth of plant reduces.

• **High energy usage:** Vertical farming needs high energy usage for working automation, irrigation systems and so on. Artificial lightning also requires high energy usage as vertical farming is done on indoors.

• **Requires experienced personnel:** Vertical farming needs highly educated people from fields like engineering, software development, agricultural sciences, data management. The companies also have to be prepared to pay higher salaries for those experienced personnel. Also, there is lack of availability for these experienced personnels in the labour market.

Future potential of vertical farming

High environmental impacts in the current fossil-based economy can be caused by the usage of artificial lightning in indoors. However, change towards nuclear and renewable energy resources will make the vertical farming more sustainable than traditional farming . Vertical farming can also reduce water use, eutrophication and food transport requirements.

As there is high investment and running costs for vertical farming, it gains popularity only among some places. Need to expand the market opportunities of vertical farming to make it more widely applicable. There are many technological advancements are going on integration of automation and artificial intelligence on vertical farming. Many researches are also going on for generating dwarf, fast growing, high -yielding, high quality and easy to harvest crops through breeding adapted to vertical farming. Researchers are also focusing on developing vertical farming in low and middle-income nations rather than high income nations. They are trying to develop local farming methods, local irrigation systems and to use the local solar power to run the vertical farming.

Conclusion

Vertical farming has been gaining popularity in nation because it is emerging as a promising solution for sustaining food production in urban homesteads. This innovation technology has a vertical design which maximises the use of limited space, cultivate crops on controlled environment and reduces the environmental impacts. However, the challenges such as initial cost set up, energy requirement, high experienced personnel contracted the set up of vertical farming in high income nations only. The economic feasibility and long-term sustainability of vertical farming systems needs to be evaluated for the widespread adoption. Various researches are going on to change the source of energy, suitable crops and to improve the yield through vertical farming. So, inorder to get the full potential of vertical farming, economic factors and technological advancements are need to be considered in the long run.

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MEDICINAL IMPORATNCE OF DRAGON FRUIT: QUEEN OF THE NIGHT

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Introduction

The dragon fruit (*Hylocereus undatus*) is indigenous to the Americas. Its name comes from its appearance - leather-like skin and scaly spikes on the exterior of the fruits. It is also known as 'Pitaya', 'Pitahaya', 'strawberry pear', 'noble woman' and 'Queen of the night' throughout the world. Dragon fruit, as the name suggests, resembles a dragon. It grows on climbing cactus known as Hylocereus, which can be found in tropical regions. The outer covering of dragon fruit is in shades of red and pink or yellow. Their leaves resemble a dragon and have spikes that shoot up like a flame around the fruit. Hylocereus originally grew in Southern Mexico, South & Central America, and the French brought it to Southern East Asia during the early 19th century.

The dragon fruit was introduced to home gardens in India in the 1990s. It gained wider popularity among farmers due to its profitability and the fact that it needed lower inputs once established. The plant sustains yield for more than 20 years, is high in nutraceutical properties and good for value-added processing industries.The low maintenance and high profitability of dragon fruits has attracted the farming community throughout India. This has led to a steep increase in dragon fruit cultivation in Maharashtra, Karnataka, Andhra Pradesh, West Bengal, Telangana, Tamil Nadu, Odisha, Gujarat and the Andaman and Nicobar Islands, as well as in many north eastern states.A recent estimate by Indian Council of Agricultural Research-National Institute of Abiotic Stress Management, Baramati in Maharashtra found that dragon fruits are cultivated on 3,000-4,000 hectares in various states of India. The country produces approximately 12,000 tonnes of the fruit every year.

The fruit can be exported to Persian Gulf countries, the European Union and the United States. In June 2021, India exported its first consignment of dragon fruit from a farmer of Maharashtra to Dubai in the United Arab Emirates.The dragon fruit plant is a member of the cacti family. It is hardy and grows in diverse climatic conditions with varied soils, especially in the semi-arid and arid regions of India. It prefers slightly acidic soil and can tolerate some salts in soil too. Several dragon fruit types are available, which are cultivated across the world. The inside of a dragon fruit is white, semi-solid fruit that can be eaten with a spoon and has nutty seeds sprinkled all over it. It is juicy with a slightly sweet taste, whereas the seeds have a nutty flavour. There are many benefits of dragon fruit that we will discuss in this paper

Importance of Dragon Fruit

- Following are some other importance of dragon fruit.
- Helps in lowering cholesterol
- Helps in weight management
- High in fats and proteins
- Good source of antioxidants
- Helps in preventing arthritis
- Helps in improving heart health
- High in vitamins & minerals
- Helps in fighting against ageing
- Helps in preventing asthma

Types of Dragon fruits:

1. Hylocereus Undatus

Its other name is Pitahaya and has white flesh with pink skin. The fruit has 6-12 cm length, 4-9 cm thickness and edible black seeds. It is famous among types of dragon fruit.

2. Hylocereus Polyrhizus

Red Pitaya is the other name of this variety, and has red flesh with its pink skin. The native country of this variety is Mexico, but now it is available in many countries. This variety is profitable among different types of dragon fruit varieties.

3. Hylocereus Costaricencis

The other name of this variety is Costa Rican Pitaya, native to Costa Rica. It has violet-red flesh and pink skin, and its fruits are magenta, and the seeds are pear-shaped. We can easily cultivate this variety of dragon fruit in India.

4. Hylocereus (Selenicereus) Megalanthus

It's native to South America and renowned for its white flesh with yellow skin. It looks beautiful among other dragon fruit varieties.

Climatic Requirements:

This fruit plant grows in poor soil conditions and temperature variations. So, the tropical climate conditions are perfect for dragon fruit farming. The ideal annual rainfall for Protected Cultivation is 50 cm. The temperature for dragon fruit cultivation must be between 20 °C to 30 °C. The dragon fruit plants cannot tolerate too much sunlight. So if you want to cultivate it in a high sunlight area, just do it by providing shading.

Soil for Dragon Fruit Cultivation:

Dragon fruit is grown in different types of soil, from sandy loam to clay loam. However, the ideal soil for its cultivation is sandy soils with good organic matter and a perfect drainage system. The pH of 5.5 to 7 is best for dragon fruit farming.

Land Preparation:

Plough the field until the soil achieves its fine tilth and is weed-free. Apply any type of organic compost in a proportionate ratio.

Plantation Method:

The most common dragon fruit propagation method is **cuttings**. However, it can also propagated by seeds. plant to plant distance of 2 meters x 2 meters. dig 60 cm x 60 cm x 60 cm for the size of the pits. In addition, fill these pits with topsoil and manure, including 100 grams of superphosphate. In this way, we can accommodate about 1700 plants in 1 acre of land.

Training:

To get the huge dragon fruit farming profit or proper plant growth, you should give support of concrete or wooden columns. You have to tie Immature plants with these columns. To maintain the dragon shrub, you have to use a round/circular metal frame.

Dragon fruit Plant

Dragon fruits

Manures and Fertilizers:

- For the good growth and development of the dragon fruit plant, organic manure plays a crucial role.
- Apply each plant with a minimum of 10 to 15 Kg of organic compost. After that, you have to increase the manure by 2 kg per year. Along with the organic, it also needs inorganic fertilizers to give good vegetative growth.
- The fertilizer ratio for vegetative stage is muriate of potash:superphosphate:urea = 40:90:70 grams /plant.

Dragon Fruit Irrigation:

This plant requires less water in comparison to others. Iirrigate the field frequently during the planting, flowering & fruit development stages and hot/dry climate conditions. For effective water usage, you can use drip irrigation.

Pests and Diseases:

This is the highest benefit in this farming in that it has no pests or diseases. So, no need to treat the plants with other chemicals. Therefore, it reduces the dragon fruit cultivation cost per acre.

Harvesting:

- Dragon fruit starts appearing on the plants in the first year. From Aug to Dec month, it bears the fruits, and fruits are ready for harvesting after one month of flowering. Apart from this, the flowering time continues till December.
- Picking up these fruits can be done up to 6 times within this period. When the fruits turn red, it is the best time for harvesting. The ideal time for harvesting is after 3 to 4 days of colour change.
- Harvest the fruit after 1 day of colour change for exporting. Fruit yield will be 5 to 6 tonnes per acre.

Dragon Fruit Farming in the Different States of India:

- Dragon fruit is a tropical fruit that also has an increasing demand in India. Nowadays, the demand for this exotic fruit is increasing, but the supply is limited. That's why dragon fruit farming can be profitable in India.
- Thus, the Indian farmers are taking a massive interest in this farming. The farmers from *Karnataka, Kerala, Tamil Nadu, Maharashtra, Gujarat, Odisha, Andhra Pradesh, and the Andaman & Nicobar Islands* are mainly involved in commercial dragon fruit cultivation.
- In addition, *West Bengal*, *Telangana, Uttar Pradesh* and *Madhya Pradesh* are also taking up this fruit farming.

Health Benefits of Dragon Fruit:

Dragon fruit contains several health benefits along with a delicately sweet taste. Let's have an eye on the following benefits.

1. High in Nutrients

Dragon fruit has several nutrients, which helps people to stay fit and healthy. So, the nutrients are:

- Calories: 136
- Protein: 3 grams
- Fibre: 7 grams
- Iron: 8% of the RDI
- Fat: 0 grams
- Carbohydrates: 29 grams
- Vitamin E: 4% of the RDI
- Magnesium: 18% of the RDI
- Vitamin C: 9% of the RDI

2. Fight Chronic Disease

Dragon Fruit has several types of potent antioxidants. And antioxidants neutralise free radicals to prevent cell damage and inflammation.

- **Vitamin C** : Studies have found vitamin C intake reduces the cancer risk.
- **Betalains** : Betalains can combat oxidative stress and can suppress cancer cells.
- **Carotenoids** : Carotenoids have the ability to reduce the risk of heart disease and cancer.

3. Good Source of Fibre

Health authorities say to take 38 grams of fibre for men and 25 grams for women per day. However, fibre is renowned for its role in digestion. It is also valuable for minimising heart diseases, managing type 2 diabetes, reducing the risk of colon cancer and maintaining healthy body weight.

4. Strengthens Immune System

Immune System (the body's ability to fight infection) depends on different factors, including your diet quality. The dragon fruit may boost your body's ability to fight infection and prevent disease as it has vitamin C and carotenoids. It can also protect your white blood cells from damage.

5. Keeps a Healthy Gut

The community of microorganisms can impact your health, and imbalances in the gut can promote the risk of asthma and heart disease. So, we have to consume dragon fruit as it contains prebiotics. It can balance good bacteria in your gut.

6. Reduces Risk of Diabetes

Dragon fruit is known to control diabetes. It is partly due to the fibre contained in the fruit that avoids sugar spikes. Some researchers also attribute this benefit to its ability to replace damaged pancreatic cells. The pancreas produces insulin that breaks down sugar. Hence, dragon fruit is attributed to controlling sugar.

7. Reduces Risks of Cancer

Dragon fruit is rich in antioxidants, flavonoids, phenolic acid, and betacyanin, which inhibit the damage by free radicals. Free radicals are the substances that cause cancer and premature ageing. One of the majorly occurring antioxidants is vitamin C which prevents chronic diseases such as diabetes, Alzheimer's, Parkinson's, etc. This is one of the major health benefits of dragon fruit.

8. Helps Boost Immunity

As enunciated above, dragon fruit is a major source of Vitamin C. Vitamin C is a powerful antioxidant that helps prevent diseases and boosts your immunity. Some studies suggest eating 200 grams of dragon fruit every day to ward off diseases.

9. Improves Digestion

Dragon fruit contains prebiotics such as oligosaccharides which encourages the growth of good gut bacteria. These prebiotics help in the digestion of food since they reside in the lower digestive tract, where they encourage the growth of good gut bacteria. Gut bacteria help break down food by making them easily absorbed. They also provide vitamins that protect the body against various diseases

10. Improves Heart Health

Our body contains Haemoglobin (Hb) which is an iron-rich cell. These Hb cells help in transporting oxygen from the heart to other body parts. Dragon fruits are a rich source of iron and hence aid in the manufacture of haemoglobin. The dragon fruit with red-coloured pulp contains betalains, which are unique nitrogen-containing pigments. Betalains are uniquely known to lower the bad cholesterol in the body. Apart from that, the fruit also contains black seeds that are abundant in omega-3 and omega-9, which are good for the heart and lower the chances of cardiovascular diseases.

11. Fights against Ageing Skin

As enunciated above, dragon fruit contains antioxidants that help fight ageing from pollution, stress, poor diet, etc. Vitamin C in dragon fruit also brightens the skin.

12. Good for Hair

Studies suggest that taking dragon fruit every day with milk reduces hair damage caused by pollution and artificial colours. It also makes our hair soft and shiny, enhancing its beauty.

13. Healthy Bones

Dragon fruit contains magnesium that strengthens bones, helping us avoid injury and pain associated with old age. Hence, it is highly recommended that individuals who are at a higher risk of bone diseases consume dragon fruit regularly.

14. Good For Eyes

This fruit contains beta-carotene, which breaks down into Vitamin A. The human eye lens is rich in lutein, zeaxanthin, and meso-zeaxanthin, which help maintain eye health and prevent ophthalmic diseases. Research suggests that humans should take 3 milligrams to 6 milligrams of beta carotene every day to prevent eye diseases.

15. Boost Low Iron Levels

Dragon fruit is an iron-containing fruit. The work of iron is to transport oxygen throughout the body. It also plays a vital role in breaking the food into energy.

16. Good Source of Magnesium

Dragon fruit offers magnesium around 18% of your RDI (Recommended Dietary Intake) in just one cup. In addition, your body contains 24g of magnesium.

17. Good During Pregnancy

Dragon fruit helps during pregnancy in the following ways: -

- **Rich source of fats -**

  Good fats help maintain high energy levels in the body and also assist in the development of the foetal brain.

- **Guards against infections -**

  Dragon fruit safeguards one against infections and helps in cell regeneration.

- **Relief from constipation -**

  Fibres in dragon fruit prevent constipation and other gastric diseases in pregnant women.

- **Elevation of haemoglobin levels -**

  The iron in the dragon fruit helps improve the blood cells' capacity to carry oxygen, thereby boosting haemoglobin levels, which is highly essential for pregnant women.

Conclusion

Till now, we have seen that dragon fruit has innumerable health benefits. Easy ways to eat dragon fruit are to have it with salad, use it as a topping for greek yoghurt, squeeze it in juices, or put it in ice cream. Eating dragon fruit on a regular basis will help you ward off diseases and improve your health.

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REVIVING THE EARTH: HARNESSING THE POWER OF BIOREMEDIATION

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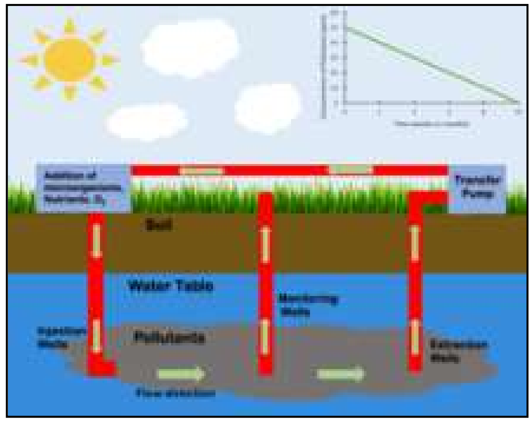
Introduction:

The term of bioremediation has been made of two parts: **"bios" means life** and refers to living organisms and **"to remediate" that means to solve a problem**. "Bioremediate" means to use biological organisms to solve an environmental problem such as contaminated soil or groundwater. Bioremediation is a waste management technique that involves the use of organisms to remove or neutralize pollutants from a contaminated site. Bioremediation is the use of living microorganisms to degrade environmental pollutants or to prevent pollution. Bioremediation is a means of cleaning up contaminated environments by exploiting the diverse metabolic abilities of microorganisms to convert contaminants to harmless products by mineralization, generation of carbon oxide and water or by conversion into microbial biomass.



Kinds of Bioremediations:

A. In situ bioremediation:

To eliminate the pollutants in contaminated soils and groundwater. It is a superior method for the cleaning of contaminated environments because it saves transportation costs and uses harmless microorganisms to eliminate the chemical contaminations.

1. Bioventing:

Bioventing is a process that increases the oxygen or air flow into the unsaturated zone of the soil, this in turn increases the rate of natural *in situ* degradation of the targeted hydrocarbon contaminant (García Frutos *et. al.,* 2010).

2. Bio stimulation:

Bioremediation can be carried out by bacteria that are naturally present. In bio stimulation, the population of these helpful bacteria can be increased by adding nutrients. (Kapah and Sachdeva 2019 and Kalantary *et. al.,* 2014).

3. Bioattenuation:

During bioattenuation, biodegradation occurs naturally with the addition of nutrients or bacteria.

4. Biosparging:

Biosparging is the process of groundwater remediation as oxygen and possible nutrients, is injected.

B. Ex Situ Techniques:

1. Biopiles:

Biopiles, similar to bioventing, are used to reduce petroleum pollutants by introducing aerobic hydrocarbons to contaminated soils.

Essential Factor for bioremediation:

Sr. no.	Factors	Desired Conditions
1.	Microbial Populations	Suitable Kinds of organisms that can biodegrade all of the contaminants Ex: Pseudomonas
2.	Oxygen	About 2% oxygen in the gas phase and 0.4 mg/lit in the soil water.
3.	Water	Soil moisture 50%-70%
4.	Nutrients	Nitrogen, Phosphorous, Sulfur and other nutrients to support good microbial growth
5.	Temperature	Appropriate tem. (0-4 ^{0}c)
6.	pH	6.5-7.5

Advantages of bioremediation:

- Natural process:
- Complete destruction:
- Economic process:

Disadvantages of bioremediation:

- Limited up to biodegradable compounds
- Specificity
- Technological advancement and Regulatory uncertainty.

