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6th International Conference on Advances in Agriculture Technology and Allied Sciences

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Preface

Vigyan Varta An International E-Magazine for Science Enthusiasts (E-ISSN: 2582-9467) is an online multidisciplinary magazine covering all the domains of science. It publishes all types of writings including popular articles, newsletters, meeting reports, success stories, etc. that undergo a peer review by the strong editorial team that we have. It had its inception in May, 2020 and has successfully completed 3 volumes with 12 issues each year. Currently, the magazine is in its 4th volume and apart from publishing articles, our magazine has also conducted skill development workshops and webinars for the academic community. Vigyan Varta has a vision of creating and developing scientific writing skills and acumen among young researchers.

It's a privilege for us to collaborate and bring out our first special issue in the 6th International Conference on Advances in Agriculture Technology and Allied Sciences (ICAATAS 2023) in Hybrid Mode (Online & Offline) (June 19-21, 2023) organized by organized by the Society of Agriculture Research and Social Development (New Delhi) & Loyola Academy, Secunderabad, Telangana. The conference has given notable insights on varied topics of agriculture and allied sciences and has enabled scientists, students, researchers and academicians round the country and abroad to bring their work to the forefront.

This special issue highlights articles from diversified fields of agriculture and gives a concise overview of innovative topics to the readers.

We are happy that ICAATAS 2023 has given us a chance to be its media and publication partner and help in popularising the art of writing popular articles among the scientific community. We look forward to more such informative and insightful special issues in future as well.

Happy Learning!!

Jai Hind.

Suvangi Rath

Miss Suvangi Rath
Founder-Editor & Proprietor
Vigyan Varta

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Transgenics and Cisgenics in Vegetable Crops

Y Sravani[1], Dr. E. Padma[2] and Dr. K. Usha Kumari[3]

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ABSTRACT

Transgenic and cisgenic are two techniques used in plant breeding to introduce new traits or modify existing traits in plants. Transgenics refers to the process of transferring genetic material from one species to another. This can be accomplished through various methods, such as recombinant DNA technology or direct microinjection of DNA into cells. The resulting organism is known as a transgenic organism or genetically modified organism (GMO). The goal of transgenics is often to introduce a new trait into an organism that it did not naturally possess. It is important to thoroughly assess the risks and benefits of transgenics before introducing new technologies into the environment. Cisgenics is a term used in plant breeding to describe the process of creating new plant varieties through conventional breeding methods, such as cross-pollination or hybridization, within the same species or closely related species. In other words, it involves the transfer of genes from one individual to another within the same or closely related species, without the introduction of genes from other species. Cisgenics is considered a safer and more acceptable alternative to transgenics. In conclusion, both transgenic and cisgenic techniques have their own unique applications and advantages in plant breeding. While transgenic techniques can introduce

new traits from other species, cisgenic techniques can introduce new traits within the same species, making them a more targeted and precise approach to plant breeding.

INTRODUCTION

One third of the children are born malnourished and half of children are underweight. One third of the adult population has a Body Mass Index (BMI) of below 18.5, one of the worst in the world. To feed 9 billion people in 2050, we urgently need to adopt the most efficient techniques. Yes, by integrated gene management (Nothing but Plant breeding) i.e., Introduction, Selection, Hybridization, Mutation, Tissue culture and Genetic engineering (Transgenics and Cisgenics).

Transgene is a gene from a non-crossable species or it is a synthetic gene. It represents a new gene pool for plant breeding.

Cisgene is a natural gene from a crossable and sexually compatible plant. Such gene includes its introns and is flanked by its native promoter and terminator in the normal sense orientation.

Steps involved in genetic engineering

Isolation of the gene of interest
⇓
Formation of recombinant DNA
⇓
Introduction of r-DNA into a suitable host
⇓
Integration of gene into the plant cell genome
⇓
Regeneration of genetically modified cells

Achievements in transgenics

- In Oct. 2009- GEAC cleared Bt Brinjal for commercialization in India
- In 2013 – Bt brinjal released for commercial cultivation in Bangladesh
- In Oct, 2022 – Bt brinjal approved for commercial cultivation in Philippines

A. Transgenic for biotic resistance

Bt Brinjal - Bt brinjal is a transgenic brinjal created by inserting a gene cry1Ac from the soil bacterium Bacillus thuringiensis subsp. kurstaki strain HD73 through Agrobacterium mediated gene transfer into brinjal by cocultivating cotyledonary explant, resulted in the development of a plant resistant against lepidopteran

B. Transgenic for Abiotic Stress Tolerance

- Transgenic tomato expressing the Arabidopsis CBF1 gene showed enhanced resistance to drought and chilling stresses (Grover *et al*., 2003)
- At CPRI Shimla, Scientists has been transferred a tobacco osmotin gene to several potato cultivars to improve tolerance to water stress (Chakraborty *et al*.,2003)
- Salinity resistant transgenic potato developed by inserting glyceraldehyde-3-phosphate-dehydrogenase (GPD) gene from oyster mushroom into potato plant genome (Jeong *et al.*, 2001)

C. Transgenic Vegetables with Herbicide Resistance

- A gene (aroA) coding for a glyphosate tolerant has been introduced into tomato plants and reported up to 3 times more tolerant to glyphosate (Botterman and Leemans,1998)
- The bxn gene coding nitrilase enzyme from Klebsiela pneumoniae was transformed in tomato which detoxify bromoxynil herbicides

D. Transgenic for reducing post-harvest loss

Flavr savr tomato- This was the first "genetically modified" food developed by Calgene American company approved by the FDA in 1994.

E. Transgenic for nutritional quality - Transgenic Orange Cauliflower with High β-Carotene

- Orange cauliflower developed by transferring Or mutant gene
- It has a high nutritional value and visual impact with bright orange curds.
- Orange cauliflower contain 31.3µg/g dry weight β-carotene where as control only 2.9

CISGENICS - "A SUSTAINABLE APPROACH FOR VEGETABLE CROP IMPROVEMENT"

Cisgenesis - Cisgenesis is described as specific alleles/genes in the breeder's gene pool are introduced into new varieties without the accompanying linkage drag (co-transfer of DNA sequences that are linked to the gene of interest) which occurs in conventional breeding.

Applications of cisgenesis

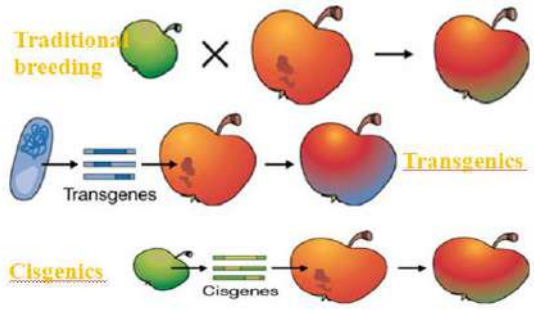
- Intra- specific hybridization
- MAS
- Male sterile line
- Disease resistance varieties
- Improvement of quality
- Tolerance for abiotic stress
- Best tool for vegetatively propagated crop improvement
- Gene pyramiding
- Cultivars for organic cultivation

How Cisgenic differs from Transgenic and Conventional breeding?

Cisgenesis: Cisgenesis is the genetic modification of a recipient plant with a natural gene from a crossable—sexually compatible—plant. Such a gene includes its introns and is flanked by its native promoter and terminator in the normal sense orientation.

Transgenesis: Transgenesis is the genetic modification of a recipient plant with one or more genes from any non-plant organism, or from a donor plant that is sexually incompatible with the recipient plant.

Traditional breeding: Encompasses all plant breeding methods that do not fall under current GMO regulations.



CONCLUSION

Transgenics- Genetically-modified foods have the potential to solve many of the world's hunger and malnutrition problems, and to help in protect and preserve the environment by increasing yield and reducing reliance upon chemical pesticides and herbicides. Yet there are many challenges in the areas of safety testing, regulation, international policy and food labeling. However, we must proceed with caution to avoid causing unintended harm to human health and the environment as a result of our enthusiasm for this powerful technology.

Cisgenics - Breeding of crops using traditional sources of genetic variation by cisgenesis can speed up the whole process dramatically, along with usage of existing promising varieties. This is specifically case with complex (allo) polyploids and with heterozygous, vegetative propagated horticultural crops.

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Blue Tea: A Magic Tea

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Blue tea, Beverage, Health benefits

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ABSTRACT

Blue tea is mainly a flower-based tea. It is a unique herbal beverage derived from the butterfly pea plant (Clitoria ternatea), that is a tropical herbal plant native to countries viz. Thailand, Malaysia, and Vietnam; and have been used for centuries in traditional ayurvedic and medicine. Blue tea gained popularity because of their cultural significance, visual appeal, and specially health benefits. This blue colour tea is a caffeine-free beverage for that it is used as antioxidant activity, neurogenic potential, antimicrobial activity. It is promoting healthy hair and skin, supporting brain health, aiding digestion and reducing inflammation. For its colour changing properties it is also called as Magic tea. Overall blue tea represents a blend of cultural tradition, visual allure, and potential wellness benefits in today's health-conscious society.

INTRODUCTION

Tea holds a special place in many people's lives, whether as a daily ritual, a source of comfort, or a social gathering and some tea play a significant role in human's health with different flavour. Different types of tea, like Green tea, Black tea, White tea are available in market with several health benefits. Tea lovers all around the world have been enthralled with blue tea, also known as butterfly pea flower tea, which has emerged as an intriguing and aesthetically attractive brew. Blue tea, which is made from the petals of the Clitoria ternatea plant, is a visual treat thanks to its captivating blue hue. It has been prized for generations in Southeast Asia for both its aesthetic appeal and medicinal qualities. Its origins can be found there. The distinctive blue hue of the tea is attributed to the presence of anthocyanins, which are natural pigments that also support the tea's potential health benefits. Blue tea holds cultural significance in nations like

Thailand, Malaysia, and Vietnam and is traditionally used to create vibrant desserts and beverages. Blue tea gained popularity for their potential application on both modern medicine and agriculture and as a source of natural food colorants and antioxidants. The aroma of brewed blue tea is delicately flowery with hints of earth. Its flavour characteristic is delicate and energizing, frequently referred to as mildly woody or green tea-like. Some tea drinkers like to enhance the flavour of their tea by adding a squeeze of lemon or some honey.

Importance and Uses:

Blue tea has gained significant importance and recognition for its various uses and benefits. Here are some key aspects that highlight the importance and versatile uses of blue tea:

1. **Visual Appeal:** The alluring blue hue of blue tea is one of the main factors contributing to its appeal. The vivid colour gives foods, drinks, and artistic endeavours a touch of visual attraction. Blue tea is frequently used to give foods, pastries, and drinks an aesthetically appealing and whimsical touch.

2. **Applications in Culinary Arts:** Blue tea has established itself as a natural food colouring agent in the field of culinary arts. It can be used to colour rice, noodles, pastries, and other foods, resulting in presentations that are both aesthetically pleasing and Instagram-worthy. Blue tea is frequently used by chefs and food aficionados to experiment with novel recipes and infuse their culinary creations with a bit of imagination.

3. **Health Benefits:** Blue tea is well known for its potential health advantages. Antioxidants found in abundance in it aid in the fight against free radicals and shield the body from oxidative stress. Additionally essential to preserving general health and wellbeing are antioxidants. Due to its propensity to increase collagen, blue tea is thought to have anti-inflammatory characteristics and is linked to maintaining healthy hair and skin.

4. **Traditional and Herbal Medicine:** Blue tea has been used for its therapeutic effects in traditional medical procedures. Due to its calming qualities, it is frequently used as a natural cure for stress and anxiety. Blue tea is used to improve the function of the liver and kidneys and is said to have cleansing effects. It has also been utilized to encourage good digestion and as a diuretic.

5. **Mixology:** In the field of mixology, blue tea has become a popular ingredient. Blue tea is used by mixologists and bartenders to make visually appealing and reviving cocktails and mocktails. Its striking blue hue adds a distinctive and captivating aspect that improves the drinking experience as a whole.

6. **Natural Dye:** Fabrics, papers, and other objects can be dyed naturally using the rich blue hue of blue tea. It is an environmentally safe substitute for synthetic dyes and gives different artistic and craft projects a unique and lovely touch.

The significance and applications of blue tea are widespread in the culinary, health & wellness, mixology, and creative industries. It is adored and sought-after as an ingredient in many different applications due to its vivid colour, potential health advantages, and adaptability. Blue tea continues to amaze and inspire people all around the world, whether it is for aesthetic appeal, flavour enhancement, or well-being promotion.

Preparation of Blue tea:

Blue tea is mainly mild, smooth and refreshing. Preparation of blue tea from butterfly pea flower is a simple process, which is given below.

1. Start by bringing water to a boil in a kettle or pot. In the same manner as other teas, blue tea is normally made with hot water.

2. Measure the necessary quantity of dried butterfly pea flowers for the blue tea while the water is still boiling. Use 1 teaspoon of dried flowers per 8 ounces (240 ml) of water as a basic rule of thumb. Depending on whether you prefer a stronger or milder brew, change the amount.

3. Steep the Flowers: Place the dried butterfly pea flowers in a teapot or other heat-resistant container after the water reaches the desired temperature (about 195-205°F or 90-96°C). After adding the boiling water to the flowers, let them steep for five to seven minutes. The steeping time can be changed to achieve your desired strength of tea.

4. Use a fine-mesh strainer or a tea infuser to strain the tea to get rid of the petals after the steeping period. A vivid blue infusion will be the end product. A few drops of lemon juice can be added to the tea to change the colour to a vibrant purple if you'd prefer a brighter tone.

5. Blue tea can be drunk on its own or with optional additions, depending on your preferences. To improve the flavour, some individuals like to add a squeeze of lemon or a drizzle of honey. To suit your personal preferences, feel free to try out various additions.

6. Pour the freshly brewed blue tea into mugs or teacups, and take pleasure in its exquisite appearance and distinctive flavour. For a refreshing tea experience, blue tea can be served hot or chilled over ice.

Remember that based on your preferences and the particular brand or kind of blue tea you are using, the brewing time and water temperature may vary slightly. For the best brewing results, it's always a good idea to follow the directions on the package.

Market Value and Case Study:

Market values can fluctuate on various factor, such as Demand, supply, consumer preference and economic conditions. In India some of Farmers, young entrepreneur, and tea gardens are jointly tried to grow this business a high level. Here are some case studies.

1. In West Bengal, A tea garden (Rungpur Tea association Ltd.) which is situated on Alipurduar, they started Blue tea processing and selling this product. They are producing more than 35 varieties of tea and blue tea is different and unique one. From this tea garden, the products reach different parts of India. The name of the tea is ‘Blue pea Butterfly Green tea’. Firstly they cultivated this butterfly pea flower in their own garden and using 100% organic manures. At first, they collect butterfly pea flower from the garden and sterilized it 3 times then Blend all the dried flowers. After that mixed it with green tea is being marketed. They started this tea from 2022. They sell this product with purity and proper license. This blue tea is filled with health benefits, so it’s much costly than other teas.

2. In Gobardanga, West Bengal, A farmers group started to supply dried butterfly pea flowers for blue tea and this is very helpful for farmers mainly. A big Flowers market is located there and everyday a lot of flowers are wasted. Then they decided to recycle this flower in different process. They contact with a company and started to supply the flower which is main ingredient of blue tea. They collect butterfly pea flower from the market and farmer’s also and then washed and picked the flower. Then it is dried in the Sun and in rainy season they used machine and after processing the selling it all over

3. India. They started it from 2018. 15 kg fresh flower is required for 1 kg dried flower. At first they supplied dried flower and now they started to supply dust flower also with proper packaging. A lot of local people involved with this business and it generates local income.

4. In India, two young entrepreneurs started a brand 'Blue Tea', producing and selling Blue tea from 2018. They sell their products through online all over India. At first they collected the butterfly pea flower then dried it and market it in teabag form. They sell 10 flavors of Blue tea. Their sell is approx. 10 crore (2022). The conservation of blue tea covered 60% in USA. They claim that Blue tea is in special demand in foreign countries.

CONCLUSION:

In conclusion, blue tea has become more popular due to both its possible health benefits and its high market value. Blue tea, which is high in antioxidants, provides a healthy strategy to fight free radicals and advance general wellbeing. Its increased commercial appeal reflects the expanding desire for distinctive beverages with eye-catching packaging. Blue tea continues to enthral tea lovers and carve a niche in the ever-evolving tea industry thanks to its diversity in culinary applications, wellness associations, and growing consumer interest. Blue tea represents a harmonious union of aesthetic appeal and wellness promotion. While scientific research on blue tea is limited, it is important to note that more research is needed to fully understand its effects on human health. As with any herbal tea or supplement, it is advisable to consult with a healthcare professional before it incorporating it into your routine.

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Present Status and Prospects of Inland Fisheries in Telangana

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ABSTRACT

Telangana, the 29th state of India, came into existence in 2014 through a process of bifurcation. Though the state is landlocked with no coastal line, it is the third largest inland water resource territory in the country where only inland fish production exists. The total water spread area in the state is 6.55 lakh hectares comprising of 88 reservoirs, 4,623 fisheries departmental tanks, and 19,926 Gram panchayat tanks. The state recorded 3.37 lakh tonnes of fish production in the year 2020. District with highest fish production Nalgonda. Semi-intensive pond aquaculture, cage culture, and recirculatory aquaculture system (RAS) various technologies adopted in Telangana for rearing of fish.

INTRODUCTION

Fish is a critical source of protein and nutrition for millions of people. Global fisheries and aquaculture production178 million tonnes in 2020. India is the third largest producer of fish and second largest producer of inland fish in the world after China. The total water spread area was 82,46,662.17 hectare (2017-18). Total fish production was 12.59 MMT (2017-18).

Telangana is blessed with huge and diverse water bodies for aquatic resources which are

utilized by the rural people for their livelihood and acquiring employment and playing a crucial role in meeting the growing demand of fish (Suresh, 2018).Documenting the district wise status of freshwater resources, production and various technologies adopted for rearing of fish in the state of Telangana provides a foundation for evidence-based decision-making for policy makers regarding renovation of water bodies, protection, and promotion of fish population. In this context the present study was conducted to study inland freshwater resources, fish production and technology used in rearing of fish in Telangana.

Materials and Methods:

Secondary data related to district wise fish production, water spread area and various technology adopted for fish rearing for state of Telangana were collected from Department of Fisheries, Telangana.

Analytical Tools:

1. Tabular Analysis

Tabular method using percentages and averages were adopted to interpret the data collected for various parameter like water spread area, fish production and various technology used for rearing of fish in the state of Telangana.

2. Annual growth rates

Annual growth rates were calculated to analyse the growth rate of inland fish production in the state of Telangana.

The percentage change from one period to another is calculated from the following formula.

$$PR = \frac{V_{present/future} - V_{past/present}}{V_{past/present}} X\ 100$$

Where,

PR = per cent change

V present/future = present or future value

V past/present = past or present value

The annual percentage growth rate is calculated by dividing the per cent growth divided by the number of years, N.

Results and Discussion:

1. Fresh water resources in Telangana

Telangana, a state in southern India, is home to numerous water bodies, including reservoirs, fisheries departmental tanks, and gram panchayat tanks leased to fishermen cooperatives. According to Table 1.1, the total water spread area in Telangana is 6,55,005 hectares, distributed across 88 reservoirs, 4,623 fisheries departmental tanks, and 19,926 Gram panchayat tanks. Among these, Nalgonda district has the highest water spread area of 53,200 hectares.

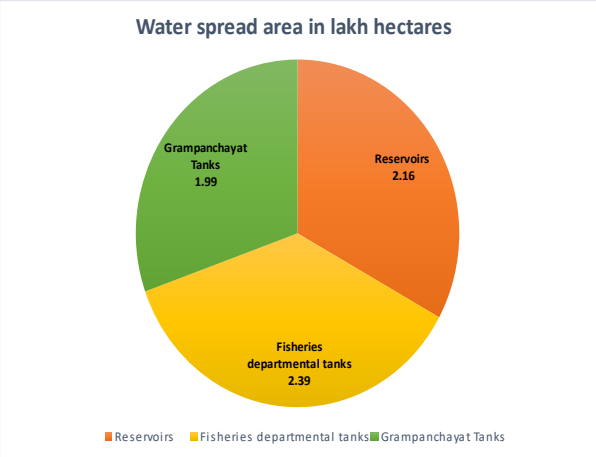

Figure 1: Water spread area under various water resources in Telangana state

To promote the fisheries sector in the state, the Telangana government has taken up the massive renovation of tanks. This offers further opportunities for fisheries and can contribute to the overall development of the sector.

Table 1.1. District wise water spread area in Telangana

Sl. No.	District	Reservoirs			Dept. Tanks		GP Tanks		Total Area
		No. of Reser Voirs	Area (ha)	No. of Tanks	Area (ha)	No. of Tanks	Area (ha)	No. of Tanks	Area (ha)
1	Nalgonda	9	23,870	215	19,833	564	9,497	788	53,200
2	Nirmal	5	24,050	158	6,917	476	13,462	639	44,429
3	Nizamabad	1	16,720	347	16,853	548	7,586	896	41,160
4	Suryapet	2	8,610	202	14,339	1,057	11,956	1,261	34,905
5	Siddipet	4	10,574	244	13,342	1,224	10,558	1,472	34,474
6	Sangareddy	2	17,726	184	12,282	313	2,981	499	32,989
7	Medak	2	1,964	315	21,955	1,274	8,780	1,591	32,699
8	Kamareddy	2	13,514	189	7,482	401	8,779	592	29,775
9	Peddapalli	1	8,140	112	8,206	988	9,733	1,101	26,079
10	Mancherial	6	16,152	110	4,235	255	4,265	371	24,652
11	Nagarkurnool	6	9,735	136	10,730	1,126	4,146	1,268	24,611
12	Yadadri Bhuvanagiri	-	-	181	12,816	1,029	9,841	1,210	22,657
13	Karimnagar	1	8,000	141	5,100	775	8,185	917	21,286
14	Jagtial	1	8,140	182	6,465	437	2,358	620	16,963
15	Jangaon	9	2,875	114	6,729	422	7,080	545	16,684
16	Mahabubnagar	1	1,036	139	6,945	1,062	8,311	1,202	16,292
17	Warangal Rural	2	1,128	194	9,080	621	5,967	817	16,175
18	Mahabubabad	-	-	210	6,361	866	9,223	1,076	15,584
19	Wanaparthy	5	2,333	144	8,379	1,105	4,477	1,254	15,189
20	Khammam	4	3,679	197	6,834	762	4,169	963	14,682
21	Rajanna Sircilla	2	9,000	90	1,949	270	3,213	362	14,162
22	Jogulamba Gadwal	6	9,949	35	956	125	2,847	166	13,752
23	Narayanpet	3	4,538	103	3,542	487	5,285	593	13,365
24	Bhadradri Kothagudem	3	1,570	86	4,053	602	6,289	691	11,912
25	Mulugu	2	4,513	32	1,559	383	4,549	417	10,621
26	KumuramBheem	4	4,902	42	2,042	450	2,749	496	9,693
27	Jayashankar	1	877	109	3,626	320	5,020	430	9,523
28	Warangal Urban	1	835	101	4,984	456	3,462	558	9,281
29	Rangareddy	-	-	119	3,506	507	5,297	626	8,803
30	Adilabad	2	1,052	62	3,389	201	4,121	265	8,562
31	Vikarabad	1	697	91	3,593	444	2,896	536	7,186
32	Medchal-Malkajgiri	-	-	38	1,193	376	2,267	414	3,460
33	Hyderabad	-	-	1	200	-	-	1	200
	TOTAL	**88**	**2,16,180**	**4,623**	**2,39,475**	**19,926**	**1,99,351**	**24,637**	**6,55,005**

Source: Department of Fisheries, Government of Telangana, Dept. tanks: Tanks vested with fisheries department, GP tanks: Tanks vested with Gram panchayat

2. Inland fish production in Telangana

In Table 1.2, the growth rate of inland fish production in Telangana is given. It shows that the total fish production in the state increased from 2,28,186 tonnes in 2015 to 3,37,117 tonnes in 2020, with an annual growth rate (AGR) of 9.55%. This is a positive sign for the fisheries industry in the state, which has been showing steady growth.

The highest fish production in Telangana was recorded in Nalgonda district, which had an

annual growth rate of 7.17%, followed by Nirmal, Nizamabad, and Khammam. The growth rate in fish production was high in districts that had the highest water spread area.