Conclusion

Bioremediation is a waste management technique that involves the use of organisms to neutralize pollutants from a contaminated site and is a similar approach used to treat wastes including wastewater, industrial waste and solid waste. Being natural process is accepted by the public as waste treatment method for contaminated material such as soil and is employed for the complete destruction of a wide variation of contaminants.

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PLASTIC MULCHING: A GAME-CHANGER FOR VEGETABLE GROWERS

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Abstract

Mulching is a widely used technique in intensive agriculture to improve soil quality and overall growing conditions of crops. These plastic mulches offer several advantages such as reducing water loss, preventing erosion, controlling weeds, and maintaining soil temperature. The selection of mulch types depends on ecological situations and primary and secondary aspects of mulching. This article highlights the importance of plastic mulching in vegetables and its benefits in improving crop yield.

Introduction

Plastic mulching in vegetables is a horticultural practice where plastic sheets are laid on the soil surface to modify the microclimate, conserve moisture, and suppress weed growth. This technique is commonly used in high-value crops such as lettuce, muskmelons, honeydews, watermelons, squash, cucumbers, tomatoes, peppers and cole crops including pumpkins *etc*. The plastic mulch acts as a barrier between the soil and the atmosphere, reducing evaporation, keeping the soil warm, and creating a more favourable crop-growing environment. Additionally, the reflective properties of the plastic sheets can increase the amount of sunlight available to the crops, which can improve yields, improved fruit quality, and earlier harvest times. Low-density polyethene (LDPE) and biodegradable plastics are the most used plastic materials for mulching. The plastic mulch is usually removed at the end of the growing season and can be recycled or disposed of properly.

Advantages of Plastic Mulching in Vegetable Farming

Mulching is an effective way of insulating and protecting delicate plant root systems against harsh weather conditions. Plastic mulching increases the temperature of the plough layer, reduces soil moisture loss during crop growth, and enhances radiation and water use efficiencies. This leads to increased production of photoassimilates and expands both source and sink size during crop growth, ultimately resulting in higher crop yields. Moreover, plastic mulching aids in weed control by blocking light protects the soil from erosion and compaction, and enhances soil structure and fertility. The reflective properties of plastic mulch can increase the amount of sunlight available to the crops, leading to improved yields. Plastic mulching serves as a barrier to pests, reducing the need for chemical pesticides and improving crop health. It also helps in creating the barrier between soil particles and edible parts of the crop which eliminates soil deposition due to the splashing of raindrops hence, harvested produce will be clean with a good appearance. Coloured plastic mulches interfere with the movement of insects and can also reduce the incidence of whiteflies which transmit viral diseases in solanaceous crops thus, it can be an integral part of Integrated Pest management (IPM). Plastic mulching helps farmers to use resources more efficiently by reducing water and fertilizer needs, and by improving crop yields and can save time and labour by reducing the need for manual weeding and other cultural practices. Overall, plastic mulching is an effective tool for improving the health and yields of vegetable crops and can help to maximize the efficiency and profitability of vegetable farming operations.

Disadvantages of Plastic Mulching

While plastic mulching has many advantages in vegetable production, there are also some drawbacks. One of the most significant concerns is the environmental impact of plastic waste generated by the practice. Plastic mulching sheets can accumulate in the soil, causing pollution and posing a hazard to wildlife. The production and transportation of plastic mulch can contribute to greenhouse gas emissions, contributing to climate change. Additionally, plastic mulching can alter the soil's chemical and biological properties, reducing microbial activity and nutrient availability, leading to long-term soil degradation. Furthermore, the use of plastic mulching requires careful management, such as proper disposal of the plastic sheets and monitoring of soil moisture levels to prevent waterlogging. Plastic mulch can make it difficult for farmers to access the soil for tasks such as planting, fertilizing, and harvesting, leading to increased labour costs, and making it less accessible to small-scale farmers. Overall, while plastic mulching can provide benefits, it needs to be balanced with environmental considerations and responsible management practices.

TYPES OF PLASTIC MULCHES

1. Black mulches
2. Clear or transparent mulches
3. White mulches
4. Two-side colour mulches
    a. Yellow/black
    b. White/black
    c. Silver/black
    d. Red/black
5. Degradable mulches
    a. Photo-degradable
    b. Bio-degradable

1. Black plastic mulch: This type of plastic mulch is widely favoured and extensively utilized due to its popularity. It serves the purpose of absorbing a range of wavelengths, such as UV, visible and infra-red, from incoming radiation and then redirects them through thermal radiation or long-wavelength infra-red radiation. This, in turn, transfers heat from the mulch to the soil, causing the soil temperature to rise by approximately 2-4°C during the daytime. Moreover, this mulch is also effective in limiting weed growth as it obstructs light from penetrating the soil.

2. Clear or transparent mulches: Transparent films can be used to solarize soil, which is a process of using sunlight to kill soil-borne diseases and pests. The film traps heat in the soil, which can raise the temperature to levels that are lethal to many pathogens. Transparent films can also be coated with herbicides to prevent the growth of weeds. This is a common practice in nursery cultivation, where solarizing the beds before planting seeds can help to ensure high germination rates and a healthy nursery.

3. White mulch: This type of material is designed to reflect incoming radiation back into the plant canopy rather than absorbing it, which means it has minimal impact on soil temperature. As a result, it can be particularly useful for establishing crops during hot summer weather.

4. Bicoloured plastic mulches: Photo-selective or wavelength-selective films are designed to absorb specific wavelengths of solar radiation, which modifies the spectrum of the sunlight that passes through the film or is reflected into the plant canopy and can significantly impact plant growth and development. These films offer growers greater control over various plant properties, such as fruit and leaf size, colour, root development, yield, and more. Additionally, they warm soil temperature, block weed growth, and improve carbohydrate transport. These films have lower heat re-emission rates than black mulches, which can result in lower leaf temperatures. These films also alter red-far-red light balance, influencing plant morphology *via* phytochrome processes. They reflect more ultraviolet radiation, repelling insects like aphids, thrips, and whiteflies that transmit viruses. White/black, silver/black, or aluminized black combinations are ideal for cooler root-zone temperatures in various Indian regions.

The effects of some of the coloured mulches are given below:

Yellow/black- may attract certain insects and act as a trap for them, helping to prevent disease.

White/black- tends to have a cooling effect on the soil.

Silver/black- Also cool the soil but may not be as effective as white/black film. Silver/black mulches may also repel some aphids and thrips.

Red/black – These mulches are partially translucent, allowing radiation to pass through and warm the soil. At the same time, they reflect radiation back into the plant canopy, altering the ratio of red to far-red light. These factors can cause variations in plant vegetative growth, flower development, and metabolism, ultimately leading to early fruiting and increased yields in certain fruit and vegetable crops.

4. Degradable plastic mulches: Degradable mulches have many of the same properties as non-degradable plastic mulches, with the added benefit of being able to break down after receiving a certain amount of sunlight. These mulches may be either bio-degradable or photo-degradable, which helps to solve the problem of plastic mulch disposal. Depending on the type of degradable mulch, it can break down within a period of 6-10 months when exposed to sunlight. However, the edges of plastic mulches that are buried in the soil will not degrade until they are exposed to sunlight after being lifted out of the soil.

The choice of mulch to be used depends on the specific ecological conditions as well as the primary and secondary requirements for mulching. Below are some suggested mulches for different situations:

Response of The Plastic Mulch on The Yield of The Crop

S.No.	Crop	Thickness of mulch film (micron)	Increase in yield (%)
1.	Chilli	25	50-60
2.	Potato	25	35-40
3.	Cauliflower	25	40-50
4.	Tomato	25	45-50
5.	Capsicum	25	35-45
6.	Okra	25	50-60
7.	Brinjal	25	30-35

Selection of Mulch

Rainy season	-	Perforated mulch
Orchard and plantation	-	Thicker mulch
Soil solarisation	-	Thin transparent film
Weed control through solarisation	-	Transparent film
Weed control in cropped land	-	Black film
Sandy soil	-	Black film
Saline water use	-	Black film
Summer cropped land	-	White film
Insect repellent	-	Silver colour film
Early germination	-	Thinner film

Durability of The Plastic Mulches

The durability of plastic mulches depends on various factors such as the type of plastic used, the thickness of the film, the amount of exposure to sunlight, and the soil conditions.

Generally, thicker plastic films are more durable than thinner ones and are less likely to tear or degrade quickly. The durability of plastic mulches also varies depending on their intended use. For example, mulches designed for short-term use, such as for a single growing season, are generally less durable than those designed for long-term use, such as for perennial crops. Another factor that affects the durability of plastic mulches is their exposure to UV radiation from the sun. UV radiation can cause the plastic to break down, become brittle and lose its strength, leading to tears and holes. Mulches made from UV-stabilized plastic are designed to withstand prolonged exposure to sunlight without breaking down quickly. Finally, soil conditions can also affect the durability of plastic mulches. Rocks and other sharp objects in the soil can puncture the plastic, while wet or muddy conditions can cause the film to tear more easily. Proper installation of the mulch can also impact its durability, as a secure and tight fit will help prevent tearing and damage. In general, plastic mulches can be expected to last for one growing season to several years, depending on their intended use, thickness, and quality.

Cost Economics of Mulching

The economic cost of mulching is a crucial consideration when deciding whether to use this technique. In general, plastic mulching is a capital-intensive process, and the initial cost of investment can be high. However, the long-term benefits of plastic mulching, such as improved crop yields, reduced water consumption, and weed control, can outweigh the initial investment cost. The amount of mulch required for a field depends on the type of field and the method of mulching. For a levelled field, the area of mulch required is almost the same as the field area. However, for a field with ridges and furrows, the amount of mulch required is significantly greater than the field area. This is because the mulch must cover both the ridges and the furrows. Mulching is typically carried out in strips that cover 50-60% of the field area. This helps to conserve mulch and reduce the cost of mulching. In the current era, where conserving moisture and minimizing rainfall is a priority, the cost of mulching becomes less important, particularly when considering the value of a precious commodity like water. A cost-benefit analysis can help farmers determine the economic feasibility of plastic mulching. This analysis considers the cost of plastic mulching and the expected increase in crop yields, which can be translated into revenue. In some cases, government subsidies or loans may be available to help offset the initial cost of plastic mulching.

Conclusion

Plastic mulching is an agricultural practice that involves the use of plastic sheets to cover the soil surface to enhance crop production. The plastic sheets are laid over the soil, creating a microclimate that promotes plant growth and development by increasing soil temperature, reducing water evaporation, and suppressing weed growth. The practice has gained popularity due to its effectiveness in increasing crop yields and reducing production costs. However, plastic mulching has been associated with environmental concerns, including the generation of plastic waste and soil pollution. Researchers have proposed alternative materials and management practices to mitigate these environmental impacts. Overall, plastic mulching has potential benefits and drawbacks, and a balanced approach is necessary to maximize its benefits while minimizing environmental impacts.

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IMPROVED CULTIVATION PRACTICES OF SMALL MILLET RAGI

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Introduction

Millets represent some of the earliest cultivated crops, referring to a group of grass species whose seeds are utilized for food or animal feed. There are five main commercially significant millet species: proso, foxtail, barnyard, browntop, and pearl. Historical records from China trace the cultivation of foxtail and proso millet back to 2000 to 1000 BC. Foxtail millet (Setaria italica L.), likely originating in southern Asia, holds the distinction of being the oldest cultivated millet and is alternatively referred to as Italian or German Millet. The cultivation of foxtail millet gradually expanded westward into Europe over time. While foxtail millet was seldom cultivated in the United States during colonial periods, its cultivation significantly surged in the Great Plains after 1850. However, the introduction of Sudan grass led to a decline in the acreage dedicated to foxtail millet cultivation. Millets possess several health benefits: they are anti-acidic, gluten-free, aid in detoxifying the body, and contain Niacin (vitamin B3), which can contribute to lowering cholesterol levels. Additionally, millets are believed to help prevent breast cancer, type 2 diabetes, and are effective in reducing blood pressure.

Ragi, also referred to as finger millet, is a small gluten-free grain renowned for its richness in nutrients such as calcium, iron, and fiber. It is hailed as a nutritional powerhouse, boasting essential nutrients vital for health. With its reddish-brown hue, ragi finds widespread use in South Indian cuisine, where it is utilized to prepare various dishes like ragi dosa, ragi malt, and ragi balls. Its slightly nutty flavor and coarse texture render it a versatile ingredient suitable for both sweet and savory recipes.

Ragi is often considered a nutritious substitute for rice and wheat owing to its exceptional nutritional profile. Karnataka, Maharashtra, Uttarakhand, Tamil Nadu, Andhra Pradesh, Jharkhand, Odisha, Chhattisgarh, and Gujarat are among the major states where ragi cultivation is prevalent. In India, finger millet, or ragi, is cultivated across approximately 1.19 million hectares, resulting in a production output of 1.98 million tonnes and an average productivity of 1661 kg per hectare. By adhering to these steps and adopting suitable management practices, farmers can effectively cultivate ragi and harness its manifold nutritional and agronomic advantages.

Season

Finger millet, or ragi, is cultivated across all cropping seasons in various regions of the country. Over 90% of the area is under rainfed conditions, with cultivation predominantly occurring during the Kharif season. Ragi is typically grown during the rainy season or in areas with adequate irrigation facilities. The precise planting season may vary based on local climatic conditions and agricultural practices, but it generally spans from June to August in tropical regions.

Field Preparation and Sowing of Direct Seeded Crop

During April or May, it is advisable to conduct one deep ploughing using a mould board plough, followed by two ploughings with a wooden plough. Prior to sowing, secondary tillage with a cultivator and multiple-tooth hoe is essential to create a smooth seedbed. Minor land smoothening before sowing aids in better in-situ moisture conservation. Given that ragi seeds are very small (400 seeds/gram) and take 5-7 days to germinate, utilizing high-quality seeds and thorough land preparation facilitates better germination, minimizes weed issues, and effectively conserves soil moisture. In regions like Uttaranchal, where frequent ploughing operations are challenging, effective digging and soil turning, removal of perennial weeds, land smoothening, and the creation of inward slopes with shallow drains are recommended to manage excess rainwater B. Umesh and S. C. Ravi (2016).

Prepare a well pulverized seed bed for direct seeding of ragi. Apply FYM or compost 5t/ha and incorporate well into the soil along with fertilizer before sowing. Before planting, the land is plowed and harrowed to create a fine seedbed. Seeds can be sown directly into the prepared soil at a depth of 2-3 centimeters and spaced according to the desired plant density with a seed rate of 10 kg/ha will be adequate for line sowing crop.

3. Nursery:

In some cases, ragi seeds are germinated in nurseries before being transplanted into the main field. This method allows for better seedling establishment and weed control, particularly in areas with poor soil fertility or water logging issues. Seedlings should be raised in well prepared nurseries in an area of $500m^2$ for transplanting of 1 ha area. Apply 20 basket of FYM and small dose of fertilizer to help rapid growth of the seedlings. The seedling will be ready within 25 to 30 days. 8-10 kg of seeds will be sufficient for transplanting one ha.

Transplanting

Ragi seedlings are usually transferred into the main field when they reach a height of 15-20 centimeters. This strategy promotes regular plant spacing and early establishment, resulting in higher yields. Line sowing is helpful because it promotes intercropping and good weed control. It is critical to maintain an optimal plant population of 4–5 lakh plants per hectare. Apply manure and fertilizer once the land has been prepared. Transplantation should be closed. Spacing: Early kinds are 20x10cm, while medium-duration varieties are 22.5x10 cm. When the next furrow is drawn, cover the plant's base with earth. Shallow planting at 5 cm depth promotes quick establishment and better tillering.

Fertilization

Ragi reacts well to both organic and inorganic fertilizers. Farmers can stimulate initial growth by applying a basal dose of nitrogen, phosphorous, and potassium fertilizer before to planting. Additional nitrogen can be supplied during the vegetative stage to promote optimal development. It is preferable to apply fertilizer based on soil test recommendations. 40:20:20 NPK kg/ha for short-duration varieties grown in rainfed settings; 60:30:30 NPK kg/ha for short and medium-duration varieties grown in irrigated conditions. Nitrogen should be administered in two parts, 50% as a base and 50% as a top dressing, right before hoeing and weeding to absorb fertilizer into the soil. Entire P_2O_5 and K_2O must be given at the time of sowing

Bio-fertilizers

Treating seeds with *Azospirillum brasilense* (N fixing bacterium) and *Aspergillus awamori* (P Solubilizing fungus) @ 25 g/kg seed is beneficial. In case seeds are to be treated with seed dressing chemicals, treat the seeds first with seed dressing chemicals and then with bio-fertilizers at the time of sowing.

Procedure for inoculating seeds with bio-fertilizers

Bio -fertilizer culture specific to the crop is to be used @ 25g per kg of seed. Sticker solution is necessary for effective seed inoculation. This can be prepared by dissolving 25g jaggery or sugar in 250 ml water and boiling for 5 minutes. The solution thus prepared is cooled. Smear the seeds well using the required quantity of sticker solution. Then add culture to the seeds and mix thoroughly so as to get a fine coating of culture on the seed. The culture-coated seed is to be dried well in shade to avoid clumping of seeds. Use the inoculated seeds for sowing.

Weed Management

Weed competition may significantly influence ragi yields, so proper weed management is crucial. Manual weeding, herbicide application, and intercropping with leguminous crops are standard tactics for controlling weed development and maintaining crop health. Early weeding of the direct planted crop is critical for achieving high yields. The first hoeing and weeding is done about 2 to 3 weeks after seeding. When necessary, a second weeding can be done 15-20 days after irrigation. In continuous rainfall and irrigated areas: Pre-emergence spray: Isoproturon @ 0.5 kg a.i./ha (rainfed areas), Oxyflurofen @ 0.1 lta.i/ha (irrigated areas). Post-emergent spray with 2,4-D sodium salt at 0.75 kg a.i./ha. Weeds can be effectively controlled by spraying about 20-25 days after seeding.

Water Management

Ragi is relatively drought-tolerant but requires adequate moisture during critical growth stages. Depending on the availability of rainfall and irrigation facilities, farmers must monitor soil moisture levels and apply supplemental irrigation as needed to ensure optimal plant growth and development. Excess irrigation should be avoided. Rabi & Summer ragi should be irrigated at 20-25 days intervals.

Plant Protection

Ragi is susceptible to various pests and diseases, including birds, rodents, aphids, and blast disease. Integrated pest and disease management strategies, such as crop rotation, use of resistant varieties, and timely application of biopesticides or fungicides, are essential to minimize damage and maintain crop productivity.

Insects

Finger millet attracts several pests of which army worm, cutworm, stemborer, leaf aphid, grasshoppers, grey weevil, shootfly and ear caterpillars are important.

Stem borer : spray nursery bed once at 15-20 days after germination with Chloropyriphos or Monocrotophos @ 40ml/ 10 cm nursery area.

Before transplanting apply Phorate @ 0.5kg or Carbofuran 3G 1.2 kg/ha.

Aphids- Spray Methyl Demeton @1000 ml/ha at pre flowering stage.

Ear caterpillars- Dust crop with Malathion 5% @ 25 kg/ha

Diseases

Finger millet is affected by a variety of diseases of which blast caused by Pyriculariagrisea is the major problem. The disease is quite severe in kharif crop at all the growth stages. The losses caused will be more if the disease appears in the nursery and on the ears affecting the neck and fingers.

Management practices

By growing resistant varieties like GPU 28, GPU 26 and GPU 48. Treating seeds with fungicides like carbendazim @ 2g/kg a day before sowing. If necessary spraying the nursery with carbendazim (0.05%) or kitazin (0.1%) or Ediphefos (0.1%) or Saaf (0.2%). Spray any of the above fungicides at 50 per cent flowering and repeat 10 days later if Kitazin or Ediphenfos were used to control neck and finger blast.

In recent years, brown spot caused by Drechsleranodulosa is gaining importance. Its damage could be severe if the crop is subjected to drought or nutrition deficiency. The disease can be effectively managed by proper nutrition and water management. Need based spraying of Mancozeb or Saaf (0.2%) can be resorted to. Other diseases affecting the crop are mottle streak & streak virus, foot rot (Sclerotiumrolfsii), downy mildew or green ear (Sclerosporamacrospora), grain smut (Melanopsichiumeleusinis). Besides, at higher altitudes Cercopspora a leaf spot and in the coastal regions sheath blight (Rhizoctonia sp.) also appear, but are of minor importance.

9. Harvesting and Yield:

Ragi is typically harvested when the grains are fully mature and the stalks have dried out, usually around 3-4 months after planting. Depending on the variety and growing conditions, average yields can range from 800 to 1200 kilograms per hectare. After harvesting, the grains are threshed and winnowed to separate them from the straw. The crop matures in about 120 - 135 days depending on the tract and the variety. The ear heads are harvested with ordinary sickles and straw is cut close to ground. Its yield is possible to harvest 20 - 25 qtl/ha of grain and 60 - 80 qtl/ha of fodder. The Straw of finger millet makes nutritious fodder.

10. Nutritional Benefits of Ragi:

Ragi is a rich source of calcium, iron, protein, fiber and other minerals. The cereal has low fat content and contains mainly unsaturated fat. It is easy to digest and does not contain gluten. Finger millet is considered one of the most nutritious cereals which helps in keeping weight in control, maintaining bone health, lowering blood cholesterol, control anaemia and for diabetics because of lower glycemic response i.e lower ability to increase blood sugar level. Ragi is rich in amino acids which are vital in normal functioning of body and are essential for repairing body tissues. If consumed regularly, M. Sankaran (2017) Ragi could help in keeping malnutrition, degenerative diseases and premature aging at bay. Green ragi is recommended for conditions of blood pressure, liver disorders, asthma, lactating mother and heart weakness. Its high intake could increase quantity of oxalic acid in the body. Therefore, it is not advised to patients having kidney stones. Finger Millet can be value added to prepare cakes, roti, dosa, porridge, upma, pitha, halwa, biscuits from the powder of Ragi.

By following these steps and implementing appropriate management practices, farmers can cultivate ragi successfully and reap its numerous nutritional and agronomic benefits.

Conclusion

The cultivation of ragi encompasses a combination of traditional knowledge, modern agricultural practices, and ongoing research and innovation. By understanding the intricacies of its growth cycle and addressing challenges related to pest management and post-harvest handling, farmers can maximize yields and ensure the sustainability of this ancient grain for generations to come. Through continued investment and collaboration, ragi has the potential to make a meaningful contribution to global food security and nutrition.

Finger millet (ragi) varieties grown in India:

VLMandua-204: A robust variety with an average yield of approximately **12 to 15 quintals per hectare** (rainfed conditions).

VLMandua-146: Another high-yielding variety.

VLMandua-314: Known for its sturdy culm and non-lodging characteristics.

VLMandua-315: Offers good yield potential.

H-22: A reliable variety with decent yields.

K 1: Widely cultivated for its grain production.

Hullubele: Known for its resilience.

Karegidda: A popular choice among farmers.

Gidda: Provides satisfactory yields.

Jasarilambi: A promising variety.

Madayyanagiri-1 and **Madayyanagiri-2**: Both offer good yield prospects.

Dodda: A traditional variety.

Jadesanga: Known for its adaptability.

Jenumudda: A reliable choice for farmers.

VL Mandua-124, **VL Mandua-149**, **CO-9**, **CO-13**, **CO (Ra)-14**, and **TRY-1**: These varieties exhibit varying yield potentials.

Paiyur-1 and **Paiyur-2**: Suitable for different agro-climatic conditions.

VL Mandua-101: A versatile variety.

Remember that actual yields can vary based on crop management practices, soil quality, and local conditions. For rainfed crops, an average yield of **12 to 15 quintals per hectare** can be expected, while irrigated crops may yield **40 to 45 quintals per hectare.**

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CONFRONTING TOMATO LEAF CURL VIRUS: HARNESSING THE POTENTIAL OF RESISTANCE BREEDING IN TOMATO

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Introduction

Tomato belongs to the family Solanaceae, which includes more than 3000 species. Solanum section Lycopersicum includes the cultivated tomato, *Solanum lycopersicum* L., the only domesticated species. Tomato was one of the most widely eaten vegetable in the world. India is the second largest producer of tomato after China with an annual production of 19.69 million t from an area of 8.08 million ha and 24.36 MT/ha productivity. The demand for tomatoes is increasing day by day but as its production is affected by many diseases and stresses (biotic and abiotic stress). Moreover, there are many factors, which are also responsible for the limited production and growth of tomato such as drought, high or low temperature, salinity and insect and pest attacks. Tomato yield has been affected by more than 200 diseases caused by fungi, bacteria, viruses, and nematodes worldwide. Among them viral diseases are major limiting factor in plant cultivation and extremely difficult to control or eradicate. About 136 viral species have been described to infect tomato crops, which is notably higher to any other vegetable crop. Among that Tomato Leaf Curl Virus (TYLCV) is one of the most economically important virus causing disease in tomato plant world-wide. Usually, the disease causes a loss of the order of 28-92%, but may be as high as 100%. Therefore, development of disease resistant varieties are main objectives for plant breeding.

Understanding Tomato leaf Curl Virus

Tomato leaf curl disease (ToLCD) is the most devastating disease of tomato, affecting a large area under cultivation; it can be on the scale of an epidemic. In India, Tomato leaf curl disease (ToLCD) was first reported by Vasudeva in 1948 from Northern India and Sam Raj in 1950 from Central India. The disease is caused by different species having circular single-stranded DNA (ssDNA), of the genus Begomovirus, family Geminiviridae. Currently, 322 begomovirus species have officially been accepted by International Committee on Taxonomy of Viruses (ICTV) from all over the world causing infection in different crops, out of them 82 are reported from India. Among them, around 19 species of begomovirus have been shown to cause leaf curl disease in tomato. Two species namely Tomato leaf curl New Delhi virus and Tomato leaf curl Palampur virus predominantly distributed in Northern India and one species namely Tomato leaf curl Bangalore virus is dominant in Southern India (Muniyappa *et al*.,2000; Kirthi *et al*., 2002).

Disease symptoms

The symptoms of leaf curl disease are intricate, manifesting in various ways such as curling and puckering of leaves, yellowing of veins, stunted growth, increased branching, and leaf size reduction. Additionally, it can cause severe leaf distortion, plant stunting, and premature shedding of flowers and fruits. In certain plant types, it leads to specific symptoms like green vein banding, leaf twisting, and the appearance of green enations on the underside of leaves. Depending on the plant genotype and the stage of infection, symptoms may vary. At a cellular level, observable changes include nucleus hypertrophy, accumulation of dark granules, and the presence of virus-like particles in the cytoplasm.

Transmission of virus and host range

Under natural conditions, whiteflies transmit the tomato leaf curl viruses (ToLCVs) from infected to healthy plants. Even a single whitefly can transmit the virus. Minimum acquisition access period and inoculation access period of 30 min each is required for successful transmission to occur. Pre-acquisition and pre-inoculation starving of the vector results in higher levels of transmission. ToLCV can persist up to 10 days after acquisition in a single adult whitefly. Females are more efficient transmitters than the males. The virus is also transmitted by dodder (*Cuscuta reflexa* Roxb.). Under artificial conditions, grafting can transmit the disease. It is also known that some of the isolates of ToLCVs are also sap transmissible under laboratory conditions. ToLCVs can infect crops such as *Lycopersicon esculentum, L. peruvianum, L. hirsutum, L glandulosum, L. pimpinellifolium, Capsicum annuum, Nicotiana tabacum, Vigna unguiculata*, and *Luffa cylindrica.* The viruses perpetuate on many weed hosts, viz. *Acanthospermum hispidum, Ageratum conyzoides, Blainvella rhomboids, Euphorbia hirta, Fraveria hirta, Parthenium hysterophorus, Malvastrum coromandalinum,* and *Croton bonplandianum.*

Resistance breeding for ToLCV

Development of genetic resistance is the best solution for any virus problem, and especially for whitefly-transmitted viruses such as ToLCV.

Steps in breeding programme

- Screening of tomato genotypes for ToLCV
- Identification of major sources and inheritance of resistance genes.
- Breeding methods

Screening of tomato genotypes for ToLCV

Since ToLCV is not mechanically transmitted, whitefly-mediated transmission method has long been employed for screening tomato genotypes, which can ensure up to 100 per cent transmission, with an uniform (as much as possible) inoculum pressure. Tomato genotypes are screened by using three different methods.

1. Field screening with spontaneous natural infection

   Screening tomato genotypes through spontaneous infection under field conditions is largely based on the occurrence of ToLCD at high level so as to induce 100% infection in the control genotype by a single virus species of interest through the whitefly individuals possessing uniform viral load.

2. Screening by whitefly-mediated transmission under glasshouse conditions

   Screening under controlled glasshouse inoculations enables the researchers to manipulate and have control over the species & age of whiteflies being used, acquisition feeding period, inoculation feeding period, number of viruliferous whiteflies per plant, species of begomovirus of interest against which the genotypes are to be screened and much more. There are three types

   i) Free choice method

   ii) No choice method

   iii) Clip-Cage no choice method

3. Screening by Non-whitefly-mediated transmission

Transmission through whiteflies is a tedious process due to the involvement of aseptically maintained pure culture of known virus species, known biotype and species of aviruliferous whiteflies, a well-furnished insect-proof glasshouse and the skilled manpower. To ivercome these challenges, non-whitefly-mediated inoculation procedures were employed.

i) Graft Inoculation

ii) Agroinoculation with infectious clones of virus

iii) Agro–infiltration with infectious clones of virus

Identification of major sources of resistance genes

Many ToLCD resistance genes (Ty-1/Ty-3, Ty-2, Ty-4, ty-5, ty-6) have been identified till date, most of which are recognized from wild tomato species including *S. pimpinellifolium, S. peruvianum, S. chilense, S. habrochaites and S. cheesmaniae* (Ji *et al*., 2007b; Verlaan *et al*., 2013). These resistant genes are well characterized and mapped using molecular markers, Ty-1 (Zamir *et al*., 1994) and Ty- 3 (Ji *et al*., 2007a) mapped on chromosome 6 from *S. chilense*. However, recent studies demonstrated that Ty-1 and Ty-3 are allelic and code for an RNA-dependent RNA polymerase (Verlaan *et al.*, 2013). Another major gene, Ty-2 identified in *S. habrochaites* and mapped on chromosome 11 (Hanson *et al.* 2000). A recessive resistance gene, ty-5 identified in tomato cultivar Ty-King, mapped on chromosome 4 (Anbinder *et al*., 2009; Hutton *et al.*, 2012). In addition to recently ty-6 resistance gene was identified in *S. Chilense*, mapped on chromosome 10 (Kadirvel *et al.,* 2013).

Breeding methods

The most important breeding techniques used in order to improve tomato for ToLCV resistance are Introduction, Selection, Hybridization, Pedigree and Backcross method. But these conventional methods are not much effective in breeding resistance to virus because all the resistance genes identified are majorly present wild species, so it is difficult to transfer the genes to cultivated species very precisely. There may be chance of transfer of undesirable genes, which will effect yield and quality of fruit. So, it is better to use biotechnological approaches along with conventional method is the better way to breed for resistance varieties/hybrids against virus. The biotechnological approaches used are Marker assisted selection, Marker assisted backcross, Gene pyramiding, Gene silencing and genome editing technologies.

1) Traditional Breeding: Traditional breeding involves crossing tomato plants with known resistance to ToLCV with susceptible varieties. The offspring are then evaluated for resistance to the virus. Through several rounds of selection and crossing, tomato lines with improved resistance can be developed.

2) Marker-Assisted Selection (MAS): MAS involves identifying molecular markers linked to genes conferring resistance to ToLCV. These markers can be used to screen tomato plants at an early stage of development, allowing breeders to select plants with resistance genes more efficiently. This method accelerates the breeding process by eliminating the need for time-consuming and labor-intensive field evaluations.

3) Pyramiding Resistance Genes: Pyramiding involves combining multiple resistance genes into a single tomato variety to provide broader and more durable resistance against ToLCV. This strategy reduces the likelihood of the virus overcoming resistance conferred by a single gene, thereby increasing the longevity and effectiveness of resistance in tomato cultivars.

4) Genetic Engineering: Genetic engineering techniques can be employed to introduce resistance genes into susceptible tomato varieties. This involves the insertion of specific genes from a resistant source into the tomato genome. Genes encoding resistance proteins or those involved in signalling pathways that enhance plant defense mechanisms against ToLCV can be introduced. Transgenic tomato plants expressing these genes can exhibit improved resistance to the virus.

5) Gene Silencing: RNA interference (RNAi) technology can be used to silence specific genes essential for ToLCV replication or transmission in tomato plants. This approach disrupts the virus's ability to infect and spread within the plant, leading to reduced disease symptoms and severity.

6) Genome Editing: Genome editing technologies, such as CRISPR-Cas9, can be used to precisely modify the tomato genome to introduce or enhance resistance to ToLCV. This method allows for targeted changes in the DNA sequence, including the insertion, deletion, or modification of specific genes associated with resistance.

By employing these breeding methods, breeders can develop tomato varieties with enhanced resistance to ToLCV, ultimately reducing the impact of the disease on tomato production. However, it's essential to consider the efficacy, durability, and potential environmental impacts of each breeding strategy before widespread deployment in agricultural contexts.

Resistant varieties developed in India for Tomato leaf Curl Virus

Many tomato varieties and hybrids that are resistant to tomato leaf curl virus were released by public and private sectors. Some of the examples are Abhinav, Hissar Anmol, Pusa Early Dwarf, Vyabhav, Kashi amul, Nandi, Sankranthi, Arka Vishesh, Arka Apeksha, Arka Rakshak, Arka Samrat, Arka Abhed etc.

Conclusion

The Tomato Leaf Curl Virus poses a significant challenge to tomato cultivation in India, exacerbated by additional symptoms caused by whitefly infestation. To address these challenges, researchers are exploring a comprehensive understanding of the virus's diversity and its spread, aiming to develop effective management strategies. Identification of resistance for ToLCV is necessary. Artificial screening is appropriate to identify resistant genotype which is possible using wild genetic resources as donor parents. Resistance in wild species is controlled by a single, dominant gene and is promising material for genetic improvement of resistance to tomato. Resistance breeding offers a beacon of hope in the fight against Tomato Leaf Curl Virus, offering farmers a sustainable and effective means of protecting their crops. By leveraging the power of genetics and collaboration, we can cultivate a resilient tomato industry that is better equipped to withstand the challenges posed by ToLCV and other viral threats.

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BEYOND THE FIELD: EXTENSION EDUCATION'S INFLUENCE ON COMMUNITY AND ECONOMY

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Introduction

Extensions are essential for nodes to facilitate access and transfer information across different organizations inside the innovation system. Extension education, a core objective of the land-grant university (LGU) system, significantly impacts community and economic growth. It converts research-based discoveries, optimal methods, and knowledge into informal educational programmes that are easily available to both corporations and people. This distinctive method enables extension educators to include community-specific research and teaching into their research plan, promoting a culture of ongoing learning and improvement.