Table 1.2. District wise inland fish production in Telangana (2015-2020)

Sl. No.	District	Fish Quantity in Tonnes						Annual growth rate (%)					
		2015	2016	2017	2018	2019	2020	I	II	III	IV	V	Overall
1	Nalgonda	18,686	18,905	27,661	19,921	23,797	25,389	1.17	46.32	-27.98	19.46	6.69	7.17
2	Nirmal	12,465	9,979	10,773	14,223	13,252	22,673	-19.94	7.96	32.02	-6.83	71.09	16.38
3	Nizamabad	9,820	6,566	12,549	14,516	17,226	22,618	-33.14	91.12	15.67	18.67	31.3	26.07
4	Khammam	14,855	9,442	12,621	16,264	18,001	20,425	-36.44	33.67	28.87	10.68	13.47	7.5
5	Siddipet	3,009	1,007	13,983	10,951	15,134	17,628	-66.53	1288.58	-21.68	38.2	16.48	97.17
6	Mahabubabad	10,215	10,382	9,568	17,063	10,620	16,451	1.63	-7.84	78.33	-37.76	54.91	12.21
7	Suryapet	11,622	8,065	15,410	18,485	15,325	16,402	-30.61	91.07	19.95	-17.09	7.03	8.23
8	Sangareddy	9,349	4,873	13,823	15,979	10,904	14,975	-47.88	183.67	15.59	-31.76	37.33	12.04
9	Nagarkurnool	7,614	6,080	11,306	11,056	14,517	14,526	-20.15	85.95	-2.21	31.3	0.06	18.16
10	Wanaparthy	7,642	3,657	7,722	10,323	11,972	12,180	-52.15	111.16	33.68	15.97	1.74	11.88
11	Medak	7,800	6,209	21,515	13,247	11,780	11,864	-20.4	246.52	-38.43	-11.07	0.71	10.42
12	Kamareddy	9,165	6,585	7,857	13,110	8,662	10,459	-28.15	19.32	66.86	-33.93	20.75	2.82
13	BadradriKothagudem	7,315	3,956	7,913	4,571	9,831	9,761	-45.92	100.03	-42.24	115.07	-0.71	6.69
14	Yadadri	7,678	8,013	6,361	7,045	8,197	9,652	4.36	-20.62	10.75	16.35	17.75	5.14
15	Warangal- Rural	6,555	5,700	7,973	9,871	8,006	9,333	-13.04	39.88	23.81	-18.89	16.57	8.48
16	Karimnagar	20,124	22,858	6,829	4,584	8,160	9,230	13.59	-70.12	-32.87	78.01	13.11	-10.83
17	Jangaon	5,913	5,323	6,337	9,319	8,860	8,994	-9.98	19.05	47.06	-4.93	1.51	10.42
18	Jagitial	3,980	4,030	2,713	3,217	7,265	8,065	1.26	-32.68	18.56	125.86	11.01	20.53
19	ashankar (Bhupalpalli)	4,234	4,410	7,373	6,033	9,015	7,934	4.16	67.17	-18.17	49.42	-11.99	17.48
20	Jogulamba-Gadwal	5,494	3,015	4,302	7,272	6,085	7,910	-45.12	42.69	69.04	-16.32	29.99	8.8
21	Peddapalli	8,776	9,846	5,131	5,513	7,220	7,671	12.19	-47.89	7.44	30.96	6.25	-2.52
22	Narayanpet	8,582	4,587	7,650	10,863	7,137	7,195	-46.55	66.78	42	-34.3	0.81	-3.23
23	Mancheriyal	4,085	4,818	4,791	5,890	5,925	6,009	17.94	-0.56	22.94	0.59	1.42	9.42
24	Warangal- Urban	3,154	2,845	4,327	4,989	5,805	5,893	-9.8	52.09	15.3	16.36	1.52	17.37
25	Mulugu	2,181	2,375	3,631	2,586	5,171	5,429	8.87	52.91	-28.8	99.99	4.99	29.78
26	maramBheemAsifabad	3,385	3,111	3,580	4,499	5,667	5,178	-8.09	15.08	25.67	25.96	-8.63	10.59
27	Adilabad	2,016	2,280	2,389	4,295	4,038	4,954	13.1	4.78	79.78	-5.98	22.68	29.15
28	Rangareddy	4,082	5,510	3,780	4,212	4,522	4,305	34.98	-31.4	11.43	7.36	-4.8	1.09
29	Vikarabad	1,733	2,498	3,952	3,501	3,645	4,258	44.14	58.21	-11.41	4.11	16.81	29.14
30	RajannaSiricilla	3,225	3,422	1,837	1,524	2,789	3,744	6.11	-46.32	-17.04	83.01	34.24	3.22
31	Mahabubnagar	2,146	1,529	3,279	5,849	8,864	3,269	-28.75	114.43	78.41	51.54	-63.12	10.47
32	Medchal-Malkajgiri	1,262	1,827	3,291	3,419	2,471	2,743	44.77	80.13	3.89	-27.73	11.01	23.47
33	Hyderabad	24	29	25	20	7	-	20.83	-15.52	-18.78	-64.82	-100	-20
	TOTAL	2,28,186	1,93,732	2,62,252	2,84,210	2,99,869	3,37,117	-15.1	35.37	8.37	5.51	12.42	9.55

Source: Department of Fisheries, Government of Telangana

One of the reasons for the growth rate in inland fish production is the state government's initiative to release fingerlings to the water bodies free of cost. This contributes to the increase in fish production and supports the livelihood of local fishermen. Additionally, the state government has taken various measures to promote aquaculture and provide necessary support to farmers and fishermen.

Telangana state has enormous potential for the fisheries sector with its vast water spread area. The government's efforts to promote the industry and the growth rate in fish production offer promising opportunities for the sector's growth and development.

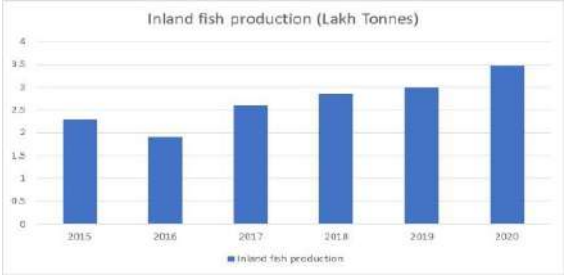

Figure 2: Fish production in Telangana (2015-2020)

3. Technologies used for fish production in Telangana.

Fish production is a vital aspect of the agricultural industry in Telangana, India. In recent years, several technologies have been implemented to enhance fish production in the state. These include semi-intensive pond aquaculture, cage culture, and recirculatory aquaculture system (RAS).

3.1 Semi-intensive pond aquaculture

Semi-intensive pond aquaculture involves rearing fish in artificially constructed ponds by providing supplementary feed.

In Telangana semi-intensive ponds are constructed mostly in low lying areas which are unsuitable for agriculture. Canal water serves as main source of water. Area under semi-intensive pond-aquaculture in Telangana (2020) was 1,237.843 hectares which constitute 204 rearing ponds (424.27 ha) and 533 culture ponds (813.58 ha). Rearing ponds were exclusively used for rearing fish fry to fingerling stage. Culture ponds are grow-out ponds where fish fingerlings were grown up to marketable size. Nalgonda had highest area under semi-intensive pond culture which was 369.94 ha that included 22 rearing ponds (29.73 ha) and 222 culture ponds (340.21 ha). District wise area under semi-intensive pond aquaculture in Telangana was given in Table 1.3.

Table 1.3. District wise area under semi-intensive pond aquaculture in Telangana (2020)

Sl. No.	Name of the District	Rearing ponds		Culture Ponds		Total	
		No. of farmers	Area in ha	No. of farmers	Area in ha	No. of farmers	Total area in ha
1	Nalgonda	22	29.73	222	340.21	244	369.94
2	Khammam	69	88.73	21	43.45	90	132.18
3	Nizamabad	24	64.33	28	25.75	52	90.08
4	J Gadwal	16	41.82	9	41.36	25	83.18
5	Mahabubabad	10	10.48	54	65.90	64	76.38
6	Narayanapet	3	10.00	32	65.00	35	75.00
7	Wanaparthy	3	4.15	41	61.00	44	65.15
8	Suryapet	12	25.00	15	25.00	22	50.00
9	Warangal (R)	8	41.52	2	2.00	10	43.52
10	Bhadradri	3	3.00	23	36.38	26	39.38
11	Karimnagar	5	12.75	16	26.39	21	39.14
12	Mancheriyal	3	28.00	0	0.00	3	28.00
13	Jagitial	7	26.60	0	0.00	7	26.60
14	Y.Bhongir	0	0.00	23	18.00	23	18.00
15	Nirmal	3	3.36	11	14.32	14	17.68
16	Jangaon	2	11.99	3	3.00	5	14.99
17	Kamareddy	2	3.53	8	9.32	10	12.85
18	Sangareddy	0	0.00	8	11.50	8	11.50
19	Mahabubnagar	1	2.00	5	6.00	6	8.00
20	J. Bhupalpally	1	7.28	0	0.00	1	7.28
21	KB Asifabad	2	2.00	3	5.00	5	7.00
22	Nagarkurnool	1	1.00	4	6.00	5	7.00
23	Warangal (U)	3	3.00	1	3.00	4	6.00
24	Adilabad	2	2.00	3	3.00	5	5.00
25	Rangareddy	2	2.00	0	0.00	2	2.00

26	Siddipet	0	0.00	1	2.00	1	2.00
	TOTAL	**204**	**424.27**	**533**	**813.58**	**732**	**1237.84**

Source: Department of Fisheries, Government of Telangana

3.2 Cage culture

Cage culture is a technology that involves rearing fish in an enclosed space in water that maintains free exchange of water with the surrounding water body.

In Telangana, a total of 646 cages were installed in 8 districts out of 33 districts. The highest number of cages were installed in Khammam, followed by Nalgonda, Karimnagar, Mahabubnagar, Mancherial, Sangareddy, Nirmal, and Nizamabad.

The cages in a battery are arranged in caterpillar design for better exchange of water thereby facilitating relatively high dissolved Oxygen NFDB (2016). The cage aquaculture sector has grown very rapidly during the past 20 years and is presently undergoing rapid changes in response to pressures from globalization and growing demand for aquatic products Karnatak and Kumar (2014).

Table 1.4: District wise Cages installed in each reservoir in Telangana

Sl. No	District	Name of the Reservoir	Number Cages Installed
1	Khammam	Palair reservoir	92
		Lankasagar reservoir	20
		Wyra	20
		Sub Total	**132**
2	Nalgonda	Moosi reservoir	70
		Nagarjunasagar reservoir	50
		Sub Total	**120**
3	Karimnagar	Lower Manair Dam	92
		Sub Total	**92**
4	Mahabubnagar	Sangambanda reservoir	60
		Koilsagar reservoir	20
		Sub Total	**80**
5	Mancherial	SripadaYellampalli	80
		Sub Total	**80**
6	Sangareddy	Singoor reservoir	40
		Bogulampally, Husnabad reservoir	20
		Sub Total	**60**
7	Nirmal	Sriramsagar Project	30
		Kadam Project	12
		Suddavagu	10
		Sub Total	**52**
8	Nizamabad	Alisagar reservoir	10
		Gangicheruvu (Renchal)	10
		Ooracheruvu (Velmal)	10
		Sub Total	**30**
	GRAND TOTAL		**646**

Source: Department of Fisheries, Government of Telangana

Cage culture in Telangana:

In Telangana a total of 646 cages were installed in 8 districts out of 33 districts. The highest number of cages were installed in Khammam (132) followed by Nalgonda (120), Karimnagar (92), Mahabubnagar (80), Mancherial (80), Sangareddy (60), Nirmal (52) and Nizamabad (30). Out of 88 existing reservoirs these cages were installed in 17 reservoirs.

Government of Telangana had started cage culture initiative in the year 2014-15 by installing 36 demonstration cages in three reservoirs (Palair, Lower Manair Dam and Kadam project) to bring awareness among the fish farmers. Out of 646 cages, 486 cages were operated by fishers' cooperatives and 160 cages were operated by the entrepreneurs. District wise cages installed in reservoirs of Telangana were given in Table 1.4.