After the green revolution, there has been a significant improvement in the situation, leading to the attainment of food security. New poverty alleviation programmes have been implemented to decrease rural disparities. Breakthrough technologies have stopped advancing in recent years. The effect of the 'technology push', which was significant in the 60s and 70s, is no longer as crucial to demonstrate its immediate impact. Experience has shown that the extension service faces obstacles when it becomes static and loses its dynamism in addressing regional and temporal variances or challenges in expanding agriculture.

Agriculture encounters a wide range of requirements, possibilities, and future outlooks. To effectively address emerging difficulties, more focus must be placed on information-based technology and enhancing methods of disseminating knowledge to farmers. State Departments of Agriculture (DoAs) were the only arbiters of agricultural extension before to the 1960s. A coordinated strategy allowed for the expansion to take place. Various development programs, such as IADP, IAAP, etc., were launched. Working with the KVKs, ICAR launched programs in the 1990s such as the Lab-to-Land and Operational Research Programs. Training programs for authorities and farmers were launched by State Agricultural Universities (SAUs), who also organized demonstrations and exhibitions. Each State Agricultural University established a Directorate of Extension to implement the University-based Extension Education Approach.

The Commodity-based Extension Approach and the Command Area Development Authorities were two such groups that spearheaded extension initiatives. Since the public sector was responsible for overseeing the whole process of technological creation and transmission, the expansion was seen as a public benefit. The primary objective was to increase the number of extension specialists and launch a number of initiatives in order to broaden the scope of extension services throughout the country. The Commodity-based Extension Approach and Command Area Development Authorities were both set up to aid certain commodities and areas with their respective extension programs. Because the public sector was entrusted with the exclusive responsibility of managing the development and distribution of technology, extension was seen as a public benefit. The major goal was to increase the number of extension specialists and launch several programs in order to expand extension services throughout the nation.

In the 1980s, many nations implemented the World Bank-funded Training and Visit (T&V) system. Enhancements were made to the funding and personnel distribution for extension services, and a unified command structure for extension was established. The T&V system had diverse results due to its failure to account for the nation's agro-climatic and socio-economic diversity. The T&V system produced diverse results due to its failure to account for the nation's agro-climatic and socio-economic diversity.

Agricultural extension programs have seen an influx of non-governmental organizations (NGOs), agro-input companies (AICs), and agro-processors since the 1980s. Extension services for certain crops and commodities are being more and more provided by farmer groups and producer cooperatives. Many extension services are being offered by input agencies, especially fertilizer companies. The increase in rural literacy has led to newspapers devoting more space to stories on the use of agricultural technologies.

Research in Extension Education

Extension education research is currently neglected, with a deficiency in fundamental research being carried out in the discipline. The focus remains on diffusion, adoption, and communication research. There is a need to revamp the postgraduate curricula in extension education to enable research in these areas, enhancing the discipline's quality and uniqueness Incorporating management ideas and techniques into postgraduate, Ph.D., and field-level extension education curricula is essential.

Production to Marketing

According to the National Commission on Farmers (NCF), farmer-to-farmer learning and technology transfer are widespread and reliable.. Establish farm schools at farms run by successful farmers in various agro-climatic regions and agricultural systems. Farm School and Farmer Field School are important instruments for farmer-led extension. It is crucial to transition extension emphasis from production-centered to market-driven extension in order to boost farm revenue via the implementation of a comprehensive methodology. Market-driven extension services assist farmers in reducing production costs, enhancing the quality of agricultural products, boosting product value and marketability, ultimately leading to increased revenue for farmers.

New growth prospects have emerged as a result of the liberalization of global agriculture trade. India's diversified agro-climatic settings, cheap labor costs, and near-total dependence on its own resources give it a competitive edge in a number of agricultural exports. A wide variety of agricultural goods, including seafood, cereals, cashews, coffee, tea, spices, oil meals, vegetables, castor, tobacco, and fruits, have been exported thanks to these qualities over the years. Although it faces competition, India has a specialized market access for goods like Basmati rice. Between fourteen and eighteen percent of the total exports of the nation are agricultural products.

Developing Cases as Tool for Technology Dissemination

Case studies are particularly valuable for explaining the reasons behind a situation or how it came to be. When drafting a case study, it is crucial to consider that it might encapsulate significant themes in a region's developmental history and must identify stakeholders impartially. Themes may be shown from several perspectives in a case, frequently allowing for greater creative expression compared to an academic article. A success story is the positive and intended consequence or outcome of a project. You wish to illustrate how 'Extension' impacts the lives of the individuals it serves. Anecdotes of success demonstrate the impact that extension services have had on individuals' lives. It delineates favorable transformation and advantages. Success stories are crafted to exchange programming ideas and determine effective strategies. Success stories are written to communicate the problem scenario, including who discovered the issue and how it was resolved, to stakeholders or farmers.

Future perspectives,

In India, extension education is mostly used for production-oriented programmes, area development initiatives, target group-based service schemes, and predominantly as a technology distribution mechanism. There is an increasing awareness of the need to transition from a technology-focused strategy to a more inclusive and comprehensive approach that takes into account the social, economic, and environmental aspects of sustainable development. Research in extension education, presently the most neglected, requires strengthening. There is a notable absence of fundamental research in the field that requires attention. Research may provide vital insights into the efficacy of extension programmes, pinpoint emerging trends and difficulties, and guide the creation of new strategies and interventions.

Conclusion

Extension education is crucial for fostering community and economic growth. It offers resources and services to improve the well-being and prosperity of people, families, and communities, while also supporting the larger benefits of teaching and research disciplines. The obvious institutional boundaries between research, extension, farmers, farmers organizations, NGOs, and commercial firms were blurred as a consequence. It is crucial to keep investing in extension education and research to maintain its relevance and effectiveness in meeting the changing demands and problems of our communities in the future. The innovation system must provide effective institutional mechanisms to enhance overall performance. Failing to provide this crucial duty will further marginalize extension.

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CHICKPEA LANDRACES: A VALUABLE AND DIVERGENT SOURCE FOR HEAT TOLERANCE

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Abstract

Heat-tolerant chickpea landraces offer a sustainable solution for farmers facing drought and heat stress. Chickpeas are crucial for crop rotation, intercropping, and soil fertility maintenance, contributing significantly to farming systems sustainability. A narrow genetic base has hindered efforts to enhance chickpea productivity, leading to low genetic gains in breeding improved varieties. In order to increase chickpea resistance to abiotic conditions like heat and drought, research highlights the significance of investigating a variety of sources of genetic diversity, including wild Cicer species and landraces former cultivars.

Introduction

Chickpeas (*Cicer arietinum* L.) a globally significant crop, facing challenges from high-temperature stress, which affects growth, development and yield by affecting various physiological processes like germination, shoot growth, and leaf viability. Proline is an amino acid known for enhancing heat tolerance in plants like chickpeas. Understanding the genetic basis of heat tolerance in chickpeas by Genetic dissection has been crucial in identifying essential genes associated with drought and heat tolerance in chickpeas. By using genome-wide association studies (GWAS) to explore the genetics of heat tolerance in chickpea landraces, researchers hope to improve breeding efforts and create climate-resilient cultivars that can withstand harsh weather conditions.

Benefits chickpea landraces for farmers

Chickpea landraces are a great crop choice since they provide farmers with a number of benefits such as they are hardy in harsh conditions because they can withstand environmental shocks, such as moisture and heat stress. They contribute to both economic and nutritional security because of their low production costs, which also diversify food, nutrition, feed usage, and health advantages. Chickpeas landraces are also quite valuable on the market and are essential to the sustainable intensification of agricultural systems. Additionally, studying the diversity of chickpea germplasm broadens the genetic foundation of the crop and increases its resistance to abiotic stresses like heat and drought. Chickpeas landraces significantly impact farming systems because they improve soil fertility by fixing nitrogen and releasing phosphorus, which benefits the entire soil ecosystem.

Chickpeas are grown in a variety of agroclimatic settings throughout the world and are vital to mixed cropping systems, intercropping, and crop rotation. Before germplasm can be used for agricultural improvement, it must be characterized. Characters are immediately observable, highly heritable, and expressive in all contexts, and they are recorded in phenotypic characterization. The ICRISAT genebank's descriptors were created for characterization (https://genebank.icrisat.org/IND/Char_Chickpea?Crop=Chickpea).

Research has demonstrated the economic potential of chickpea production by using centers of diversity for chickpea is the West Asia and North Africa (WANA) region as well as its advantages in terms of low production costs, tolerance to climate shocks, high market value, and sustainable intensification. These illustrations highlight the various ways in which farmers in various locations employ landraces of chickpea, underscoring the significance of these age-old cultivars in farming and food security. These landraces help ensure farmers financial and dietary stability since they thrive in harsh conditions. Furthermore, examining the genetic diversity of landraces chickpea expands the genetic basis of the crop and increases its resistance to abiotic stresses like heat and drought. Chickpeas also contribute significantly to the sustainable intensification of farming systems by fixing nitrogen in the soil and releasing phosphorus, which improves soil fertility and the soil ecosystem as a whole. Many regions have emphasised the economic potential of chickpea production, highlighting the advantages of these traditional types for smallholder farmers concerning market value, adaptability, cost of production, and sustainability.

Chickpea landraces differ from commercial varieties

There are a number of reasons why chickpea landraces are different from commercial cultivars in terms of quality and output. Ethiopian landraces and other landraces from the crop's centre of origin are rather similar, possessing distinctive seed traits such small, black, and angular seeds, low attachment of the initial bean, and low seed yield. Comparing these characteristics to commercial kinds can affect both yield and quality. Conversely, commercial types are frequently bred for particular qualities such as market preferences, uniformity, disease resistance, and increased yield potential. They go through rigorous breeding programmes aimed at improving the quality and productivity that farmers and consumers want. Comparing this breeding focus to traditional landraces may result in variations in yield potential and overall quality.

Factors affecting the yield of chickpea landraces and commercial varieties

Studies indicate that higher plant densities can improve competition for resources like light, space, and nutrients, resulting in improved soil moisture retention and possibly higher yields. Plant density is a key factor in determining chickpea output. Chickpea yield gains are also highly influenced by fertiliser application; NPK and occasionally S fertilisers have been shown to have positive benefits on productivity. Furthermore, the yield and quality of grown chickpeas are significantly influenced by environmental factors such as terminal heat stress and limited rainfall, underscoring the significance of climate conditions in chickpea cultivation. The yield discrepancies between landraces and commercial types are also influenced by genetic potential; hence, breeding programmes aim to generate high-yielding cultivars to maximise productivity under target conditions. Unpredictable climate changes, including increased frequency of drought, high temperatures (>30°C), and low temperatures (<15°C), pose challenges to chickpea production by reducing grain yields considerably. Rainfall patterns influence chickpea growth and development, with drought stress being a significant constraint that can reduce crop yields by about 45-50% globally. Drought conditions can hasten maturity in chickpeas by stopping growth, while late-season rains can cause plants to green back up, affecting overall yield potential. Temperature extremes, both cold and heat stress, impact chickpea productivity and quality. High temperatures during flowering can lead to flower abortion and reduced pod set, affecting yield potential. Graph of monthly average temperature of chickpea growing season of 2021 to 2023 in three different regions of India (Figure1).

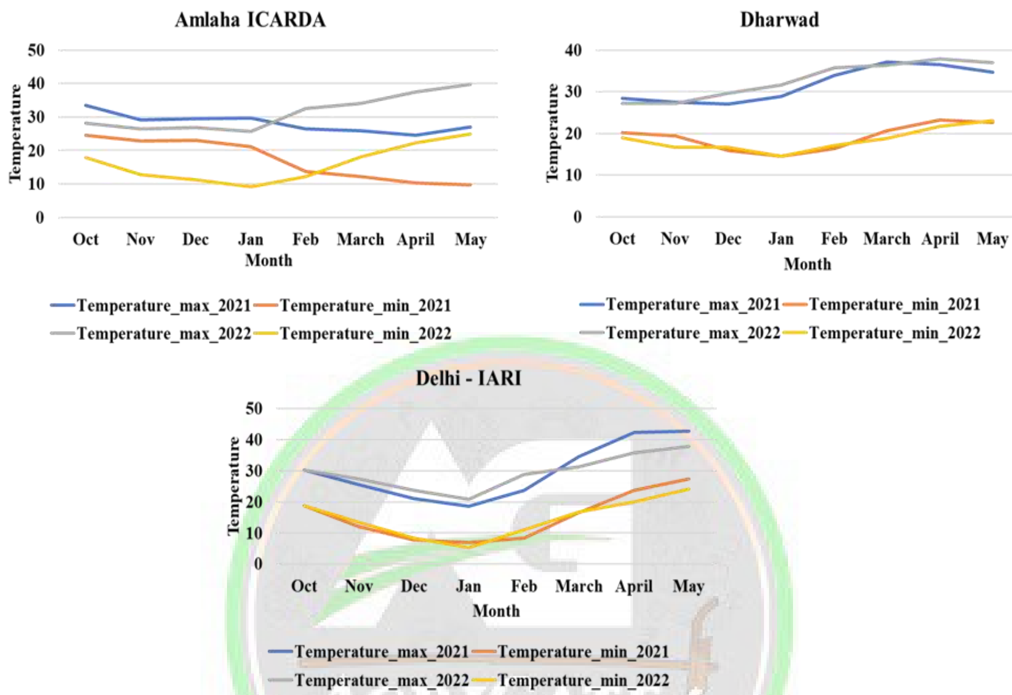

Figure 1. Graph of monthly average temperature of chickpea growing season of 2021 to 2023 in Three different regions of India.

Chickpea landraces and commercial varieties differ in their ability to adapt to environmental stresses due to various factors. Landraces, being traditional varieties, often exhibit greater genetic diversity and adaptability to local conditions, making them more resilient to environmental stresses like drought and heat compared to commercial varieties. These landraces have evolved over time to survive in diverse environments, allowing them to cope better with fluctuations in rainfall patterns and temperature extremes. On the other hand, commercial varieties are often bred for specific traits like high yield potential, uniformity, and disease resistance, which may compromise their ability to adapt to a wide range of environmental stresses. While commercial varieties may excel under optimal conditions with intensive management practices, they may struggle to perform well under challenging environmental conditions compared to the more adaptable landraces.

Effects of high temperature stress on chickpea

Chickpeas have a way to escape from high temperatures, although heat stress during the reproductive stage can cause significant production losses from germination and seedling establishment to seed yield. Reduced pod set, flower abortion, and eventually poorer yields can result from heat stress during the reproductive phase. Landraces be more resilient to heat stress than commercial cultivars cultivated for particular qualities, such as high yield potential, because of their genetic diversity, local adaptation and broad genetic base. Studies indicate that improving heat tolerance in landraces and commercial varieties requires the development of climate-resilient chickpea genotypes through physiological and molecular methods.

Symptoms of high temperature stress in chickpea

1. Anther and Pollen Abnormalities: Rising temperatures have the potential to cause structural irregularities in anthers and pollen, which can result in a decrease in pollen yield and set, as well as lower fertility and germination (Figure 2).

2. Pollen Sterility: Reduced seed number, weight, and overall yield can be the result of heat stress-induced pollen sterility in chickpeas, which affects fertilisation and seed development.

3. Oxidative Stress: Rising temperatures have the potential to intensify oxidative stress in chickpea plants, resulting in a reduction of soluble carbohydrate levels, ATP concentrations in the pistil, and leaf photosynthesis, ultimately impacting nutrient delivery and overall plant growth.

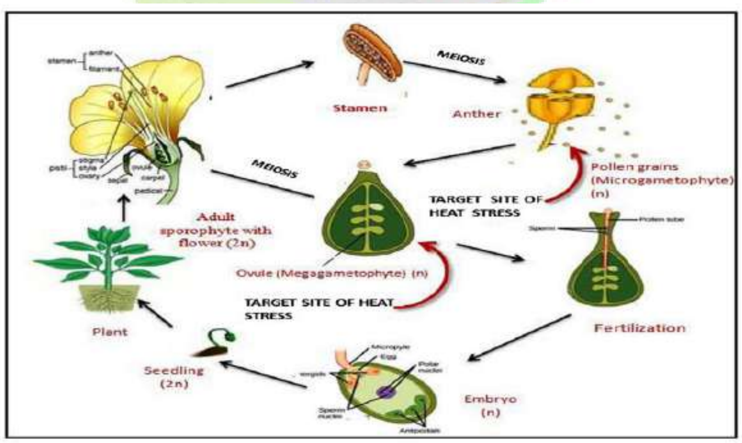

Figure 2. Target sites of heat stress on reproductive growth (Source: Kaushal et al., 2016)

These symptoms demonstrate the harmful effects of high temperatures on chickpea plants, affecting seed formation, reproductive processes, and potential yield overall.

4. Poor Pollen Germination: After anthesis, heat stress can lead to poor pollen germination, pollen tube expansion, and fertilisation, which can lower chickpea seed set and yield.

5. Pod Abortion: In high temperatures, heat-tolerant genotypes exhibit improved pod set and reproductive success, while heat-sensitive genotypes may undergo pod abortion.

Breeding strategies

There are several ways to improve chickpeas' capacity to tolerate high temperatures, including increasing their heat tolerance. These tactics include marker-assisted breeding, pre-breeding with wild relatives, omics-based technology, and conventional breeding techniques (Figure 3). The identification of potential genes and major QTLs (Quantitative Trait Loci) associated with heat stress tolerance provides important information for molecular breeding initiatives. Furthermore, physiological characteristics that have been investigated as markers of chickpeas' ability to withstand heat include chlorophyll content, the normalised difference vegetation index (NDVI), and canopy temperature. The main goal of these breeding techniques is to create superior lines with increased heat tolerance. The heat tolerant genotype having lower heat susceptibility index (Table 1).

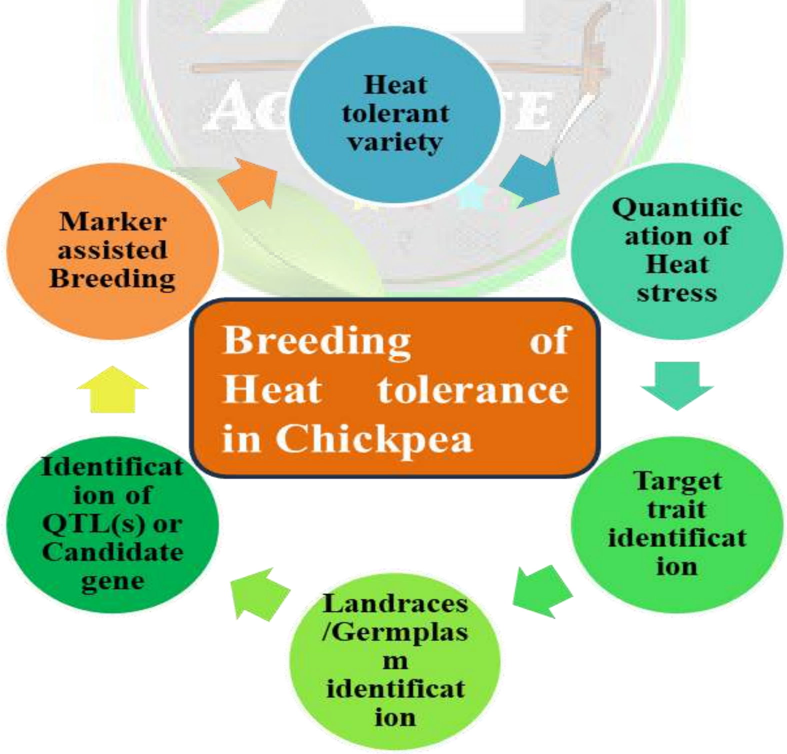

Figure 3. Breeding strategies for heat tolerance in chickpea

Table 1. Landraces with their heat susceptibility index values of individual environment.

S. No.	Accession	Collection/Source	HSI_Amlaha_2021	HSI_Dharwad_2021	HSI_Delhi_2021	HSI_Amlaha_2022	HSI_Dharwad_2022	HSI_Delhi_2022
1	ILC8666	Portugal	0.38	0.21	0.12	0.17	0.57	0.32
2	IG5871	Syria	0.12	0.12	0.18	0.07	0.1	0.08
3	JG14	Jabalpur, India	0.23	0.14	0.24	0.04	0.09	0.04
4	IG5862	Jordan	0.83	1.03	0.37	0.87	0.76	0.6
5	IG5896	Iraq	0.88	0.94	0.45	0.87	0.59	0.67
6	IG6002	Tunisia	1.28	0.41	0.67	1.24	1.44	0.79
7	ILC1932	Jordan	0.78	0.79	0.75	0.67	0.82	0.52
8	IG5874	Syria	0.69	1.2	0.75	1.16	0.55	0.86
9	IG5884	Iraq	0.84	0.85	0.88	0.67	0.86	0.82

(Source: Danakumara et al., 2023)

Future Prospects

The future of enhancing heat tolerance in chickpeas holds promising prospects through continued research and breeding efforts:

1. Genetic Dissection and Marker-Assisted Breeding (MAB): Additional important genes linked to heat stress tolerance may be found by further investigating the genetic basis of heat tolerance in chickpeas using cutting-edge methods like genome-wide association studies (GWAS) and marker-assisted breeding. Through a fuller understanding of the molecular pathways behind heat tolerance, this genetic dissection will make it easier to produce cultivars that are climate-resilient.

2. Omics-Based Technologie: Understanding of the biochemical reactions of chickpeas to heat stress, including transcriptomics, proteomics, and genomes. Researchers can identify certain pathways and molecular markers linked to heat tolerance by examining the expression of genes and proteins under high temperatures.

3. Phenotypic Characterization and Trait Selection: To uncover characteristics linked to heat tolerance, more phenotypic characterisation of chickpea germplasm especially landraces will be necessary.

Conclusion

Chickpea breeding techniques to increase heat tolerance through the integration of advanced technologies such as omics-based approaches and marker-assisted breeding with conventional breeding methods. Chickpea landraces are a useful tool for breeding initiatives aimed at improving heat tolerance. A comprehensive strategy that incorporates physiological characteristics, genetic insights, and environmental factors will be essential going forward to create superior chickpea lines that can flourish in the face of growing heat stress difficulties.

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GENETIC REDESIGN FOR IDEAL PLANT ARCHITECTURE IN GRAIN LEGUMES THROUGH INDUCED MUTAGENESIS

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Abstract

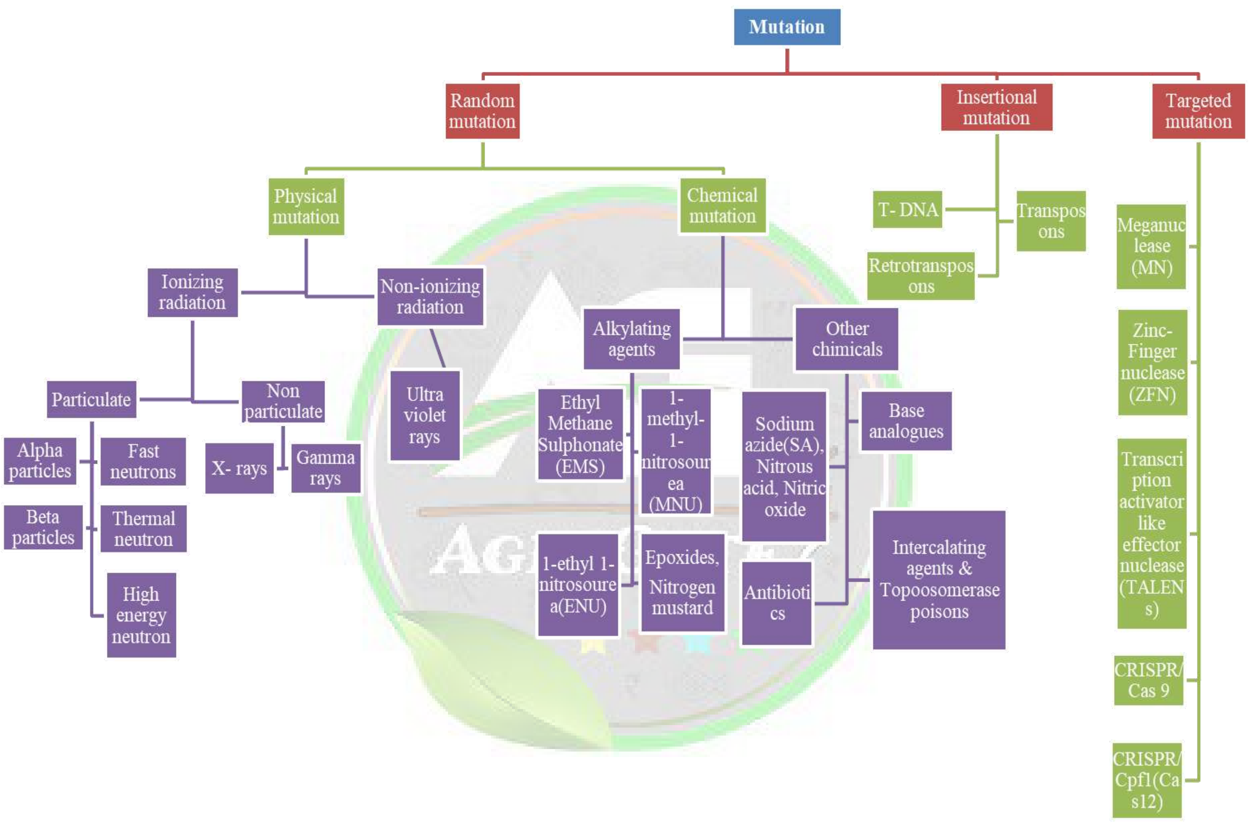
Grain legumes are serve as the important source of dietary protein for Indian diet. The genetic enhancement of grain legumes are need to be accelerated due to their narrow genetic variability and limited resources exploited. Majority of the grain legumes are cultivated in the rainfed areas and they are affected by many biotic and abiotic stresses. Mutagenesis is the elite approach for generating genetic variants that possess economically desired characteristics like improvement of yield, resistance to pests and diseases and tolerance to abiotic stresses. By using induced mutation many superior varieties were developed in grain legumes throughout India. In this paper, the utilization of mutation in grain legumes improvement is explained in detail.

Keywords: Grain legumes, physical and chemical mutagen, genetic variability, biotic and abiotic stresses.

Introduction

Grain legumes or Pulses are of high value and low input requiring nutritious protein (20-25%) rich dietary crop throughout the globe compared to cereals (7-17%). They are rich and cheap source of protein for both vegetarian and non-vegetarian diet ,serve as feed for livestock and rejuvenate the soil fertility through symbiotic biological nitrogen fixation. Grain legume seeds are the rich source of proteins, soluble and insoluble fibre, slowly digestible starch, micro and macro nutrients, vitamins and numerous bioactive phytochemicals or secondary metabolites like flavonoids and other antioxidants (Bassett et al., 2010; Scalbert et al., 2005). They provide many health benefits such as consumption of soybean & Lupin products in human diet can reduce the risk of cardiovascular disease, lowering blood cholesterol, repressing hypertension, diabetics (Sirtori et al., 2012; Bertoglio et al., 2011). In India, pulses are being grown on about 30.73 million hectares overall, producing 27.302 million tons at an average productivity of 888 kg/ha (Indiastat,2021-22).

Classification of Mutation



Source: Viana et al., 2019

Mutation in grain legumes

Grain legumes are mostly grown as rainfed crop in India which leads to often experience of drought at critical crop growth stages. They are susceptible to many pest and disease. Therefore, the lack of biotic (pest & disease) and abiotic (drought, heat, cold, salinity) stress resistant varieties are the prime need in the grain legumes cultivation. In grain legumes, the variability within the available germplasm is low. So, mutation is very useful method to create desirable variations in the population. In India, the institutes such as Bhabha Atomic Research

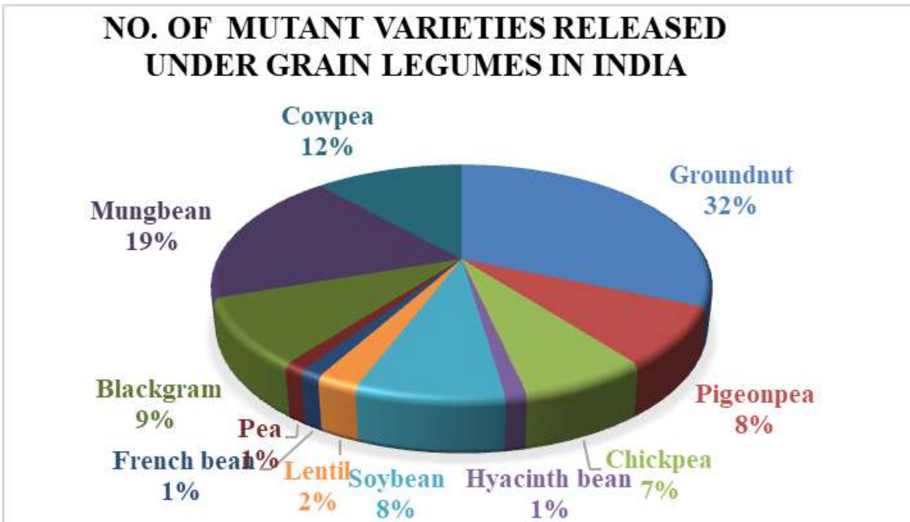
Centre (BARC), Trombay, Mumbai, Indian Agricultural Research Institute (IARI), New Delhi and Tamilnadu Agricultural University (TNAU), Coimbatore are carrying the mutation works. The list of cultivars of grain legumes that were created by induced mutation were depicted in the table. Through mutation breeding, a total of 523 varieties have been developed globally in grain legumes. Out of which 86 mutant varieties were developed in India (http:/mvgs.iaea.org). In India the maximum mutant varieties developed in groundnut (27) followed by green gram (16), cowpea (10), black gram (8), pigeon pea (7) and soybean (7).

List of Grain legume mutant varieties released

S. No.	Latin name	Common name	No. of varieties released throughout world	No. of varieties released in India
1	*Arachis hypogaea* L.	Groundnut	80	27
2	*Cajanus cajan* L. Millsp.	Pigeonpea	7	7
3	*Cicer arietinum* L.	Chickpea	27	6
4	*Dolichos lablab* L.	Hyacinth bean	1	1
5	*Glycine max* L. Merr.	Soybean	182	7
6	*Lathyrus sativus* L.	Grass pea (Khesari)	3	0
7	*Lens culinaris* Medik.	Lentil	19	2
8	*Lupinus albus* L.	White lupin	13	0
9	*Lupinus angustifolius*L.	Blue lupin	2	0
10	*Lupinus cosentinii* Guss.	Sandalplain lupin	1	0
11	*Lupinus luteus*L.	Yellow lupin	3	0
12	*Phaseolus vulgaris* L.	French bean	59	1
13	*Phaseolus coccineus*L.	Scarlet runner bean	1	0
14	*Pisum sativum* L.	Pea	34	1
15	*Vicia faba* L.	Faba bean	19	0
16	*Vicia sativa*L.	Common vetch	3	0
17	*Vigna angularis* Willd.	Adzuki bean	3	0
18	*Vigna mungo* L. Hepper	Blackgram	9	8
19	*Vigna radiata* L. Wiczeck	Mungbean	41	16
20	*Vigna unguiculata* L. Walp.	Cowpea	16	10
Total			523	86

(Source: https://nucleus.iaea.org/sites/mvd/)

Mutant varieties developed in Grain legumes in India



(Source: https://nucleus.iaea.org/sites/mvd/)

Advantages of mutation breeding

- ✓ It is possible to develop quickly in elite material.
- ✓ It is possible to enhance a single trait of a well-known variety that is favoured by growers, processors, and/or consumers.
- ✓ There is a chance of direct mutant varieties, or very little breeding work is needed.
- ✓ It is possible to create novel variations and can be target specific genes also.
- ✓ It is possible to create single gene mutants that have no adverse pleiotropic effects.

Disadvantages of mutation breeding

- ✓ In general, the process is unpredictable and random.
- ✓ Mutants with useful traits are uncommon and primarily recessive
- ✓ Maintenance of large population size and effective screening techniques need for isolation of desired mutants.
- ✓ Success rate is very less (0.1%)
- ✓ Health risk is their due to handling of harmful radiation and carcinogenic chemicals as mutagens.

Conclusion

Grain legumes are the important source of protein for 70% of global population. But the productivity of the crops are reduced by several biotic and abiotic factors. Because of the autogamous nature of grain legumes, the genetic variability is narrow. Mutation breeding was much useful tool for crop improvement in grain legumes. By using physical and chemical mutagenic agents many elite cultivars have been developed. Here after, using the molecular mutation breeding many of desired achievements will be made in crop improvement of grain legumes.

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CRISPR-CAS9 VS BASE EDITING IN REVOLUTIONIZING PLANT BREEDING

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Introduction

Among a few genome editing technologies which has emerged over the years to modify the genomes of plants and animals, Clustered Regularly Interspaced Short Palindromic Repeat (CRISPR)-CRISPR-associated protein (CRISPR/Cas) technology is a notable technique which has been used for crop improvement. This system uses the Cas9-sgRNA complex to create breaks in the double-strands of DNA in the organism which are corrected either through a non-homologous end joining (NHEJ) approach or homology-directed repair (HDR) mechanism. While HDR shows low frequency and the NHEJ is prone to errors and randomly makes indels, CRISPR/Cas9 system cannot be used to carry out gene base conversion. Owing to these limitations, it is imperative to look for a precise and stable approach for editing crop genomes. Base editing has been regarded as an alternative and more efficient approach. The application of base editing in plant breeding has enabled precise genome editing without causing double strand breaks, which has revolutionized crop improvement. Base editing precisely converts one base to another in the genome of plants and animals. Unlike other genome editing technologies, in base editing, there is non-generation of DSB and has effect on both dividing and non-dividing cells with high precision. Base editing creates both single and multiple nucleotide modifications in cells.

Base editing

Base editing has emerged as an innovative technique that allows for precise substitutions of nucleotides in a controlled manner, without causing gene disruption or necessitating a donor template. A base editor comprises a fusion of a catalytically inactive CRISPR–Cas9 domain (such as Cas9 variants, dCas9, or Cas9 nickase) and a deaminase domain for cytosine or adenosine, which facilitates the conversion of one base to another (refer to Figure 1). This method of making single-base changes has the potential to create desirable variations in crop plants, thereby expediting crop improvement efforts. The base-editing system can rectify single-base changes or single-nucleotide polymorphisms (SNPs) without disrupting genes, thereby reducing the occurrence of insertions and deletions. This technology proves to be highly effective for introducing new traits in agriculturally significant crops, thus playing a crucial role in ensuring food security. This technology utilizes tools like cytosine base editors (CBE) and adenine base editors (ABE), allows for targeted nucleotide substitutions with high efficiency.

Types of Base Editors

- DNA Base Editors, which includes Cytosine Base Editors and Adenine Base Editors.
- Dual Base Editors
- Transversion Base Editors
- PAMless Base Editors

Applications of base editing for crop improvement

Base editing is a powerful genome editing technology that enables precise changes to individual DNA bases without causing double-stranded breaks. This technique has significant potential for applications in crop improvement like trait modification (abiotic and biotic stresses), enhancement in the nutrient content, reduction in toxins, increased in yield and quality, reduced environmental impact (by pesticides) and precision breeding.