3.3 Re-circulatory aquaculture system (RAS):

Recirculatory Aquaculture System (RAS) is a technology where water is recycled and reused after mechanical and biological filtration and removal of suspended matter and metabolites. This method is used for high-density culture of various fish species with minimum land area and water. In this system fishes are reared in indoor/outdoor tanks in a controlled environment.

RAS in Telangana:

In Telangana 28 units RAS units were established till 2020. The highest units were established in Nalgonda (5) followed by Rangareddy, Medchal and Sangareddy. District-wise number of RAS units installed in Telangana were depicted in Figure 4.

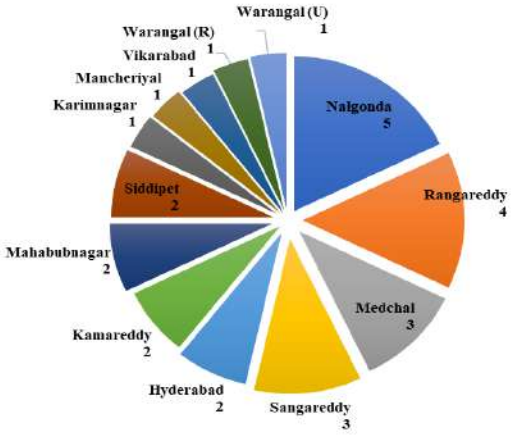

Figure 3: District wise RAS units in Telangana

From Table 1.4 it was observed that cage culture was implemented in only 17 reservoirs. Considering Re-circulatory aquaculture (RAS) only 28 units were established in Telangana state. Thus, there is a lot of scope to increase these technologies in overall state of Telangana.

The implementation of these technologies has resulted in an increase in fish production in the state. The government of Telangana has also taken various initiatives to encourage the adoption of these technologies. For example, in 2014-15, the government started a cage culture initiative by installing 36 demonstration cages in three reservoirs to bring awareness among fish farmers.

CONCLUSION:

The implementation of semi-intensive pond aquaculture, cage culture, and recirculatory aquaculture system technologies has resulted in a significant increase in fish production in Telangana. The government's initiatives to encourage the adoption of these technologies, along with the provision of subsidies, are expected to further enhance fish production in the state.

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Biofortification of Millets: The Revolution 2.0

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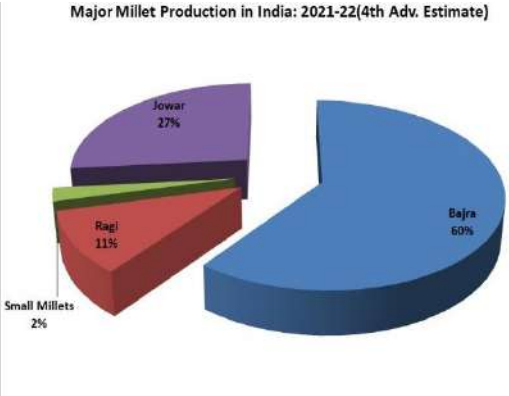
ABSTRACT

The world's population, which is heavily dependent on cereal-based diets that are lacking in micronutrients, faces a serious threat from nutritional insecurity. Thus, a healthy diet is not only a byproduct of social and economic progress, but it is also a crucial component. Millets, together with grains, are the main sources of energy throughout Asia, Africa, and the semi-arid tropical regions. Millets have great nutritional value since their grains are rich in important amino acids, minerals, and vitamins, as well as proteins. It has been established that biofortifying staple crops is a financially viable strategy to address micronutrient deficiency.

INTRODUCTION

The world's largest producer of millets is India. In 2020, the two millets grown in India, Pearl Millet (Bajra) and Sorghum (Jowar), would account for roughly 19% of global production. More than 28.61% of India's total millet production comes from Rajasthan. India produces many different types of millets, including pearl millets, sorghum, finger millet, foxtail millet, kodo millet, barnyard millet proso millet, little millet, and pseudo millets like buckwheat and amaranths. The three millets that make up the majority of India's overall millet production are Pearl millet (Bajra), Sorghum (Jowar), and

Finger Millet (Ragi). In India, millets production has increased from 0.73 lakh tonnes to 1.56 lakh tonnes since 2017-18 to 2021-22 respectively. (https://apeda.gov.in/milletportal/Production).



Source: https://apeda.gov.in/milletportal/Production

Sustainable Development Goal 2, which is one of the 17 Sustainable Development Goals established by the UN in 2015, aims at achieving "zero hunger". The official wording is: “End hunger, achieve food security and improved nutrition and promote sustainable agriculture”. To feed the 800 million people on the planet today, a significant overhaul in the food and agricultural systems is required. By concentrating on millet production, it might be feasible. Of the total global land surface, nearly 40 per cent is dryland in which millets are the most suitable crops.

Despite India's 50% increase in GDP since 2013 more than one third of the world's malnourished children live in India. Among these, half of the children under three years old are underweight.

Economic disparity is one of the main factors contributing to malnutrition in India. Their diet frequently lacks in both quality and quantity due to the low economic condition of various segments of the population. Long-term harm is caused by nutritional deficits to both individuals and society. Despite decades of investment to address this issue, India still has one of the worst rates of child malnutrition in the world. India is placed 107th out of 121 countries on the Global Hunger Index (2022), which takes into account things like child stunting, wasting, and death.

The populace must be supplied with a healthy diet and food security if the nation is to overcome its malnutrition problem. Thus, a healthy diet is not only a byproduct of social and economic progress, but it is also a crucial component. Investing in nutrition through agriculture is more than a social good. It is sound development policy and good economics. The challenges of achieving good nutrition, however, are increasingly complex. (https://www.ifad.org/documents/38714170/40321578/nutrition_e_web.pdf/9e5dbf15-68c1-4586-b7e6-963b84c169f6)

To address malnutrition, hunger and poverty, agricultural interventions have traditionally concentrated on boosting food production and revenues. Even while this is still a good strategy, it is now understood that increased production and money alone have little effect on enhancing nutrition. To maximise agriculture's contribution to healthy nutrition and make agriculture nutrition responsive, a more creative and all-encompassing strategy is required. Without compromising the traditional objectives of the agricultural sector, such an approach finds barriers and opportunities to use agriculture for better nutrition throughout a food chain.

The novel concept being worked upon is ‘Biofortification’, precisely defined as “fortification in field rather than in factory. (https://www.foodinfotech.com/biofortification-in-millets-a-welcome-step-to-fight-hidden-hunger/)

Biofortification is defined as value addition or enrichment of a crop via Genetic Manipulations. This seed-based strategy that has the potential to empower farmers also

contains a long term benefit in diminishing micronutrient deficiency. This is an agricultural nutrition strategy.

Millets are a major food source in arid and semi-arid parts of the world. Millets are good sources of energy. They provide protein, fatty acids, minerals, vitamins, dietary fibre and polyphenols. Typical millet protein contains high quantity of essential amino acids especially the sulphur containing amino acids (methionine and cysteine). Processing millet by milling removes the bran and germ layers that are rich in fibre and phytochemicals, causing significant loss. The millets are source of antioxidants, such as phenolic acids and glycated flavonoids. Millet foods are characterized to be potential prebiotic and can enhance the viability or functionality of probiotics with significant health benefits.

Because of their abundance in calcium, dietary fibre, polyphenols, and protein, millets stand apart from other cereals (Devi et al., 2011). Methionine and cysteine, two important amino acids that contain sulphur, are notably abundant in millets, which also have a higher fat content than maize, rice, and sorghum (Obilana and Manyasa, 2002).

Millets can be biofortified using one of two methods: either increasing the nutrient accumulation in milled grains or decreasing the antinutrients to boost the bioavailability of minerals.

Innovative methods of cultivation of the nutricereals:

- Plant breeding
- Application of soil and foliar nutrients
- Genetic engineering method
- Plant breeding method:

To produce advanced offspring rich in micronutrients, parent which have great concentrations of the required micronutrients can be crossed, or parent with low level of anti-nutrients can be crossed. For small holder farmers, it is a suitable technique to enhance the micronutrient in crops. But major negative in this method is, it is a time-consuming process. Firstly, the right trait must be identified by the breeder.

- **Application of Soil and Foliar Micronutrients**:

There are instances when the mineral reserves are depleted and cannot be transferred to the plant. Applying mineral fertilizers, which are inorganic substances with micronutrients to the soil can boost the amount of mineral- that are delivered to the plant's edible parts. To provide plant nutrients fertilizers are sprayed onto the tissue of above-ground plants in a process known as Foliar Fertilization. Small doses of macronutrients and micronutrients can be applied topically without endangering the plant.

- **Genetic Engineering:**

Genetic Engineering utilises another source gene and is directly injected into the crop without regard to taxonomic restrictions. When the crop lacks the necessary micronutrient at the requisite levels and standard plant breeding is unable to deliver the desired results, this approach of biofortification is most usually applied.

CONCLUSION:

Millets have the ability to end the hidden hunger brought on by a lack of certain micronutrients. Millet biofortification is a one innovative approach in millet cultivation that is a miracle cure for malnutrition and can improve the health of customers who receive inadequate nutrients. Even though millets are nutrient-rich, increasing production and enhancing millets' quality is required to shift many people from nutrient shortfall to

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sufficiency. The aphorism, 'Health comes from the farm, not the pharmacy' is at the heart of ongoing research on biofortification.

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The Sustainability of Aquaponics: Perspectives and Opportunities in Aquaculture

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ABSTRACT

Aquaponics integrates pisciculture and hydroponics, yielding both fish and plants using a shared water medium. Aquaponics is a revolutionary concept in aquaculture specializing mainly within space utilization and integrated aquaculture. Plant transpiration utilizes water, while fish metabolic byproducts form nutrient-rich wastewater. Diverse microflora counter adverse microbes, enhancing system productivity. Recirculating aquaponic designs and diverse configurations exploit microfloral benefits which are pivotal in aquaponics. Year-round premium-grade fish and vegetable production capitalizing on market demands promises a great output and produce. Effective venture management, market analysis and training optimize operations amidst supply-demand intricacies. This book chapter succinctly presents aquaponic principles and their aquacultural potential keeping in mind its myriad perspectives.

INTRODUCTION

Aquaponics is an agricultural technique that combines aquaculture (fish farming) with plant-based agriculture. It utilizes water as a shared resource between plants and aquatic animals. Plants use water through transpiration, while fish produce wastewater containing metabolic wastes. This wastewater, rich in nutrients, can be used to supply plants with the necessary nutrients for growth. By incorporating aquaculture into the water supply pathway, aquaponics allows for the production of two crops (fish and plants) from a single water source, benefiting both systems. Integrating aquaculture with traditional plant production methods offers numerous benefits such as increased farm productivity and profitability with reduced water consumption, diversification into high-value crops, and the reuse of resources like nutrients and water. It also helps mitigate the environmental impact of intensive farming systems and can offset existing farm expenses, leading to economic advantages (Lennard and Leonard, 2006). Aquaponics is believed to have originated from ancient farming practices in Southeast Asia and South America, where fish were integrated with plant production in flooded rice paddy fields and floating island agriculture. Initially, fish in rice paddy fields had low densities and provided limited nutritional benefits to the plants. The modern development of aquaponics began in the 1970s in the United States, with James Rakocy and his team at the University of the Virgin Islands pioneering the systems that form the basis of contemporary aquaponics (Rakocy *et al*., 2011).

Basic Concept of Aquaponics

Aquaponics is commonly defined as the combination of fish production (aquaculture) and soil-less plant cultivation (hydroponics) with coupled or decoupled water circulation. Recent advancements have broadened the definition to include the ecological and economic sustainability aspects, with a focus on nutrient-sharing between aquatic organisms and plants. The fish-to-plant ratio is important, and systems that rely primarily on fish waste for plant nutrition are considered integral to aquaponics.

Figure 1 below depicts the aquaponic system created and deployed at Iowa State University. The culture tank is where the fish live as they mature to marketable size. A filter is used to improve particulate waste removal. Biological filters often take advantage of nitrifying bacteria to convert toxic wastes to non-toxic forms that plants can use. The hydroponic equipment allows the plants to be in direct contact with the filtered water. Pumps essentially move water among the various system components, whilst the aerator (low volume, low pressure) or blower (high volume, low pressure) adds extra air to the system, providing appropriate air volume.

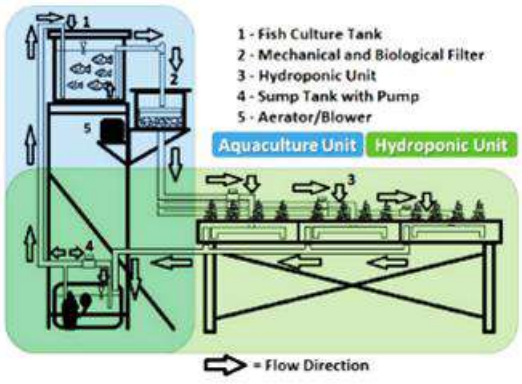

Figure 1. Structure of an aquaponic system (Source: Pattillo, 2017)

Principles of Aquaponics

Efficient nutrient and water use is a fundamental principle in aquaponics, where fish waste serves as the primary food source for plants. The system design should minimize waste production and environmental impact while being suitable for controlled

environments like greenhouses. By optimizing nutrient dynamics and utilizing microflora, plants access and utilize transformed fish metabolic wastes as nutrient sources (Halwart and Gupta, 2004).

Water is crucial in aquaponics as it serves as the medium for nutrient transfer and creates the chemical environment for fish and plant cultivation. The source water composition plays a significant role in shaping the system's inputs and overall habitat. While fish feeds provide nutrition primarily for fish, additional nutrients are often required to meet the specific nutrient requirements of plants for optimal and efficient growth in aquaponic systems.

In fully recirculating aquaponics systems like the UVI design, fish feeds serve as the primary nutrient source for both fish and plants. However, additional nutrient supplementation is needed to meet the specific nutrient requirements of plants, such as calcium, potassium, and iron. A buffering regime and controlled infusions of basic salts and iron chelates are employed to maintain pH levels and provide these essential nutrients to support optimal plant growth. Understanding the chemical nature of the water source is crucial for achieving ideal nutrient levels. Ideal water sources include rainwater or chemically treated water, while ground waters and river waters should be tested for appropriate nutrient and chemical concentrations. Sterilization and chemical separation techniques, such as reverse osmosis, are recommended to ensure water quality in aquaponics systems.

Hydroponic Growing Methods Used in Aquaponics

Aquaponic systems commonly utilize five popular hydroponic growing techniques: flood and drain, deepwater culture, nutrient film technique (NFT), drip irrigation, and bucket culture. Flood and drain systems immerse the plants in nutrient-rich water before draining, promoting root health. Deepwater culture suspends plants with roots submerged in water, offering simplicity and reliability. NFT involves a thin film of water flowing along a channel, allowing roots to access both air and water. Drip irrigation provides a steady supply of water and air to the root zone, while bucket culture combines flood and drain with NFT for large vining crops.

In the context of aquaponics, the most suitable fish culture technology is the Recirculating Aquaculture System (RAS) as it allows for controlled fish growth with low water replacement rates, facilitating the accumulation of fish waste nutrients for efficient hydroponic plant production. Soil-based aquaculture systems are not recommended as they cannot meet the nutrient requirements of the plants in aquaponics. Some of the commonly cultivated fish species in aquaponics include tilapia, which is known for its fast growth and adaptability to different environments. Trout, with its high market demand and excellent taste, is another popular choice. Catfish, such as Clarias and Ictalurus species, thrive in aquaponic systems and are valued for their rapid growth and robustness. Barramundi, a sought-after species in culinary circles, is also suitable for aquaponics. Apart from this, perchs, carps (common carps), goldfish, koi carp (ornamental value) also suffice as excellent species for aquaponics due to its growth potential as well as market value. Lastly, Murray cod, a prized freshwater fish, is gaining attention in aquaponics due to its growth potential and market value.

Aquaponics as an Ecological Approach

Aquaponics recognizes the importance of microorganisms in performing essential biological functions, with the historical viewpoint favoring a non-sterile and biologically diverse approach. The presence of diverse microflora helps prevent the dominance of harmful organisms, leading to

enhanced fish and plant productivity. This perspective has influenced the design methodology of recirculating aquaponics systems, while more decoupled designers are also embracing the ecological benefits of a diverse aquaponic microflora.

CONCLUSION

Aquaponic systems offer year-round production of high-quality fish and vegetables, allowing farmers to take advantage of out-of-season markets and premium prices. The freshness and local food trend increase consumer demand, providing potential for profitability and market expansion. However, success in aquaponics requires careful business planning, market research, and hands-on training to optimize production efficiency and navigate supply and demand dynamics.

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Digitalization in Agriculture

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ABSTRACT

There is hope for the future of agricultural production due to the promising impact of digital technologies in agriculture. There are others who believe that the intelligence provided by digital tools can help us to overcome the persistent food shortage. But there are serious societal, moral, political, artistic, and ecological concerns connected to the digital revolution. We present the advantages and hazards of agricultural digitalization within the context of the artificial tram dilemma, in which one must decide whether or not it is acceptable to endanger someone who is taking precautions to avoid the more widespread negative consequences. We also emphasise the importance of figuring out how to steer the digital revolution in agriculture in ways that will improve food production while minimising unintended consequences for society. Although digitalization is often seen as a silver bullet for accelerating the shift of agrifood supply towards environmentally friendly paradigms, the consequences may be complex and in-depth examinations of the numerous justifications in digitalizing farms are necessary. Science is now required to provide evidence that digitization does have good effects on society at large. However, it is important to develop and use reliable evaluation methodologies in order to measure and estimate the scale of the consequences that technological developments may have. In conclusion but not least, policy should highlight the requirement to establish open and welcoming environments for agricultural digitization.

INTRODUCTION

The United Nations estimates that by 2050, the world's food supply will need to feed 9 billion people. Urgent action must be taken to redesign an effective and environmentally friendly food production system so that everyone can eat without damaging the overall ecology (Du & Hatzenbuehler., 2023). Sustainable food production can be hindered by a number of factors unique to rural areas, including a lack of educational and health facilities, a growing elderly population, and poor transportation. In light of these problems, it has been reported that the process of digitalization can benefit the agricultural sector (by helping to make more efficient use of goods) and rural communities (by defining new and improved services) (Upendra et al., 2023). While digitization is credited for its potential to help rural communities achieve the United Nations' 17 interconnected Sustainable Development Goals (SDGs), including "no poverty," "zero hunger," and "climate action," the complete opposite is also true (Bhattarai & Pandit., 2023).

The term "digital transformation" has been making headlines in the agriculture and food industry for almost a decade. It has made it possible for both businesses and governments to take advantage of digital technology advances in order to rethink established practises and create novel economic models (Mohr & Hohler., 2023)

The term "digital" has a variety of meanings depending on whom you ask and where they sit in the organisation. For some, this may mean using cutting-edge tech to improve efficiency and gain a competitive edge; for others, it may be the key to copying closer ties with clients and customers. To another, it can signify the elimination of paper records in favour of digital storage that saves both time and money (Kara et al., 2023).

The Role of Technology in Modern Farming

Digital farming relies heavily on technological advancements. Agriculture technology, or agritech for short, refers to the use of internet-enabled modern technologies to reimagine agricultural practices on a worldwide scale. Companies of all sizes have benefited from digitization because it has made it possible to collect and analyse vast amounts of agriculture data, which in turn has allowed a wide range of stakeholders to add greater value to the operations they manage (Purcell et al., 2023). Producers now have the ability to acquire critical farm data around the clock thanks to a overabundance of sources, such as mobile-based agriculture applications, sensors, drones, farm machinery and tools, robotics equipment, and other devices. When combined with GPS and weather data, this information enables farmers to track crop growth during near-real time, evaluate plot performance, and make relatively precise yield estimates (Subesh & Mehta., 2021).

There are several ways in which artificial intelligence could be used to improve agricultural operations. It enables farmers to transform raw agriculture data into useful insights that can be put into practise to boost both crop quality and yield. With the help of AI, farmers may pick the most resource-efficient crops and kinds for their areas and use automated farming practices. Communication between many participants in the agri-ecosystem is being strengthened by the digitization of every stage, from cultivation and harvest to storage and distribution. Supply chain transparency and efficiency both have been greatly improved as a result of digitalization, which has also increased accessibility throughout the supply line (Mudda et al., 2017).

Current Use of Technology in Farming

Producers now have the ability to acquire crucial farm data around the clock thanks to a plethora of sources, such as mobile-based agricultural apps, detectors, drones, farm machinery and tools, robotic equipment, and other IoT devices (Gautam et al., 2021).

Using AI to improve farming operations is just one of the possible applications of precision agriculture. It enables farmers to transform raw agricultural data into useful insights that enhance both crop quality and yield. With the help of AI, farmers may pick the most resource-efficient crops and kinds for their areas and use automated farming practices (Baryshnikova et al., 2019).

Interaction between many participants in the agri-ecosystem is being strengthened by the digitization of every phase, from cultivation and harvest to storage and distribution. Supply chain transparency and efficiency have both been greatly improved as a result of digitalization, which has also increased transparency along the supply chain for the many sectors (Mohr & Hohler., 2023).

How Does Digitalization Affect the Agriculture Industry?

With the introduction of Agriculture, farmers now have access to surplus of automated farming instruments and information management platforms, allowing them to maximise their output while using fewer resources. Farms that have embraced technology advances have clearly moved away from more labor-intensive and inefficient methods in favour of those that are more streamlined and save money. More resilient and environmental friendly agri-food systems worldwide can be achieved with the help of digital agriculture, which can also be used by management to better align organisational approaches with the goals of Sustainable Development (Upendra et al., 2023).

CONCLUSION

As farming becomes increasingly digital, farmers gain access to innovative instruments that streamline their operations. Professional farmers who focus on pesticide farming, for instance, can intervene quickly in the development of weeds. This ensures that all of the plants have the same amount of time to mature before harvest. The benefits of automated are twofold: first, it ensures successful yields by removing the need for farmers to spend time, energy, and effort monitoring their crops; and second, it allows farmers to focus on operating their farming business. Additionally, developments such as machine learning-powered robot harvesters can assist farmers during harvest by eliminating the need for manual harvesting of plants. The future of the economy lies in digitization, and not just in agriculture. Ease of utilisation, accessibility, familiarity, acceptability, and popularisation of benefits to farmers who are eager to learn and appreciate the benefits; farmer is the last mile in utilising digitisation; administration must allocate time as well as resources for socializing the digitization benefits; private sector should join forces; and India's leading software companies can help.

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Importance of Biosensors in Agriculture

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ABSTRACT

The development of biosensors has been the focus of research during the last few decades. Biosensors can serve as very efficient, inexpensive instruments for this purpose in addition to being employed in other widespread applications. Especially in third-world countries, it is evident that agricultural produce needs to be checked for quality and food safety. This problem can be tackled more precisely, conveniently, and sensitively by employing biosensors than by using conventional techniques. In-situ evaluations of fertiliser management, the detection of soil and water quality, the measurement of pesticide residues, and the monitoring of waste water are some of the essential components for crop growth and, as a result, for ensuring food security. The development of a broad transducer lineup was facilitated by the gradual blending of biosensors and nanotechnology, and expanded the sensing mechanism.

INTRODUCTION

Biosensors are analytical instruments that can convert biological reactions into electrical signals. Biosensors ought to be extremely accurate, reusable, and unaffected by external factors like pH and temperature. A biosensor is a small analytical tool that uses an electric current to analyse, find, and record biological data. Either a discrete or continuous digital electrical signal can be produced by it. The primary purpose of this apparatus is to ascertain concentration of chemical and other biological components in food production and agricultural fields are specifically utilised in this device, they also occur in the biosensors. Leland C. Clark Jr. is known as the "Father of Biosensors" since in 1956 he created the first real biosensor for oxygen detection.

Biosensors in Agriculture

Agriculture includes both the raising of crops and the keeping of animals. These elements play a significant role in our daily life. These products have historically been thrown away due to deterioration from diseases and pest infestations. Early detection is crucial in the agricultural field because crop diseases, insect damage, weed infestations, water shortages or surpluses, managing floods, assessing crop nutrition, and other issues are all preventable. There is cause for concern since herbicide, pesticide, and heavy metal concentrations are increasing in agricultural areas. Biosensors can be used to measure the levels of pesticides, herbicides, and heavy metals in the soil and groundwater. With the development of technology, biosensors can now be used to anticipate the probable emergence of soil disease. Using a biosensor for biological soil diagnostics allows for more effective early prevention and purification of soil illness.