Advantages of base editing over other genome editing techniques in plant breeding

Base editing in plant breeding offers several advantages over other genome editing techniques, making it a powerful tool for precise genetic modifications. The key advantages of base editing include:

Precision and Efficiency

Base editing allows for targeted and irreversible changes of a single base pair without inducing double-strand breaks (DSB), ensuring high precision in genome editing.

Non-Generation of DSB

Unlike some other genome editing methods, base editing does not create DSBs, making it safer and more predictable for both dividing and non-dividing cells.

High Precision

Base editing tools like cytosine base editors (CBE) and adenine base editors (ABE) offer high precision in nucleotide substitutions, enabling specific modifications at desired genomic sites with minimal off-target effects.

Broad Applications

Base editing has been successfully applied in various crops to enhance traits such as disease resistance, herbicide resistance, and improved quality, showcasing its versatility in crop improvement.

Future Prospects

Continuous advancements in base editing technology aim to optimize and enhance the scope and efficiency of editing, paving the way for more precise modifications in crops for sustainable production amid global changes.

Base editing compared to crispr-cas9 in terms of precision

Base editing provides a higher degree of accuracy compared to CRISPR-Cas9 when it comes to genome editing. Tools such as cytosine base editors (CBE) and adenine base editors (ABE) allow for precise point mutations without causing double-strand breaks, resulting in more precise modifications at the nucleotide level. One of the study indicates that base editing produces fewer unintended mutations compared to the use of active Cas9 nuclease, showcasing its superior precision in genome editing. Furthermore, base editing techniques have been refined to facilitate precise gene editing, making them more convenient and accurate than CRISPR-Cas9 for targeted genetic modifications. In summary, base editing is distinguished by its enhanced precision and efficiency in introducing specific nucleotide changes, making it a valuable tool in applications such as plant breeding and genetic engineering.

Base editing compared to crispr-cas9 in terms of off-target effects

Base editing exhibits fewer off-target effects compared to CRISPR-Cas9 because of its distinct mechanism. While CRISPR-Cas9 relies on inducing double-strand breaks (DSBs) in DNA, which can result in unintended mutations, base editors like cytosine base editors (CBE) and adenine base editors (ABE) operate without causing DSBs, leading to reduced off-target effects. Studies has demonstrated that base editing technologies provide greater precision in introducing single nucleotide changes with minimal off-target mutations, making them a more dependable choice for genome editing tasks. In contrast, CRISPR-Cas9 systems, particularly when using active Cas9 nucleases, may show increased off-target effects due to DSB-mediated editing. Overall, base editing is distinguished by its capability to achieve precise genetic modifications with fewer unintended mutations than CRISPR-Cas9, rendering it a valuable tool in fields such as plant breeding and genetic engineering.

Challenges in using base editing for plant breeding

- Improving the accuracy and specificity of base editors is crucial for their widespread use in plant breeding due to challenges like high off-target activity, limited PAM sites, and a wide editing window.
- Delivering these editors efficiently into plant cells and targeting them to specific genomic locations can be difficult, although techniques such as Agrobacterium-mediated transformation, biolistics, and viral vectors are commonly employed but may have drawbacks in terms of efficiency or applicability across plant species.
- Base editing is currently limited to certain types of base conversions and target sequences, which may restrict the range of genetic modifications possible.
- Additionally, compatibility between base editors and specific Cas proteins required for their function can be challenging to ensure, especially across different plant species.
- The regulatory landscape for genome-edited crops, including those edited using base editing, is still evolving, making the approval process time-consuming and costly.
- Scaling up base editing for large-scale plant breeding programs is also resource-intensive, prompting ongoing research to optimize protocols, reduce costs, and increase throughput for broader accessibility to plant breeders.

Crops that have been improved using base editing

Some examples of crops that have been improved using base editing include rice, tomato, wheat, maize, watermelon, and rapeseed. Base editing technologies like Cytidine-deaminase-mediated base editing (CBE) and Adenine-deaminase-mediated base editing (ABE) have been utilized in these crops to introduce targeted nucleotide substitutions, create herbicide-resistant plants, and generate point mutations for specific traits enhancement. Additionally, base editing has been applied in plants like Arabidopsis, tobacco, lettuce, and potato for gene functional annotation and correction. The technology has shown significant potential in revolutionizing crop breeding by enhancing disease resistance, improving fruit quality, and accelerating the domestication of wild plants.

Potential future applications of base editing in crop improvement

- Accelerating wild-plant domestication, creating genetic circuits for signal transduction in plants, and developing plant biosensors to detect internal and external signals.
- Offers the opportunity to enhance the domestication of wild plants by targeting important domestication genes and improving traits controlled by multiple quantitative loci.
- Allows for more precise point mutations and broader applications than single-base edits, presents a promising alternative for future crop improvement efforts.
- Glycosylase base editors (GBEs) and prime editing are expected to further optimize editing efficiencies and broaden the scope of applications in crop breeding.

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APPLICATION OF ARTIFICIAL INTELLIGENCE IN AGRICULTURE

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Introduction

The growth of the global population, which is projected to reach 10 billion by 2050, is placing significant pressure on the agricultural sector to increase crop production and maximize yields. To address looming food shortages, two potential approaches have emerged: expanding land use and adopting large-scale farming, or embracing innovative practices and leveraging technological advancements to enhance productivity on existing farmland Pushed by many obstacles to achieving desired farming productivity — limited land holdings, labor shortages, climate change, environmental issues, and diminishing soil fertility, to name a few, — the modern agricultural landscape is evolving, branching out in various innovative directions. Farming has certainly come a long way since hand plows or horse-drawn machinery. Each season brings new technologies designed to improve efficiency and capitalize on the harvest. However, both individual farmers and global agribusinesses often miss out on the opportunities that artificial intelligence in agriculture can offer to their farming methods.

In any nation, agriculture is a vital component of the economy. The need for food is rising daily due to the growing global population. There is currently insufficient supply to meet the need using the farmers' traditional methods. Therefore, in order to meet these needs and give many people in this industry fantastic career prospects, several new automation techniques are implemented. With its potential to expand our views and change the environment around us, artificial intelligence (AI) has started to become increasingly important in our daily lives (Kundalia et al., 2020; Gandhi et al., 2020; Ahir et al., 2020).

Artificial intelligence is one of the most important technological developments in a variety of industries, including finance, robotics, education, agriculture, and others. It has a major impact on and is radically altering the agriculture sector. Making technology function like the human brain is the core concept of artificial intelligence (Parekh et al., 2020; Jani et al., 2019). Researching how the human brain works—including how people learn, make decisions, and collaborate to solve problems—helps developers of intelligent software and systems. AI shields the agriculture sector from a range of risks, such as population growth, climate change, a lack of jobs in the sector, and food safety. The modern agriculture system can now function at a new level thanks to AI.

At the farm level, AI influences crop production many ways; particularly through proper distribution of seeds, fertilizers and other agricultural chemicals, automated irrigation scheduling, monitoring soil, crop and animal health, crop quality, yield detection, weed iden surveillance of pests and diseases, and farm machinery positions in the field.

Impact of AI on agriculture

AI-based technologies help to increase productivity across the board and manage the problems that different industries, including the agricultural sector, face, including crop yield, irrigation, soil content sensing, crop monitoring, weeding, and crop establishment (Kim et al., 2008). The purpose of agricultural robots is to provide high-value AI applications in the aforementioned industry. The agriculture industry is in danger due to the world's rapidly growing population, but artificial intelligence (AI) may be able to provide much-needed relief. Farmers can now produce higher yields with less input thanks to AI-based technology solutions, which have also enhanced the quality of the output and sped up the time it takes for the harvested crops to reach the market. Farmers will use 75 million linked devices by 2020.

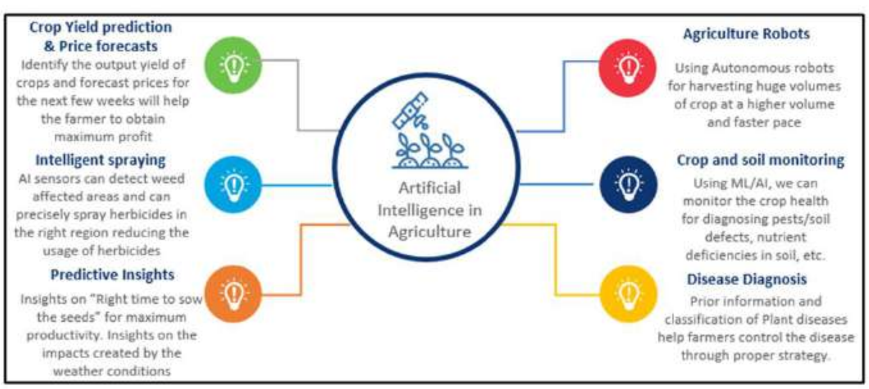
Challenges in Agriculture using traditional methods

Prior to comprehending the implications and applications of AI in agriculture, it is important to comprehend the difficulties associated with traditional agricultural practices, which are listed below:

- A variety of weather conditions, including humidity, temperature, and rainfall, are significant in farming.
- Because of pollution, the climate can fluctuate suddenly, making it challenging for farmers to plan ahead for harvesting, seeding, and soil preparation.
- Fertile soil with the right nutrients, including potassium, phosphorus, and nitrogen, is essential for improved crop yields. Crops of lower quality may result from an ineffective supply of these nutrients in the soil. However, determining this soil quality using conventional methods is challenging.
- We must protect our crops from weeds in the agricultural lifecycle. It also draws nutrients from the soil and raises the possibility of production costs. However, crop identification and weed prevention using conventional methods are ineffective.
- Using traditional methods requires a lot of time, labor, space, and difficulty to finish our works.

Applications of Artificial Intelligence in Agriculture

Farmers encounter a plethora of difficulties, much like with conventional agricultural practices. AI is being used extensively in this industry to address these issues. Artificial Intelligence has emerged as a game-changing tool for agriculture. In addition to many other ways, it benefits farmers by producing healthier crops and controlling pests and soil. Here are a few significant uses of artificial intelligence in the field of agriculture.



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

Optimizing automated irrigation systems

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

Detecting leaks or damage to irrigation systems

AI plays a crucial role in detecting leaks in irrigation systems. By analyzing data, algorithms can identify patterns and anomalies that indicate potential leaks. Machine learning (ML) models can be trained to recognize specific signatures of leaks, such as changes in water flow or pressure. Real-time monitoring and analysis enable early detection, preventing water waste together with potential crop damage.AI also incorporates weather data alongside crop water requirements to identify areas with excessive water usage. By automating leak detection and providing alerts, AI technology enhances water efficiency helping farmers conserve resources.

Crop and soil monitoring

The wrong combination of nutrients in soil can seriously affect the health and growth of crops. Identifying these nutrients and determining their effects on crop yield with AI allows farmers to easily make the necessary adjustments.While human observation is limited in its accuracy, computer vision models can monitor soil conditions to gather accurate data. This plant science data is then used to determine crop health, predict yields while flagging flag any particular issues. In practice, AI has been able to accurately track the stages of wheat growth and the ripeness of tomatoes with a degree of speed and accuracy no human can match.

Monitoring livestock health

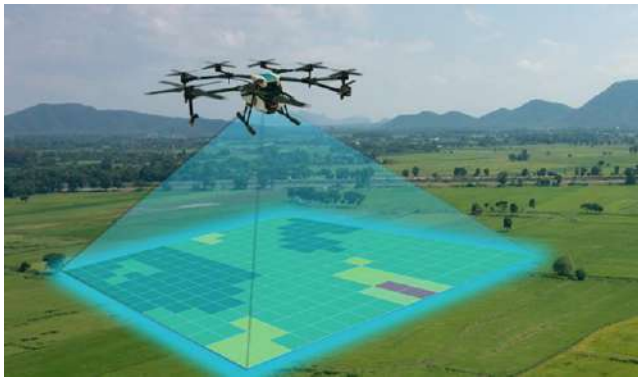
It may seem easier to detect health problems in livestock than in crops, in fact, it's particularly challenging. Thankfully, AI can help with this. For example, a company called CattleEye has developed a solution that uses drones, cameras together with computer vision to monitor cattle health remotely. It detects atypical cattle behavior and identifies activities such as birthing. CattleEye uses AI and ML solutions to determine the impact of diet alongside environmental conditions on livestock and provide valuable insights. This knowledge can help farmers improve the well-being of cattle to increase milk production.

Intelligent pesticide application

By now, farmers are well aware that the application of pesticides is ripe for optimization. Unfortunately, both manual and automated application processes have notable limitations. Applying pesticides manually offers increased precision in targeting specific areas, though it might be slow and difficult work.

Automated pesticide spraying is quicker and less labor-intensive, but often lacks accuracy leading to environment contamination.

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



Yield mapping and predictive analytics

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

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

Automatic weeding and harvesting

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

Sorting harvested produce

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

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

Benefits and Challenges of AI in agriculture

Until recently, using the words AI and agriculture in the same sentence may have seemed like a strange combination. After all, agriculture has been the backbone of human civilization for millennia, providing sustenance as well as contributing to economic development, while even the most primitive AI only emerged several decades ago. Nevertheless, innovative ideas are being introduced in every industry, and agriculture is no exception. In recent years, the world has witnessed rapid advancements in agricultural technology, revolutionizing farming practices. These innovations are becoming increasingly essential as global challenges such as climate change, population growth together with resource scarcity threaten the sustainability of our food system. Introducing AI solves many challenges and helps to diminish many disadvantages of traditional farming.

Advantages

AI enables better decision-making

Predictive analytics is really a boon for the agriculture industry. It helps the farmers solving the key challenges of farming, such as analyzing the market demands, price forecasting, and finding optimal times for sowing and harvesting the crop. Moreover, AI-powered machines can also determine soil and crop health, provides fertilizer recommendations, monitor the weather, and can also determine the quality of crop. All such benefits of AI in agriculture enable the farmers to make better decisions and do efficient farming.

AI brings cost savings.

Precision farming using AI-enabled equipment helps the farmers to grow more crops with lesser resources and cost. AI provides the real-time insights to farmers that enables them to take proper decision at each stage of farming. With this correct decision, there is less loss of products and chemicals and efficient use of time and money. Moreover, it also allows the farmers to identify the particular areas that need irrigation, fertilization, and pesticide treatment, which saves excessive use of chemicals on the crop. All these things sum up and result in reduced use of herbicides, better crop quality and high profit with fewer resources.

AI reduces labour shortage

There has always been an issue of labour shortage in the agriculture industry. AI can solve this issue with automation in farming. With AI and automation, farmers can get work done without having more people, and some examples are Driverless tractors, smart irrigation and fertilizing systems, smart spraying, vertical farming software, and AI-based robots for harvesting. AI-driven machines and equipment are much faster and accurate compared to human farmhands.

Challenges of AI adoption in Agriculture

Since most AI systems are based on the Internet, their utilization may be restricted in remote or rural areas with the absence of a web service and familiarity with handling AI operations (Eli-Chukwu N and Ogwugwam E C., 2019). By seeing the advantages of AI for sustainable farming, implementing this technology may seem like a logical step for every farmer. However, there are still some serious challenges that everyone knows, which are as follows:

Lack of familiarity with AI machines

Even though using AI to agriculture has several advantages, most people worldwide are not aware with the use of AI-enabled tools and solutions. In order to address the problems, AI businesses should first give farmers simple equipment, and then, as they become accustomed to it, more sophisticated machinery.

Lack of experience with emerging technologies

For underdeveloped nations, implementing AI and other cutting-edge technologies in agriculture might be difficult. In places where such agricultural technology is not being used, it will be extremely difficult to sell such technologies. Farmers in these places need assistance from someone in order to apply these technology.

Privacy and security issues

AI may give rise to a number of legal concerns because there are currently no defined rules and guidelines for its use. Furthermore, there can be security and privacy problems like cyber-attacks and data leaks because of the usage of software and the internet. For farmers or farm owners, all of these problems could pose serious challenges.

Conclusion

The uptake of AI solutions will determine how farming uses AI in the future. Despite ongoing large-scale research and certain commercially available applications, the agricultural industry remains neglected. Furthermore, research is currently ongoing to develop predictive solutions to address a genuine problem that farmers experience in their farming operations.

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SIGNIFICANT OF CLIMATE SMART AGRICULTURE (CSA)

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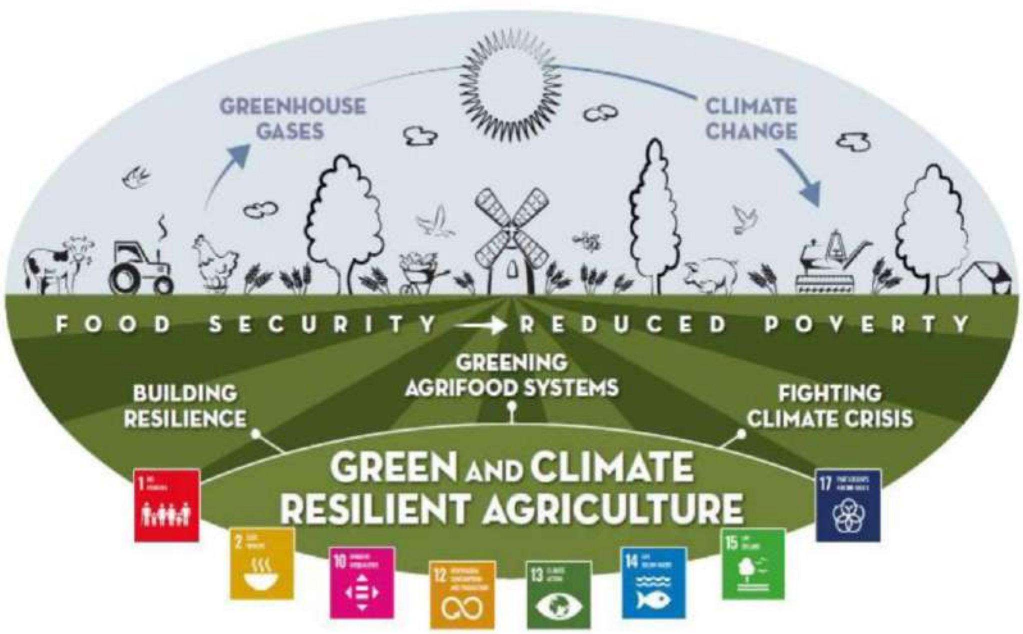
Introduction

- According to the World Bank, Climate-smart agriculture (CSA) is an integrated approach to managing landscapes Cropland, livestock, forests, and fisheries that addresses the interlinked challenges of food security and climate change.Climate Smart Agriculture is also known as Climate Resilient Agriculture. It is the development of agriculture under the new realities of climate change**.**

Benefits of Climate Smart Agriculture

- **Resilience to Climate Change -**Climate-smart agriculture practices build resilience in farming systems, it allows the farmers to cope with the impacts of climate change, such as droughts, floods, and extreme temperatures, and all abiotic conditions impact agriculture
- **Increased Crop Yields** - Efficient and timely use of resources and adoption of climate-resilient crop varieties can lead to higher crop yields, improve farmers' livelihoods, reduce the cost of cultivation, and increase income
- **Sustainable Resource Management** - Climate-smart practices focus on the sustainable management of natural resources**,** including water, soil, and biodiversity**.** This leads to reduced environmental degradation and conservation of ecosystem services.
- **Improved Food Security** - By optimizing resource use and enhancing agricultural productivity, climate-smart agriculture contributes to improved food security, ensuring a stable food supplyeven under changing climatic conditions to the global population

- **Mitigation of Greenhouse Gas Emissions -** Certain climate-smart agricultural practices, such as agroforestry and reduced tillage, can reduce greenhouse gas emissions from the agricultural sector, supporting climate change mitigation efforts.
- **Social and Economic Benefits -** Climate-smart agriculture promotes inclusivity and gender equity by empowering women farmers and vulnerable communities, it also enhances rural livelihoods by creating new income-generating opportunities and promoting sustainable ruraldevelopment.
- **Adoption of Innovative Technologies -** Climate-smart agriculture drives innovation and the adoption of advanced technologies in farming, facilitating increased efficiency and productivity



Climate Smart Agricultural Practices

- **Crop Management -** Practices include intercropping, crop rotations with legumes, using drought, wind, and flood-tolerant crop varieties, composting, mulching, and adopting organic fertilizers to manage the crop and sustainability in yield production
- **Livestock Management -** Improved feeding strategies, rotational grazing, suitable crops to feed animals, and better livestock health and husbandry.
- **Soil and Water Management -** Conservation agriculture, contour planting, check dams, and water storage, to control soil erosion problems, improve irrigation, and efficient water use

- **Agroforestry:** Planting trees as windbreaks, using nitrogen-fixing trees, and incorporating fruit orchards, Integrated Food Energy Systems Implementing biogas, improved stoves, solar power, and gravity-fed irrigation

Challenges of Climate Smart Agriculture

- **Uncertain Weather Patterns:** Climate-smart agriculture faces challenges due to the unpredictability of weather patterns and climate change impacts, the
- **Global Climate Risk Index 2024,** released recently, puts India seventh in the list of countries worst hit by extreme events
- **Limited Access to Resources:** Small and marginal farmers often face resource constraints, such as limited access to finance, technology, and knowledge about climate-smart practices

Technological and Knowledge Gaps: Adopting climate-smart practices requires access to appropriate technologies and information. Many farmers lack the awareness and technical know-how to implement such practices effectively

- **Institutional Barriers:** Weak institutional support, inadequate policies, and governance issues can hinder the scaling up of climate-smart agriculture initiatives
- **Financial Constraints:** Climate-smart agricultural practices often require initial investments in adopting these practices, especially in low-income regions
- **Adaptation and Local Context:** Climate-smart agriculture practices need to be tailored to local contexts and agroecological zones. What works in one region may not be suitable for another, necessitating region-specific approaches and adaptations

Government Initiatives for Climate Smart Agriculture

- **National Innovation on Climate Resilient Agriculture (NICRA)**
  - Launched in 2011 by the Indian Council of Agricultural Research (ICAR).
  - Aims: To increase the resilience of Indian agriculture, including crops, animals, and fisheries, to climate variability and change
- **National Action Plan on Climate Change (NAPCC)**

It was launched in 2008 to mitigate and adapt to the adverse impact of climate change, it includes various "National Mission" focusing on climate change awareness, adaptation and mitigation, energyefficiency, and natural resource conservation

- **National Mission on Sustainable Agriculture (NMSA)** It is one of the eight Missions underthe NAPCC risks associated with climate change by devising appropriate adaptation and mitigationmeasures

- **National Adaptation Fund for Climate Change (NAFCC)** Established in 2015 to meet the cost of adaptation to climate change for the State and Union Territories of India that are particularly vulnerable to the adverse effects of climate change.
- **Climate-Smart Villages (CSV)** CSV is an institutional strategy to implement and promote CSA at the locallevel, enhancing farmers' ability to adapt to climate change, CSV Take a portfolio of actions to address climate challenges, covering various farm activities
- **Pradhan Mantri Krishi Sanchay Yojna (PMSKY):** Launched to prioritize water conservationand management in agriculture, PMSKY aims to expand irrigated areas.

It focuses on **More crop per drop"** by offering end-to-end water solutions, from source generation to delivery networks.

Way Ahead for Climate Smart Agriculture

- **Climatic Risk Assessment:** Identifying specific climatic risks is crucial, as different farms face varying challenges, tailored approaches are needed, considering factors like water shortages or frequent flooding.
- **Access to Technologies:** Ensuring access to climate-smart technologies is vital for small-scale farmers, Bridging the gender gap and reducing greenhouse gas emissions through better fertilizer use, water management, and livestock practices are essential.
- **Enabling Policy Integration:** Governments must design and implement policies that support CSA and incorporate it into national agricultural strategies and plans.
- **Promoting Knowledge and Capacity Building:** Encourage knowledge-sharing and build capabilities among farmers, extension workers, researchers, and policymakers through training programs and digital technology.
- **Research and Development:** Invest in R&D to understand climate change effects on agriculture and develop climate-resilient crop varieties, innovative cropping systems, and climate information service.
- **Advancing Climate-Smart Livestock Production:** Promote sustainable livestock management practices, such as improved feed efficiency, better waste management, and using climate-resilient cattle breeds

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HYDROPONICS MUSHROOM

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Introduction

Mushrooms are a diverse group of organisms belonging to the fungi kingdom. They are different from plants and animals and having unique characteristics and come in a wide variety of shapes, sizes and colors. Hydroponic mushrooms are growing mycelium without soil. Mushrooms, despite the fact that they do not have roots, can easily be grown in a standard hydroponic set-up. Hydroponic mushrooms grow quickly and are quite tasty. As a result of urbanization, industrialization and other causes soil-based agriculture is facing considerable issues.

Importance of mushroom farming

Mushrooms existed much before the man existence, as evidenced from the fossil records. They contain proteins, carbohydrates, fats, vitamins, mineral constituents and possess medicinal importance and antioxidant activity. The amount of protein present in mushroom depends upon the composition of substrate, size of pilus, harvest time and species of harvest. They contain certain essential amino acids which are found in animal proteins. The carbohydrate content of mushroom represents the amount of fruiting body accounting for 50-65% on dry basis. The mannitol, also called as mushroom sugar constituents about 80% of the total free sugars, hence it is dominant. Fat content is low in mushrooms compared to carbohydrates and proteins. The fats present in mushroom is dominated by the unsaturated fatty acids.

They are also one of the best sources of vitamin B. Fruiting bodies of mushroom are characterized by high level of well assimilated mineral elements.

Nutritional value per 100 g (3.5 oz)	
Energy	**113 kJ (27 kcal)**
Carbohydrates	4.1 g
Fat	0.1 g
Protein	2.5 g
Thiamine (vit. B_1)	0.1 mg (9%)
Riboflavin (vit. B_2)	0.5 mg (42%)
Niacin (vit. B_3)	3.8 mg (25%)
Pantothenic acid (B5)	1.5 mg (30%)
Vitamin C	0 mg (0%)
Calcium	18 mg (2%)
Phosphorus	120 mg (17%)
Potassium	448 mg (10%)
Sodium	6 mg (0%)
Zinc	1.1 mg (12%)
Percentages are relative to US recommendations for adults. Source: USDA Nutrient Database	

Importance of Hydroponic farming

Hydroponics is method of growing of plants without soil where they receive nutrients through water-based solutions. The absence of soil renders plants immune to soil borne illness, allowing them grow healthier and more nutrient rich crops. Advantages of hydroponics over conventional farming include higher yields, herbicide and pesticide free, adaptability and low contamination.

Steps in hydroponics farming

Hydro Mushroom Growing Set Up: A hydroponic mushroom set up must contain a tank filled with growing media and nutrients with proper aeration

Suitable Mushrooms for Hydroponic Mushroom Farming: Mushrooms like oyster, shiitake, nameko, lions mane, manitake, button, cinnamon cap and enokitake are suitable for hydroponic systems.

Growing Media for Hydroponic Mushroom Farming: The growing medium must contain all essential nutrients required for the crop to grow. Nutrients can be provided by mixing non-bleached flour with a media of perlite and vermiculite in the ratio of 50:50. Mushrooms synthesize the nutrients they want from organic materials. The most important nutrients required for their growth are starch, sugar, lignin, fats, proteins and nitrogen.

Climatic Requirements for Hydroponics Mushroom Farming: For the germination, the temperature should be 24-27˚C and 27-29˚C and the humidity should be maintained at 90% for better yield.

Harvesting: The mushrooms must be harvested by gently holding the caps with forefingers and slightly twisting them off.

Methods of growing hydoponic mushrooms

- Populating a growing medium with spores
- Using mushroom growing kit

Coco coir

Wheat Straw

Wood Shavings

Soya hulls

Populating a growing medium with spores

- Required mushroom species is selected
- Preparation of growing media : Sterile inert growing medium like perlite, vermiculite or a mixture of both is chosen
- Preparation of Spore Syringe: spore syringe containing spores of the selected mushroom species is procured
- Inoculation: Sterile environment for the inoculation process is selected and the spore solution is injected into the sterilized growing media using the syringe and the spores are spread evenly over the surface
- Sealing and Incubation: Container having inoculated medium is sealed and is placed in a dark, temperature controlled area for mycelium colonization. The mycelium will start spreading through the medium after few weeks.
- Transfer to the Hydroponic System: Once the mycelium is fully colonized, the medium is transferred to the hydroponic system ensuring the growing medium is fully submerged in nutrient solution.
- Harvesting: Mature mushrooms are harvested by cutting or twisting them off the growing medium

Mushroom growing kit

Mushroom growing kits are designed to ease the cultivation of hydroponics mushroom. The kit contains:

- Growing medium: A sterile and ready to use growing medium designed for hydroponics system (Perlite, Vermiculite etc.)
- Spore syringe or Spawn

- Nutrient solution or may provide instructions for preparing a nutrient solution
- Instructions on how to set up hydroponic system, inoculation process and harvest of mushrooms.
- Sterile environment supplies: Gloves, alcohol wipes, still air box which help to maintain a sterile environment during inoculation process
- Hydroponic Components: Depending on the kit, certain hydroponic system components like floating platforms or a deep water culture may be provided
- Mushroom species selection: Some kits offer a choice of mushroom species suitable for hydroponic cultivation

Merits of hydroponic mushroom farming

- Mushrooms are of high and consistent quality
- Higher and faster yield with low investments
- Space efficiency
- Reduced contamination
- Year round cultivation
- Reduced labor requirements

Conclusion

Hydroponic mushroom cultivation requires specialized knowledge and equipment and the success of hydroponic mushroom cultivation depends on proper management and maintenance of the system. Though hydroponic mushroom cultivation might seem a bit difficult to carry out, if familiarized, double profit amount can be earned in half the time, with higher quality mushrooms.

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ROLE OF SOIL HEALTH IN CROP YIELD ENHANCEMENT

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Introduction

Soil health is a vital aspect of agriculture that often goes unnoticed. It is the foundation of a thriving ecosystem, providing the necessary nutrients and environment for plants to grow. Healthy soil is rich in organic matter and beneficial microorganisms, which contribute to the fertility and structure of the soil. The health of the soil is not just about its chemical composition. It also includes its physical and biological properties. The soil's texture, structure, and water-holding capacity are all crucial factors that influence its health. Similarly, the presence of beneficial microorganisms in the soil plays a significant role in maintaining its health. A healthy soil ecosystem promotes the growth of robust and productive plants. It provides the necessary nutrients for plant growth, improves water infiltration and retention, and helps in pest and disease management. In contrast, unhealthy soil can lead to poor plant growth, reduced crop yield, and increased susceptibility to pests and diseases

Soil Health is important Because….

1. **Foundation of Agriculture:** Soil health serves as the cornerstone of agriculture. It provides the essential nutrients and environment necessary for plant growth. Think of soil as the very ground where the intricate dance of life in the agricultural ecosystem begins.

2. **Nutrient Availability:** Healthy soil ensures the availability of vital nutrients such as Primary, secondary, and trace elements (nitrogen, phosphorus, and potassium) These nutrients are fundamental for plant growth and development and lead to potential yield When soil is rich in

nutrients, plants can access what they need to thrive, resulting in robust growth and higher crop yields.

3. Water Retention: The ability of soil to retain water effectively is crucial for sustained plant growth. Healthy soil with good structure can hold onto water, ensuring that plants have a consistent water supply even during dry periods. Adequate water availability promotes optimal plant growth and development of plants and ultimately contributes to increased qualitative crop yields.

4. Pest and Disease Management: Healthy soil harbors a diverse array of beneficial soil-concerned microorganisms. These microorganisms play a vital role in controlling pests and diseases by either directly antagonizing harmful organisms or enhancing plant immunity. Consequently, healthy soil acts as a natural defense mechanism, reducing the risk of pest and disease outbreaks and safeguarding crop yield.

5. Soil Physical Properties: Soil texture and structure significantly influence its health. Different soil types have distinct properties that impact water infiltration, drainage, and root penetration. Understanding these physical properties allows farmers to implement appropriate management practices to optimize soil health and, consequently, crop yield.

6. Soil Chemical Composition: The chemical composition of soil, including factors like pH and nutrient levels, directly affects plant growth. Soil with imbalanced pH or nutrient deficiencies can hinder nutrient uptake by plants, leading to stunted growth and reduced yields. Therefore, maintaining proper soil chemistry through balanced fertilization and soil amendments is essential for maximizing crop productivity.

7. Soil Biological Activity: Beneficial microorganisms such as bacteria and fungi contribute to soil health by decomposing organic matter, cycling nutrients, and improving soil structure. Activities that disrupt soil biology, such as excessive use of chemical inputs, can harm these beneficial organisms and compromise soil health. Conversely, practices that promote soil biodiversity, such as organic farming methods, foster a thriving soil ecosystem conducive to high crop yields.

8. Sustainable Practices for Soil Health: Adopting sustainable farming practices is paramount for enhancing soil health and ensuring long-term agricultural productivity. Practices like crop rotation, cover cropping, and organic farming help replenish soil nutrients, improve soil structure, and mitigate erosion. By integrating these practices into agricultural systems, farmers can maintain soil health and sustainably increase crop yields.

9. Technological Innovations: Advancements in agricultural technology, such as precision agriculture, offer valuable tools for optimizing soil management. Precision agriculture utilizes data-driven approaches to precisely monitor and manage soil conditions, nutrient levels, and crop performance. By leveraging technology, farmers can make informed decisions that promote soil health and maximize crop yields while minimizing environmental impact.

10. Future Outlook: The future of agriculture hinges on our ability to prioritize soil health. As global population growth drives increased demand for food production, sustainable soil management practices will be essential for meeting this demand while preserving the integrity of our natural resources. Embracing innovation, research, and collaboration across the agricultural sector will be key to achieving a future where soil health sustains bountiful crop yields and supports food security worldwide

Conclusion

Soil health is paramount for sustainable agriculture and ensuring global food security. It serves as the foundation for a thriving ecosystem, providing essential nutrients, water retention, and pest management crucial for robust plant growth and high crop yields. By recognizing the interconnectedness of soil's physical, chemical, and biological properties, and implementing sustainable practices and technological innovations, we can enhance soil health and maximize agricultural productivity. The future of agriculture relies on our collective commitment to prioritizing soil health, fostering innovation, and embracing sustainable practices to meet the growing demand for food while safeguarding the environment for future generations.

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GREENING THE GAME A GUIDE TO SUSTAINABLE TURFGRASS MANAGEMENT

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Introduction

In the world of sports and leisure, the emerald carpets of turfgrass have long been synonymous with recreation and relaxation. Whether it's the lush greens of golf courses, the pristine pitches of soccer fields, or the manicured lawns of parks, turfgrass is an integral part of our outdoor spaces, Turfgrass plays a pivotal role in environmental sustainability, recreational activities, and community well-being. Its dense root systems prevent soil erosion, improve water infiltration, and sequester carbon, contributing to ecosystem health. Beyond its ecological benefits, turfgrass provides safe and versatile surfaces for sports, leisure, and outdoor gatherings, enhancing quality of life and promoting physical activity. Moreover, it serves as a natural cooling agent, mitigating the urban heat island effect and reducing energy consumption. As green spaces foster social interaction and mental well-being, turfgrass landscapes become integral components of vibrant and resilient communities, embodying the harmonious coexistence of humans and nature, Fortunately, a paradigm shift is underway in the realm of turfgrass management, driven by a growing awareness of environmental stewardship and a commitment to sustainability. From innovative techniques to eco-friendly products, the focus is shifting towards practices that promote healthy turf while minimizing harm to the environment.