Components of Biosensors

In essence, a biosensor is made up of two types of components: biological and physical. Biological component is constituted by biological substance that reacts with biological analyte (biological molecules, presence or concentration of which is to be detected) and physical components are comprised of three parts:

(a) a component of the biosensor that recognises the signal caused by the interaction of the biological biosensor component and the analyte,

(b) component responsible for transducing the known biochemical or biophysical signal into an electrical signal;

(c) biosensor's part that reads the transduced signal (the part called reader device) and gives either analog or digital output inferable by the experimenter/observer.

Types

Biosensors are classified into following broad types:

(a). Electrochemical Biosensors.

(b). Immunosensors

(c). Acoustic biosensors

(d). Amperometric biosensors

(e). Calorimetric biosensors

(f). Potentiometric

(g). Optical biosensor

(h). Conduct Metric Biosensors

Uses and role of biosensors in agriculture

(a). Biosensors in detection of crop diseases

(b). Detection of pathogens in plants

(c). Biosensors used in agronomy and soil chemistry

(d). Biosensors in pesticides and its residues detection

(e). Biosensors for detection of Herbicides

(f). Biosensors used for quantification of Nitrates in plants

(g). Biosensors for detection of food pathogens and mycotoxins

(h). Linking with nanofertilizers: an agent to promote sustainable agriculture

(i). Biosensors for pre-harvest agriculture

Advantages and Disadvantages of Biosensors

Biosensors are portable, incredibly reliable, and fairly priced. They also offer a wide linear range of sensor response. Because they have improved selectivity towards targeted ions and

ppb level detection, sensor-based responses eliminate the cost of onsite monitoring involved with collecting, separating, packaging, and transporting the sample to be analyzed. As a potential standard technology, it does have a number of issues that need to be resolved. Lack of heat sterilization, which denatures the biological component of the biosensor, high development costs, decreased enzyme and antibody stability, lack of reproducibility, lack of reusability, cell poisoning, etc. are a few of the drawbacks mentioned in the literature. Numerous authors from various fields emphasise ways to address shortcomings. To get at a better answer, though, it needs a common platform because it is a multidisciplinary strategy.

Conclusion and future role

In conclusion, despite the many advantages of biosensors and biosensing tools like nanoparticles/nanomaterials, polymers, and microbes built biosensors in addressing some of the challenges in agricultural activities with regard to environmental sustainability, there is still a need to significantly assimilate multi-faceted methods in developing biosensors that can potentially be used for diverse applications in climate smart organic/biological agriculture for enhanced environmental sustainability. Therefore, it is proposed that effective development of comprehensive and influential biosensors for contemporary future contributions to knowledge in the field of biosensor machinery in climate smart organic/biological agriculture for environmental sustainability would require the appropriate combination of biosensing as well as bio-fabrication with non-natural/synthetic biology methods by applying either/both electrochemical, optical, and bio-electronic moralities.

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Value Chain Analysis of Safflower – A Study in Vikarabad District

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ABSTRACT

The present study titled value chain analysis of safflower – a study in vikarabad was carried out in order to examine the costs and returns of safflower cultivation, to identify the Stakeholders involved in safflower movement through value chain mapping and to analyse the increments in profits through value addition to safflower. Vikarabad, a major Safflower cultivating district in Telangana was selected for the study purpose. Primary data was collected from safflower cultivating farmers and other stakeholders like market intermediaries for mapping the safflower value chain and primary data related to safflower cost of cultivation was also collected from farmers. The cost concepts proposed by Commission On Agricultural Costs and Prices were used in the study to calculate cost and returns of safflower cultivation. The costs of cultivation of safflower per hectare was found to be Rs. 44,543.59. The average yield of safflower per hectare was 17.45 quintals. The net returns generated by farmers through safflower per hectare was Rs. 50,914.57. Through value chain mapping of safflower, the major stakeholders involved in the chain were identified. The important stakeholders were public and private seed suppliers, input suppliers/dealers, farmers, market intermediaries, processors and consumers. The major value added products developed from safflower in the study area were cold pressed and refined safflower oil. Cold pressed safflower oil processing yields 20 litres oil from one quintal of seeds. When farmers sold the seeds directly without any processing the net returns generated (Rs. 2,372.1 per quintal) by them were found to be less than the returns generated when go for cold pressed oil processing. The cost of processing quintal of

safflower seeds into cold pressed oil was Rs. 4192.75 and net returns generated was Rs. 4,101.25.

INTRODUCTION

Safflower (*Carthamus tinctorious*) is one of the most important oilseed crops and is native to the part of Asia and Africa. It is mainly cultivated for oil extraction from the seeds. Safflower has great drought tolerance because of its deep tap root system and xerophytic attribute of spines. The oil content in Safflower seeds ranges from 32 to 40 percent.

The value chain analysis concept is a business management concept which was described and popularized by Michael Porter in 1985. Most of the products change hands many times before they reach the final consumer. The value chain analysis is an important tool for creating greatest possible value for the produce and it plays a key role in identifying distribution of benefits of actors in the chain (Geetha, 2011).

Input suppliers, producers, processors, wholesalers and retailers being the major stake holders in the value chain.

The value added products that could be obtained from safflower are majorly oil which is obtained from the seeds, red colour dye Carthamin which is obtained from the petals of safflower flower and herbal tea is also produced as a value added product of safflower (Menegaes, 2020). Cosmetics creams can be produced from the safflower. Hence the potential for value addition is immense in safflower.

In view of the high potential for value addition and increased demand for safflower oil and there are not many studies on Safflower, this study was carried out to analyse the profitability at the farm level, value addition to safflower and also to identify the stakeholders involved in the Safflower value chain.

Objectives: The study investigated the movement of safflower seeds from farmer to consumers and also analysed the costs and returns incurred by the safflower farmers. While tracking the movement of safflower, also identified the stakeholders involved along the chain and also the value added products developed from the safflower. For accomplishing these objectives primary data required was collected from the farmers and also the other stakeholders of safflower value chain from the study area with the help of schedules.

Materials and methods:

The study was initiated to map the value chain of safflower in Vikarabad district of Telangana where the area under the crop is highest in the state and has been increasing. From the district, 6 mandals and within the selected mandals, 12 villages and from each of the selected village 10 farmers were selected for the study purpose. To map the entire value chain, commission agents/traders at APMC in the district were selected. The data required for the selection of mandals was obtained from the Joint Directorate of Agriculture, Department of Agriculture (DOA) office in Vikarabad district and Directorate of Economics and Statistics, Hyderabad.

From each village 10 farmers were selected at random. The data on farm characteristic details on cultivation practices adopted in safflower cultivation, marketing of Safflower and problems in production and marketing were collected from the farmers through interview method with the help of pre-tested schedule.

Major regulated market for safflower in the district was Tandur, APMC market was selected to track the entire value chain. The study also intended to explore market functionaries, intermediaries at various levels of marketing as it was essential for identifying the entire value chain. Commission agents were agents between farmers and traders/processors in marketing of safflower seeds. The raw material oilseeds were purchased by the traders from the AMC market yard. Most of the commission agents were licensed. Oil processing units situated in and around Vikarabad and in Hyderabad purchase the safflower seeds from the farmers, traders/commission agents and process the produce to derive the value added output.

The cost concepts proposed by Commission on Agricultural costs and Prices (CACP) viz., Cost A1, Cost A2, Cost B1, Cost B2, Cost C1, Cost C2 and Cost C3 were used in the study to calculate the cost of cultivation of safflower. The cost of cultivation of safflower included both operational and material costs. Fixed costs incurred in cultivation for a year were also included. The variable costs which were included in cost of cultivation were costs of labor, manure, chemicals, depreciation, land revenue and interest on working capital.

Value chain of Safflower:

Value chain analysis of safflower was carried out with the help of primary data collected from the farmers and market intermediaries in the study area. Through the analysis it was observed that the major actors in the safflower value chain were input suppliers, farmers, traders and processors. Value chain analysis has identified the activities as input logistics, production, marketing and processing. Input logistics includes the activities that involve the movement of the inputs like seeds, fertilizers and pesticides from suppliers to farmers. During the production activity the major actors were farmers who carried out the cultivation of safflower. Production involves various activities like land preparation, sowing, weeding and harvesting. After the harvest farmers mostly sold the produce to the traders and few to the processors. Farmers from Mariyapur village were carrying out seed production to Indian Institute of oil seeds research (IIOR), hence they sold the seeds to the institution after harvesting. Farmers from Tandur and Basheerabad were selling the seeds to the Professor Jayashankar Telangana State Agricultural University Cold pressed safflower oil processing unit at ARS, Tandur. Next activity was identified as marketing in which the major actors were market intermediaries who purchased the harvested safflower seeds from farmers for further selling either to processors or other traders or for export purpose. Last stage in value chain was identified as processing where value addition occurred to the raw material and the major actors during processing were processors. Most of processors purchased the safflower seeds from the traders and few purchased directly from the farmers. During the value chain analysis of safflower, major value added products identified in the study area were refined and cold pressed safflower oil.

Costs and returns of safflower cultivation:

Costs and returns of safflower cultivation were calculated by collecting data from 120 farmers composed of 6 mandals from the study area. Most of the safflower cultivating farmers were small and marginal.

The size of the land holding influences the economic efficiency and returns of the farmers significantly. The holding particulars along with total owned area and area cropped under safflower for the respondents were presented in the Table 1.1.

Table 1.1 Selected growers and their distribution of land holdings (ha)

S. No	Categories	Number of Respondents	Average holding
1 .	Small and marginal (less than 2ha)	63 (52.5)	0.85
2 .	Medium (2 to 4 ha)	39 (32.5)	2.94
3 .	Large (above 4 ha)	18 (15)	5 . 4 2

The cost of cultivation per hectare of safflower was Rs. 44,543.59. The highest share in cost of cultivation was incurred on machine labour followed by human labour. The average yield per hectare of safflower was 17.5 quintals and per hectare gross returns obtained by safflower farmers was Rs. 95,458.16. The average net return obtained by farmers was Rs. 50,914.57. Hence, safflower cultivation is profitable to the farmers in the study area.

Value addition to Safflower:

Farmers incurred a cost of Rs. 2,807.90, for producing one quintal of safflower. After meeting the marketing costs and production costs, the net profit received by the farmers was Rs. 2,372.1. But, when the farmers undertake processing to produce cold pressed or refined edible safflower oil, the scope for increasing profits is more. Farmers will incur a cost of Rs. 4192.75 for processing of quintal of safflower seeds into cold pressed oil although various value-added products can be developed from safflower, the only one product popular in the study area was identified as edible oil. Through the production of quintal of safflower farmers were able to generate a net income of Rs. 2,372.1 but when they go for cold pressed oil processing after deducting the production and marketing costs and the gross returns generated were Rs. 8294. On the whole the net returns generated by the farmers through processing of safflower seeds into cold pressed oil were Rs. 4,101.25. Hence, it was observed that by taking up the value addition the returns generated by the farmers were increasing.

Results and discussion:

The value chain of safflower was observed to be complicated in the study area as it involved many stakeholders along the chain. Through the value chain analysis of safflower we have observed the major value added product developed along the chain as edible oil. Although, various other products can be developed from safflower, the processing into such products is limited due to lack of knowledge on value addition. It was observed that the cultivation of safflower was yielding positive returns to the farmers. Hence cultivation of safflower must be encouraged among the farmers. But, when farmers themselves take up the processing much higher returns can be observed. Therefore, farmers must be trained in manufacturing the value added products and they should be encouraged to take up the processing of safflower.

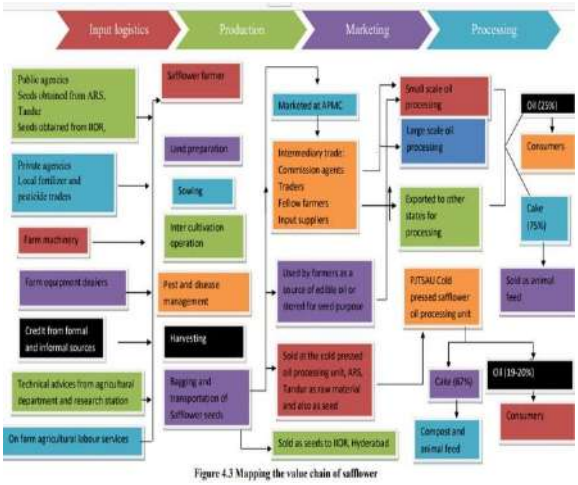

Figure 4.3 Mapping the value chain of safflower

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Bael Production in Madhya Pradesh

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ABSTRACT

Bael is a tropical fruit tree that thrives in hot and humid weather and grows well in well-drained, loamy soils. Madhya Pradesh has a tropical climate, with a monsoon season from June to September and an average temperature range of 25-30°C. With the increasing demand for healthy and organic foods, the demand for bael fruits and products made from them, such as juice, jam, and pulp, is also expected to increase. Bael is known for its various health benefits, including its ability to improve digestion, boost immunity, and treat various ailments. *Aegle marmelos* grows well in the dry forests of hilly and plain areas. It can acclimatize a wide range of habitat and can be cultivated worldwide. Madhya Pradesh is one of the major producers of Bael fruit in the country. As of the 2020-21 horticulture year, Madhya Pradesh had a total area of 1,292 hectares under Bael cultivation, with a total production of 15,102 metric tonnes. Bael production in Madhya Pradesh has a promising future due to the favorable climatic conditions and availability of suitable land for cultivation.

INTRODUCTION

Bael (*Aegle marmelos Correa*) is one of the important under-utilized medicinal and indigenous fruit crops of India. It belongs to family Rutaceae. Locally, it is known by different names in different languages viz., Bael fruit, Indian Bael, holy fruit, golden apple, Elephant apple, Bengal quince, Indian quince, stone apple in English; Baelputri, Bela, Siri-phal, Kooralam in Hindi.

Aegle marmelos grows well in the dry forests of hilly and plain areas. It can acclimatize a wide range of habitat and can be cultivated worldwide. It is native of India, with origin in the Eastern Ghats and central India. This tree has been mentioned in prehistoric manuscripts since 800 B.C. During his tour to India in 1629 A.D., the Chinese Buddhist pilgrim Hiuen Tsiang noticed the presence of this tree.

(Sharma and Dubey, 2013). Bael is also grown in Nepal, Myanmar, Tibet, Vietnam, Laos, Cambodia, Sri Lanka, Bangladesh, Thailand, Indonesia, Malaysia, Java, Fiji, Surinam, and Trinidad, as well as in some Egyptian gardens.

Area and production in Madhya Pradesh

According to the statistics available from the Ministry of Agriculture and Farmers Welfare, Government of India, Madhya Pradesh produced around 73,000 metric tons of bael fruits in the year 2019-2020. However, it's important to note that this is the most recent data available to me, and the production levels may have fluctuated since then. It's worth mentioning that the production of bael fruits in Madhya Pradesh is primarily concentrated in the Chhindwara and Balaghat districts, which together account for a significant proportion of the state's bael production. Additionally, bael is also cultivated in other states of India, including Maharashtra, Gujarat, and Rajasthan. According to the data from the National Horticulture Board, Ministry of Agriculture and Farmers Welfare, Government of India, Madhya Pradesh is one of the major producers of Bael fruit in the country. As of the 2020-21 horticulture year, Madhya Pradesh had a total area of 1,292 hectares under Bael cultivation, with a total production of 15,102 metric tonnes. The districts of Chhindwara, Seoni, Jabalpur, and Narsinghpur are the major Bael producing districts in Madhya Pradesh.

Status of Bael in Madhya Pradesh

SN	Year	Production (000 Tonnes	Share (%)
1	2021-22	2.01	2.45
2	2020-21	1.76	2.14
3	2019-20	1.63	1.99
4	2018-19	1.64	2.04
5	2017-18	1.55	1.75
6	2016-17	1.47	1.70
7	2015-16	1.46	1.70

Source: National Horticulture Board (NHB)

Promotion of Bael production in Madhya Pradesh

The government of Madhya Pradesh is taking various initiatives to promote the cultivation of bael, such as providing subsidies for the establishment of new orchards, distribution of high-yielding and disease-resistant varieties of bael, and organizing training programs for farmers on scientific cultivation practices. Bael has good potential for export, and the government is also encouraging farmers to explore export markets for bael products. The Government of Madhya Pradesh has implemented various schemes and programs to promote the cultivation of bael fruit in the state. One such scheme is the Horticulture Development Scheme, which provides financial assistance and technical support to farmers for the cultivation of various horticultural crops, including bael. Under the scheme, the government provides subsidies for the purchase of quality planting material, drip irrigation systems, and other horticultural inputs. The scheme also offers training and capacity building programs for farmers to improve their knowledge and skills in bael cultivation.

Apart from this, the Madhya Pradesh State Agro Industries Development Corporation Limited (M.P. Agro) has also launched a scheme for the promotion of bael processing and value addition. The scheme provides financial assistance and technical support to entrepreneurs for setting up bael processing units, such as juice extraction units, pulp making units, and dried fruit production units. Overall, the government of Madhya Pradesh is taking various measures to promote the cultivation and processing of bael fruit, which has immense economic and nutritional potential. To convince farmers to produce bael fruit, you need to educate them about the benefits of cultivating bael and how it can be profitable for them. Here are some steps that you can take:

- **Conduct research:** Gather information on the cultivation of bael fruit, including its requirements, growth cycles, and market demand. This information will help you to provide the farmers with a clear picture of what is involved in bael cultivation.

- **Arrange field visits:** Arrange visits to farms that already cultivate bael fruit. This will give farmers a better idea of what to expect, and they can learn from the experiences of other farmers.

- **Provide financial incentives:** Offer financial incentives to farmers to encourage them to start bael cultivation. This can include subsidies, loans, and access to markets.

- **Organize training sessions:** Organize training sessions for farmers to teach them the best practices for bael cultivation. This can include topics such as soil preparation, irrigation, pest control, and harvesting.

- **Demonstrate profitability:** Show farmers how bael cultivation can be profitable. This can include showing them the market demand for bael fruit, the potential income from selling bael fruit, and the long-term benefits of diversifying their crop portfolio.

- **Build a community:** Build a community of bael growers and provide ongoing support and resources to help them succeed. This can include access to marketing channels, technical support, **and networking opportunities.**

Marketing: Problems and overcome

Bael fruits can be sold in local markets or exported to other countries. Proper packaging, labeling and transportation are important for successful marketing. Assuming you are referring to marketing a product or service related to bael, which is a fruit commonly found in South Asian countries, here are some potential marketing problems you may face and some suggestions on how to address them:

- **Lack of awareness:** Bael is not a well-known fruit outside of South Asia, so one of the main challenges may be creating awareness about it among your target audience. To address this, you can consider using educational content such as blog posts, videos, or social media posts that explain the benefits and uses of bael. You can also try partnering with influencers or experts in the health or nutrition field to help spread the word.

- **Limited market:** Bael may have a limited market in some countries or regions, which can make it difficult to reach a large audience. In this case, you can focus on niche markets such as health-conscious consumers, people interested in traditional medicine or Ayurveda, or those looking for exotic or unusual fruits.

- **Pricing:** Bael may be more expensive than other more commonly available fruits, which can be a barrier to entry for some consumers. To address this, you can try to position bael as a premium or specialty product, highlighting its unique taste, nutritional benefits, or cultural significance.

- **Distribution:** Bael may not be widely available in all markets, so you may need to find creative ways to distribute it. This can include working with local distributors or importers, selling online, or partnering with restaurants or cafes that can use bael in their menus.

Overcome:

Effective marketing requires a thorough understanding of your target audience and the unique value proposition of your product. By leveraging the health benefits and versatility of bael fruit, as well as social media, influencer

marketing, and industry events, you can create a successful marketing campaign for your brand.

- **Understand your target audience:** Who are the people that would be interested in buying products related to bael fruit? Are they health-conscious individuals, people looking for natural remedies, or consumers interested in exotic fruits? Understanding your target audience is essential for creating effective marketing strategies.

- **Highlight the health benefits:** Bael fruit is known for its numerous health benefits, such as improving digestion, boosting immunity, and reducing inflammation. Highlight these benefits in your marketing efforts to attract health-conscious consumers.

- **Showcase the versatility of bael fruit:** Bael fruit can be used in a variety of ways, including as a juice, in chutneys and jams, or as a flavoring for desserts. Showcase the versatility of bael fruit in your marketing campaigns to attract a wider range of consumers.

- **Leverage social media:** Social-media can be a powerful tool for marketing in the food industry. Consider using social media platforms like Instagram and Facebook to showcase your products and engage with your audience.

- **Partner with influencers:** Influencer marketing can be an effective way to reach a wider audience. Consider partnering with influencers in the health and wellness industry to promote your bael fruit products.

- **Attend trade shows and events:** Consider attending trade shows and events in the food industry to showcase your products and network with potential customers and partners.

Limitations of Bael production in Madhya Pradesh

- **Limited availability of suitable land:** Bael trees require well-drained, loamy soil, and a hot and dry climate to grow well. However, suitable land for bael cultivation may be limited in some parts of Madhya Pradesh, which can constrain production.

- **Lack of access to technology:** Many small-scale farmers in Madhya Pradesh may not have access to the latest agricultural technologies and practices that can improve bael production, such as irrigation systems, high-yielding bael varieties, and pest and disease management techniques.

- **Inadequate infrastructure:** The lack of proper infrastructure, including roads, storage facilities, and market linkages, can make it difficult for farmers to transport and sell their bael produce in the market, leading to reduced profitability and limited market opportunities.

- **Limited awareness among farmers:** Many farmers in Madhya Pradesh may not be aware of the potential benefits of bael cultivation or may not have the necessary knowledge and skills to grow bael trees effectively. This can limit the adoption of bael cultivation and result in lower yields and quality.

- **Low demand:** Although bael fruits are popular in some regions of India, the demand for bael fruits in other parts of the country and internationally may be limited, which can impact the profitability of bael production in Madhya Pradesh.

Future scope of Bael production in Madhya Pradesh

Bael production in Madhya Pradesh has a promising future due to the favorable climatic conditions and availability of suitable land for

cultivation. Bael is a tropical fruit tree that thrives in hot and humid weather and grows well in well-drained, loamy soils. Madhya Pradesh has a tropical climate, with a monsoon season from June to September and an average temperature range of 25-30°C. With the increasing demand for healthy and organic foods, the demand for bael fruits and products made from them, such as juice, jam, and pulp, is also expected to increase. Bael is known for its various health benefits, including its ability to improve digestion, boost immunity, and treat various ailments. To promote the production and processing of bael in Madhya Pradesh, the state government can provide financial incentives and subsidies to farmers and entrepreneurs engaged in bael farming and processing. They can also provide technical assistance and training programs to help farmers improve their production practices and increase their yield. The state can also establish processing units and market linkages to help farmers access markets and get better prices for their produce. With the right support and investment, bael production in Madhya Pradesh has the potential to become a lucrative business, contributing to the state's economy and providing employment opportunities for its residents.

Production Technology of Bael

Soil and Climate

Bael is bestowed with a natural gift to tolerate the extremes of high temperatures and during minimum soil moisture regime by shedding its leaves during summer. However, young plants need to be protected from the temperature below 40 C and desiccating hot winds. It can thrive well in swampy, alkaline and stony soils having pH range from 5.0 to 10.00, where many other fruit trees fail to establish. It can also be successfully grown in saline, sodic and sandy wastelands provided the soil is treated with gypsum and pyrite before plantation. The extent of hardiness of bael plants under Thar desert have been observed that the plant even after being buried under sand for 2-3 months are capable of rejuvenating itself and can tolerate salinity up to 9 dsm-1. However, well-drained sandy loam soil is ideally suitable for bael orchards

Improved bael varieties

Name of verities	Developed from
Narendra Bael-5, Narendra Bael-7 Narendra Bael-9, Narendra Bael-16 and Narendra Bael-17	N. D. University of Agriculture and Technology, Kumarganj, Faizabad, Uttar Pradesh
Pant Aparna, Pant Sujata Pant Shivani and Pant Urvashi	G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand
CISHB-1and CISHB-2	ICAR-Central Institute for Sub-tropical Horticulture, Lucknow, Uttar Pradesh
Goma Yashi, Thar Divya and Thar Neelkanth	Central Horticultural Experiment Station (ICAR-CIAH), Vejalpur (Godhra), Gujara

Propagation: Plant Propagation Traditionally bael was propagated by seeds. However, there is an inherent limitation associated with the seedling progenies and generally they are not true to type and hence, seed propagation is limited for the raising of rootstock only. True to type planting materials can be produced through vegetative means only. Among the vegetative propagation techniques; budding, grafting, layering and root suckers were common methods of multiplication of bael. Now-a-days, patch budding and soft wood grafting is being adopted commercially for multiplication of bael.