Understanding Sustainable Turfgrass Management

Sustainable turfgrass management includes a holistic approach that considers the long-term health of the soil, environment, and surrounding ecosystems.

It goes beyond mere aesthetics, aiming to strike a balance between human recreation and ecological preservation

Key principles include which are include to sustainable management of turf grass

1. Soil Health - Healthy soil is the foundation of sustainable turfgrass management, Practices such as aerating, topdressing, and incorporating organic matter improve soil structure, water retention, and nutrient availability to the plants in an effective manner it all rely on soil health condition

2. Water Conservation - In an era of increasing water scarcity, efficient water management is paramount. Technologies like soil moisture sensors, drip irrigation, and rainwater harvesting help minimize water usage while maintaining turf quality.

3. Integrated Pest Management (IPM) - Rather than relying solely on chemical pesticides, IPM emphasizes preventive measures, cultural practices, and biological controls to manage pests and diseases, this reduces reliance on harmful chemicals and promotes a balanced ecosystem.

4. Renewable Energy - Adopting renewable energy sources, such as solar-powered equipment and electric mowers, reduces greenhouse gas emissions and minimizes reliance on fossil fuels.

5. Native Plant Integration - Incorporating native plant species alongside turfgrass enhances biodiversity, supports pollinators, and reduces the need for fertilizers and pesticides.

Innovative Practices in Sustainable Turfgrass Management

1. Precision Agriculture - Utilizing GPS technology and data analytics, precision agriculture optimizes inputs such as water, fertilizer, and pesticides, leading to more efficient resource utilization and reduced environmental impact.

2. Bio stimulants - Derived from natural sources such as seaweed, humic substances, and beneficial microorganisms, biostimulants enhance turfgrass health, resilience, and stress tolerance without the use of synthetic chemicals.

3. Smart Turfgrass Breeding - Researchers are developing drought-tolerant, disease-resistant turfgrass varieties through selective breeding and genetic engineering, reducing the need for water and chemical inputs.

4. Grasscycling - Instead of bagging and disposing of grass clippings, grass cycling involves leaving them on the lawn to decompose, returning valuable nutrients to the soil, and reducing waste.

The Benefits of Sustainable Turfgrass Management

1. Environmental Conservation - By minimizing water usage, chemical inputs, and habitat destruction, sustainable turfgrass management contributes to biodiversity conservation and ecosystem health.

2. Cost Savings - While initial investments in sustainable practices and equipment may be higher, long-term savings are realized through reduced water bills, lower input costs, and decreased maintenance requirements.

3. Enhanced Community Well-being - Green spaces promote physical activity, mental health, and social cohesion, enhancing the quality of life for communities.

4. Regulatory Compliance - With increasing regulations aimed at protecting water quality and biodiversity, adopting sustainable turfgrass management practices helps organizations comply with environmental laws and regulations.

Conclusion

In an era of climate change and environmental degradation, the adoption of sustainable turfgrass management practices is no longer just an option—it's a necessity. By prioritizing soil health, water conservation, integrated pest management, and innovative technologies, we can ensure that our green spaces remain vibrant and resilient for generations to come. Whether on the golf course, soccer field, or backyard lawn, let's work together to green the game sustainably.

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EMPOWERING WOMEN: THE VITAL ROLE IN ENSURING FOOD AND NUTRITIONAL SECURITY

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Introduction

Food and nutritional security are fundamental pillars of human well-being and development, contributing to overall health, economic productivity, and societal stability. The attainment of food and nutritional security is not only a matter of adequate food production but also hinges on equitable distribution, access, and utilization. In this context, women play a pivotal role as key agents in achieving sustainable food systems and ensuring the nutritional well-being of communities worldwide.

The Multi-faceted Contributions of Women

Primary Food Producers: Women make up a significant portion of the agricultural workforce in many regions, particularly in developing countries. They are responsible for various tasks along the food production chain, from planting and harvesting crops to tending livestock. Their contributions are essential for increasing agricultural productivity and ensuring a stable food supply.

Nutrition Knowledge and Practices

Women often possess valuable traditional knowledge related to food preparation, preservation, and dietary practices. They play a critical role in shaping household diets, ensuring balanced and diverse meals that contribute to the overall nutritional well-being of family members.

Food Processing and Value Addition

Women are actively engaged in food processing and value addition activities, such as milling, fermentation, and preservation. These practices not only enhance the shelf life of food but also increase its nutritional value, making it more accessible and beneficial to communities.

Community Health Workers

Many women serve as community health workers, promoting hygiene, sanitation, and proper nutrition. Their role in educating and raising awareness within their communities can lead to improved health outcomes and better nutritional practices.

Seed Preservation and Biodiversity

Women have been guardians of traditional seed varieties and biodiversity, ensuring the preservation of unique and resilient crop strains. This contributes to the overall resilience of food systems in the face of environmental challenges.

Challenges and Empowerment

Despite their critical contributions, women often face numerous challenges that limit their ability to fully participate in ensuring food and nutritional security:

Limited Access to Resources

Women frequently have limited access to land, credit, and agricultural inputs, hampering their potential to engage in productive farming activities.

Unequal Decision-making Power

Gender disparities in decision-making processes related to food production, distribution, and household expenditures can hinder the adoption of more equitable and nutritious food practices.

Time and Workload

Women's multiple roles, including household chores and caregiving responsibilities, often leave them with less time and energy for income-generating activities or accessing education and training.

Lack of Education

Limited access to education can prevent women from accessing valuable information on nutrition and agriculture impeding their ability to make informed choices for their families.

Climate Change Vulnerability

Women are disproportionately affected by climate change, which can disrupt agricultural patterns, reduce yields, and impact food security.

Empowering women is crucial to overcoming these challenges and harnessing their full potential in ensuring food and nutritional security

Access to Resources

Providing women with access to land, credit, and modern agricultural technologies can enhance their productivity and income-generating opportunities.

Education and Training:

Offering training in sustainable agricultural practices, nutrition, and financial literacy can empower women to make informed decisions and adopt more resilient farming methods.

Gender-sensitive Policies

Governments and organizations must implement policies that promote gender equality, recognize women's contributions, and ensure their active participation in decision-making processes.

Supporting Women Entrepreneurs

Encouraging women to engage in food processing, value addition, and entrepreneurial activities can enhance food availability and diversity in local markets.

Climate Resilience

Integrating gender-sensitive approaches into climate change adaptation strategies can help women and their community's better cope with environmental challenges.

Conclusion

The role of women in ensuring food and nutritional security is multifaceted and indispensable. Recognizing and addressing gender disparities in agriculture, nutrition, and related sectors is crucial for achieving sustainable development goals and building resilient food systems. Empowering women with education, resources, and opportunities will not only contribute to improved food security but also promote healthier communities and a more equitable world.

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HAPLOTYPE: MAGNIFYING THE GLORY OF VARIATION IN CROP IMPROVEMENT

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Introduction

Genetic variation serves as a cornerstone in crop improvement efforts, offering opportunities to select and enhance desirable traits. However, the conventional method of directional selection based solely on phenotype poses a threat by potentially erasing crucial alleles from the gene pool. To address this challenge, molecular markers such as SSRs, InDels, and SNPs have emerged as valuable tools for resolving genetic variation.

Single Nucleotide Polymorphisms (SNPs)

Single Nucleotide Polymorphisms (SNPs) stand out among molecular markers due to their widespread distribution, abundance, amenability, and ease of detection. Despite these advantages, SNPs are typically biallelic, which limits their ability to fully capture the complexity of SNP-trait relationships and results in lower per-marker information content.

To overcome the limitations of SNPs and enhance the allelic resolution of candidate genomic regions, researchers have turned to haplotypes. Haplotypes represent specific combinations of nucleotides or markers inherited together within the same chromosome segment. The combination of multiple tag SNPs forms a haplotype block, characterized by minimal recombination and strong linkage disequilibrium.

The construction of SNP blocks and the preparation of HAPMAP facilitate a clearer understanding of haplotype structures and their associations with phenotypic performance. Haplotype-based approaches have proven effective in crop improvement programs, with superior haplotypes identified based on significantly higher average phenotypic performance compared to other haplotypes.

Genome-wide association studies (GWAS)

In genome-wide association studies (GWAS), the identification of rare alleles associated with extreme phenotypes can be challenging. However, GWAS-based haplotype analysis offers a promising solution to this issue, enabling the discovery of rare alleles that may have been overlooked using conventional methods.

Multi-trait Haplotype Approach

For phenotypically challenging traits, such as root characteristics, the Multi-trait Haplotype Approach, in the context of selective sweeps, emerges as a powerful tool for target selection. Varshney et al. (2005) highlighted the immense potential of haplotypes for whole-genome selection based on comprehensive haplotype maps.

Furthermore, recent research has underscored the significance of haplotype x haplotype interactions in influencing various agronomic traits, highlighting the intricate interplay between genetic factors. By leveraging haplotype-based approaches, breeders can gain deeper insights into the genetic basis of complex traits and develop more effective strategies for crop improvement.

Conclusion

The integration of haplotype-based approaches offers a promising avenue for enhancing crop breeding efforts, enabling the selection of superior traits and the development of more resilient and productive crop varieties

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DEVELOPMENT OF IFS MODULE AND POPULARIZATION OF FISH CUM DUCK FARMING IN NORTH TRIPURA DISTRICT

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Introduction

The farmers of North Tripura district are mainly associated with traditional fish culture methods like culture of Indian Major Carps, exotic carps and few other minor carps in traditional way under normal fish culture activities. The earnings from this type of traditional fish culture practices are less compared to culture of high value commercial fish species. Moreover, in this part of the country, more or less every village house is having some livestock animal like poultry birds, cattle, ducks, goats etc. which are reared to meet the household requirements of farm family and little excess are being sold to the nearby market. There is very little knowledge about Integrated farming system among the farmers of this region. Keeping this in mind, development of IFS module (Fish cum Duck farming) appeared to be an innovative as well as high earning source of fish culture practice in this district.

Integrated Farming System (IFS) is an interdependent, interrelated often interlocking production systems based on few crops, animals and related subsidiary enterprises in such a way that maximize the utilization of nutrients of each system and minimize the negative effect of these enterprises on environment. The interrelated, inter-dependent-interlocking nature of IFS involves the utilization of primary produce and secondary produce of one system, as basic input of the other system, thus making them mutually integrated as one whole unit. Primary goals of IFS are-

- Maximization of yield of all component enterprises to provide steady and stable income at higher levels.
- Rejuvenation/amelioration of systems productivity and achieve agro ecological equilibrium.
- Control the built-up of insects-pest, diseases and weeds population through natural cropping system management and keep them at low level of intensity.
- Reducing the use of chemical fertilizer and other harmful agrochemicals and pesticides to provide pollution free, healthy produce and environment to the society at large.
- Increase in natural resource use efficiency by early recycling of nutrients.
- Mitigation of negative impact of agriculture or livestock on environment.

Advantages of Duck cum Fish Culture

Raising ducks over fishponds fits very well with the fish polyculture system, as the ducks are highly compatible with cultivated fishes. The system is advantageous to farmers in many ways:

- Ducks fertilize the pond by their droppings when given free range over the pond surface. Ducks have been termed as manuring machines for their efficient and labour-saving method of pond manuring, resulting in complete savings on pond fertilizer and supplementary fish feed which accounts for 60 per cent of the total cost in conventional fish culture.
- Ducks keep water plants in check.
- Ducks loosen the pond bottom with their dabbling and help in release of nutrients from the soil which increases pond productivity.
- Ducks aerate the water while swimming; thus they have been biological aerators.
- Duck houses are constructed on pond dikes; hence, no additional land is required for duckery activities.
- Ducks get most of their total feed requirements from the pond in the form of aquatic weeds, insects, larvae, earthworms, etc. They need very little feed, and farmers normally give kitchen wastes, molasses and rice bran, for the purpose.

Intervention

An innovative approach was undertaken by Krishi Vigyan Kendra North Tripura for development of Fish cum Duck farming with Indian major carps and khaki Campbell variety of

Duck among the special interested groups of farmers in different places of North Tripura district. Under this activity at first beneficiaries were selected based on their interest and two numbers of training programmes were conducted by KVK among the interested farmers.

Technology: Duck cum fish culture

30 nos. ducklings of 25 days old were given to 4 nos. farmers at Chandrapur GP under Dharmanagar Sub-Division under KVK-OFT (F.Y.- 2015-16). Also, 2000 nos. fish seed / trial were distributed. Area per trial was 0.16 ha, Culture period was 10 months.

Name of Beneficiaries

1. Smt. Babli Rani Deb. W/o- Subrata Deb.
2. Sri Siddharta Bhattacharjee. S/o- Lt. Sudhir Bhattacharjee.
3. Sri Dipan Paul. S/o- Darpa Chandra Paul.
4. Sri Bijit Paul. S/o- Bijoy Krishna Paul.


Fig: Duckling distribution under Duck cum fish culture demonstrations in Chandrapur, GP.


Fig: Duckling distribution under Duck cum fish culture demonstrations in Chandrapur GP.

Result: (In trial ponds with Khaki Campbell ducks)

a) Duck meat Yield: 35kg/unit (30 ducks per unit & on an avge.14 were male)

b) Fish Yield: 1980 kg/ha

c) Egg laying: 1200 no. egg/ trial (avge.)

d) B:C Ratio (GR/GC): 4.15

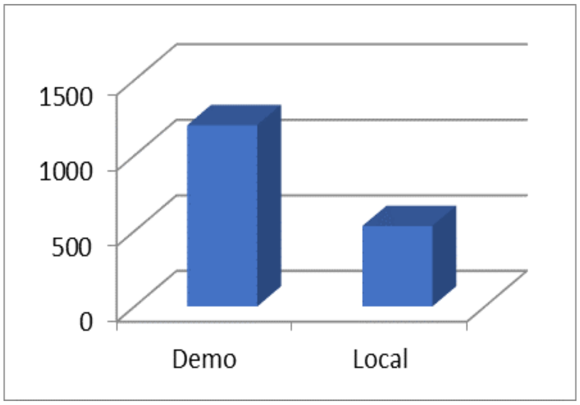
Result: (Control ponds with normal fish culture methods and local variety of ducks)

a) Fish Yield- 1300 kg/ha

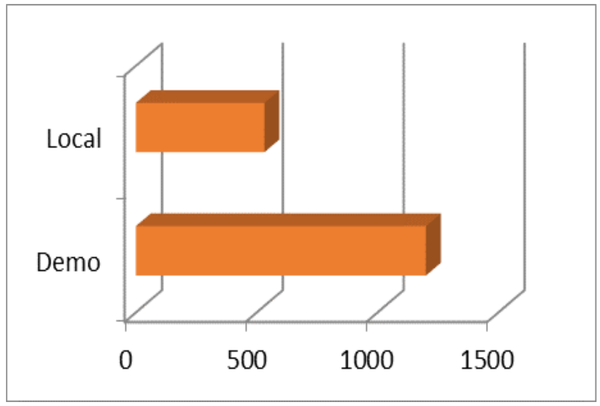
b) Duck meat yield- 32kg/unit

c) Egg laying - 532 no. egg/ unit

d) B:C Ratio (GR/GC): 2.12



Graph showing Change in total fish yield



Graph showing Change in total Egg Production

Fig: Harvesting of Fish and Duck from Duck cum fish culture Demonstration unit.

Impact of the Technology

The inputs like duckling, Pelleted fish feed and fish fingerling were distributed free of cost to the farmer under the trial. Cost of preparing duck house was barred by the farmers themselves. After 6 months female ducks started laying eggs and on an average 14 nos. ducks turned out to be male among the supplied 30 duckling to each farmers. The male ducks were sold out by the farmers when those turned 2 kg and above. The duck eggs were marketed at nearby Dharmanagar city market at a reasonable price. Two of the progressive farmers namely Sri Bijit Paul and Dipan Paul among this farmers group had kept 50 eggs separately and hatched them out to have a fresh stock of ducklings to be reared for next year in their own pond by their keen effort.

The demand of the duck meat as well as duck egg was high, the duck eggs were sold @ Rs. 4.00 / piece and duck meat were sold @ 200.00 / kg. Fishes were sold on an average @ Rs.150.00- 200.00. They received average net income of around Rs. 64,100/ 0.16 ha which was much higher compared to normal fish culture practice which was around Rs. 17,000/ 0.16 ha.

After the great experience with the Duck cum fish farming practice under the supervision of KVK North Tripura, those farmers also started sharing all of their experiences and related information about the benefit of integrated Duck cum fish farming with their neighbours & also other farmers of North Tripura.

Impact and Horizontal expansion

Similarly Duck cum fish culture was started in South Padmabil GP, West Panisagar GP and Uptakhali GP in the next financial years under Panisagar Sub division under North Tripura District among the different interested farmer's groups which showed great results and adoption among the rural farmers of the District. This in turn improved their livelihood and socio economic status like other parts of India.

Fig: Duckling distribution under Duck cum fish culture demonstrations in South Padmabil GP which is a part of popularizing this technology all over the District for it widespread horizontal expansion.

Conclusion

This Duck cum fish culture technology can also be replicated using local duck variety in case of unavailability of Khaki Campbell variety of duckling, but it will give lesser profit compared to the earlier one. Of late more and more farmers are coming frequently in the KVK North Tripura office for taking training and gathering knowledge about the benefits of Duck cum fish farming and about other integrated fish farming as well. This shows the wide and horizontal expansion of this culture technology among the rural fisher folk of this District.

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