Seed Propagation: The bael seed has no dormancy; hence fresh seeds can be sown 2-3 cm deep in the nursery within 10-15 days after extraction. The fresh bael seeds germinate in 8-15 days after sowing during summer. Since, bael belongs to recalcitrant category; the seeds

cannot be stored for longer periods under normal storage conditions. The seedlings become ready for transplanting in spring or next Monsoon. If the seeds are sown too deep, seedling emergence is delayed and there may be chance of rotting due to poor aeration. The orchard raised by seedlings is not true to type and exhibits variability. Sometimes seeds germinate while fruits are kept on tree for longer duration after ripening of tree (vivipary).

Raising of Rootstocks in Nursery: Generally, the freshly extracted seeds are used for sowing, however, if required these can be stored up to 132 days with proper treatment. For storage, three days after extraction, the seeds should be treated with fungicides such as Thiram or Captan (1: 400) and stored in alkathene bags at room temperature. For better germination, higher survival and establishment, well rotten FYM should be mixed with the soil before sowing of seeds in polythene bags. For nursery raising after fungicidal treatment seeds can be sown in 2 cm depth in the nursery within 10-15 days of extraction in raised beds. Seeds may also be sown in polythene bags with ratio of soil, FYM and sand (2:1:1) as it facilitates an easy handling of rootstocks and grafted plants. Young seedlings should be protected from frost during winter under arid ecosystem and from intense radiation in rainfed semi-arid condition.

Vegetative Propagation

Selection of Mother Plant: For selecting mother plants of bael, following basic characteristics needs to be considered –

a) Plants should be consistently high yielding

b) Quality of fruit should be very good with all desired traits

c) Plant should be free from diseases and pests

d) It should be in full bearing stage.

Detopping and Promotion of Scion Shoot in Mother Plant: Under dryland condition, leaf senescence initiated from January and leaf fall starts from March in early varieties while March–April in late varieties. Leaf initiation starts after 15-25 days after leaf fall which varied in different varieties. It is very difficult to get scion shoot during May-June under dryland conditions, some thumb size branches of mother plant are cut during March. Number of new shoots emerges below the cut portion. These shoots are used for budding purposes. For accelerated growth of shoot, plants should be irrigated after one week after cutting of branches, whereas for softwood grafting one season old shoots are used when plant starts putting forth new leaves (Singh et al., 2014h). Under dryland condition, mother plant should be irrigated one day before separation of scion shoots for budding for better success and survival.

Selection of Bud Wood: Bud wood becomes available during the active growth period in rainy season. The buds stick (1months old) with well swollen and recently matured buds (but still not open) are collected. Immature and undeveloped buds from the upper part of the new shoots are not suitable. Similarly, over mature and inactive buds should not be used. The active growth period is indicated by easy and clear separation of the bark from the wood of scion sticks. After collection, the bud wood is often stored for some period or takes same time in transportation. During this period, considerable loss of survivability may take place. Bud woods retain good survival when kept under ventilated shade and wrapped in moist jute cloth.

Patch Budding: In this method, a healthy bud is selected from the axils of leaf. Leaf blade is

removed with the help of a sharp knife leaving petiole intact. The upper cut is given about 1-1.5 cm above bud which goes downwards up to 1.0-1.5 cm below the bud without wood portion and then lower cut is given about 1.0 cm below the bud. The similar rectangle incision is made on the rootstock by placing the bud on the root stocks to mark the exact size of the bud on them and after removing the bark of root stock, the bud is placed at the juncture. The bud is pressed by hand to remove open space if any and tied tightly except the place of bud with white polythene strip (200 gauge thickness and 2 cm wide). In case, the cuts on rootstock are wider, at least one side bark of scion and stock must be matched properly. The rootstock is cut about 10 cm above the bud to facilitate bud to sprout. After union, the top of the rootstock is cut a little above the bud union and polythene strips are removed carefully. Time of budding influences the survival of plant in the different varieties.

Grafting: Grafting is the most popular asexual propagation technique for bael. It involves the joining of a scion (a part of the desired plant variety) to a rootstock (a plant of a different variety). The most commonly used grafting techniques for bael are cleft grafting, whip grafting, and side grafting.

Air-layering: Air-layering is another asexual propagation technique used for bael. It involves making a cut around a branch or stem and applying rooting hormone to the wound. The wound is then wrapped in a moist medium, such as sphagnum moss or a mix of peat and perlite. Roots will develop from the wound, and the rooted branch can be removed and planted as a new tree.

Tissue culture: Tissue culture is a technique used for the mass production of disease-free and genetically identical bael plants. It involves the growth of plant cells or tissues in a sterile nutrient-rich medium under controlled conditions. Tissue culture can produce a large number of plants in a relatively short period.

Planting: The pits of 1m x 1m x 1m are dug and exposed for solarization to kill harmful soil organisms, providing better aeration in the future rooting zone and making provision for the nutritional equirement for healthy development of plants. The pits are filled with top soil mixed with 20- 25 kg FYM . In black cotton soil, sand should be mixed with FYM and top soil to provide proper aeration. The ideal time of planting under rainfed condition is June just after first rain in monsoon. The planting of bael is done at spacing of 5m to 8m depending upon the variety and agro-climatic conditions. Under rainfed condition of hot semi-arid ecosystem, planting of vegetatively propagated plants of dwarf varieties especially Goma Yashi can be done at 5m x 5m spacing to maximize the productivity.

Canopy Management: Canopy management of the crop deals with the development and maintenance of their structure in relation to the size and shape for maximization of productivity and quality. Tree vigor, light, temperature and humidity play a vital role in production of quality fruits. The crux of canopy management lies in fact, as how best we manipulate the tree vigour and maximum use of available sunlight and temperature to increase the productivity and minimize the adverse effect of weather. Pruning in bael is done to improve and regulate tree size and shape to achieve desired architecture of the canopy and also to reduce foliage density by removing branches of the tree. Bael is a cauliflorous and ramiflorous fruit tree and flowering may be seen on newly emerged shoots after prunning.

Diseases: Bael tree is not affected by serious diseases. Some of the diseases affect the growth and development of plant is discussed below:

Leaf Spots: Alternaria leaf spot [Alternaria alternata (Fr.) Keissler.] Initially brown or dark brown coloured spots of indefinite size appear on leaves with light brown or dark brown rings. Affected leaves blighten and fall. The disease is incited by Alternaria alternata (Fr.) Keissler. Spraying trees with 0.2 per cent copper oxychloride at 15 days interval helps in controlling this disease .

Black Leaf Spot (Isaropsis sp.) The disease is caused by fungus Isaropsis sp., which develops on both the surfaces of leaves as 2-3 mm black spot. For management of the disease, spraying of difolitan (0.2%) is recommended.

Bacterial Shot Hole and Fruit Canker: It is caused by Xanthomonas bilvae and it is characterized by minute, circular, brown, water soaked spots on susceptible leaf surface which initially measure less than 1 mm in size but later increase in size to 3-5 mm, turn brown and become concave with somewhat raised oily margin. Removal of more affected twigs followed by spray with Bordeaux mixture has been suggested to manage it. Spraying once or twice with streptomycin sulphate 250 ppm or Bordeaux mixture 1% at 12-15 days interval effectively control the disease.

Insects and Pests: Generally, bael is free from the serious pest's problem but few insect pests are known to cause damage the crop, especially when environmental conditions are very conducive to pest attack.

Lemon Butterflies (Papilio demoleus Linnaeus) found throughout the year in gardens and orchards, visiting various flowers but causing no damage. However, the caterpillars feed on foliage and cause economic loss.

Harvesting: Bael fruits should be harvested when they are fully ripe but still firm. The fruit can be picked by hand or with the help of a harvesting tool. The fruit should be handled carefully to avoid bruising.

Sorting: After harvesting, the bael fruits should be sorted to remove any damaged or diseased fruits. This will help prevent the spread of disease and reduce the risk of spoilage.

Cleaning: The fruits should be cleaned to remove any dirt, debris or fungal spores that may be present on the surface. This can be done by washing the fruits with clean water or by wiping them with a clean cloth.

Storage: Bael fruits should be stored in a cool and dry place with good ventilation. The ideal temperature for storage is between 10-15°C. If the temperature is too low, the fruits may become damaged due to frost. If the temperature is too high, the fruits may spoil quickly.

Packaging: Bael fruits can be packed in crates or baskets lined with clean and dry material to protect them from damage during transportation. The packaging should be done carefully to avoid bruising or crushing the fruits.

Ripening: Bael fruits can be ripened by storing them at room temperature for a few days. The fruits should be checked regularly to ensure that they do not become overripe or spoiled.

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Innovative Approaches for Crop Protection [Disease and Pest Management]

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ABSTRACT

With the goal to ensure the health, production, and sustainability of crops in the face of several difficulties like pests, diseases, and environmental conditions, crop protection is an essential component of modern agriculture. Traditional crop protection methods usually employ chemical pesticides, which can have adverse effects on the environment, human health, and beneficial organisms. Therefore, there is an urgent need for new approaches that provide effective crop protection while minimising the shortcomings of current techniques. One important area of innovation is the creation and implementation of integrated pest control (IPM) strategies. The employment of natural enemies including predatory insects, parasitic wasps, and beneficial microorganisms is gaining popularity as a workable substitute for chemical insecticides. Genetically modified (GM) crops with improved resistance to pests, diseases, and environmental challenges have also been made possible by advances in biotechnology and genetic engineering. These crops frequently have increased yields, fewer pesticide needs, and better nutritional profiles, addressing issues with both food security and sustainability. In addition to IPM and GM crops, crop protection practises are being transformed by precision agriculture and digital technologies. Farmers can monitor crop health, identify disease outbreaks, and allocate resources more effectively thanks to remote sensing, drones, and satellite imagery. This data-driven methodology enables prompt interventions and tailored input applications, reducing waste and boosting efficiency. This abstract provides a thorough summary of recent developments and ground-breaking crop protection techniques. It investigates the new tendencies and strategies that are revolutionising how farmers protect their crops and promoting sustainable agriculture

methods.

INTRODUCTION

Food security for a growing population and meeting the world's food demand are both critically dependent on agriculture (FAO, 2020). However, there are several obstacles to agricultural production, such as pests, illnesses, and environmental pressures that can drastically lower yields and endanger farmers' livelihoods. Chemical pesticides, which have a long history in traditional crop protection techniques and have shown to be effective but have a number of disadvantages, are still used. Overuse of pesticides has been linked to environmental pollution, negative effects on beneficial creatures, pest resistance development, and potential health problems for humans (Pretty, 2008).

Innovative crop protection methods must be adopted with careful evaluation of any hazards, particularly those related to biosafety, socioeconomic effects, and public acceptance (Smyth et al., 2020). To enable the secure and ethical use of these technologies, thorough risk analysis and strong regulatory frameworks are required.

This review attempts to examine new developments and novel crop protection strategies, highlighting both their advantages and disadvantages. Farmers may alleviate the negative consequences of traditional practises, lessen their negative effects on the environment, and create sustainable agricultural systems that guarantee both food security and ecological resilience by adopting these methods.

Application of Biotechnology:

A crucial component of biotechnology is genetic engineering, which enables the insertion of particular genes into crop plants to impart resistance to pathogens, illnesses, and abiotic stresses (Chen et al., 2018). Insect-resistant Bt crops and virus-resistant plants are two examples of genetically modified (GM) crops that have shown enhanced resistance to specific pests and illnesses, resulting in lower production losses and a reduced need for chemical pesticides (Kumar et al., 2019). A potent biotechnological tool known as RNA interference (RNAi) technology can be used to silence particular genes in pests or pathogens, affecting their essential functions and limiting their capacity to cause harm (Zotti et al., 2018). Marker-assisted selection and genome editing are two plant molecular breeding techniques that allow for precise alteration of plant genomes to increase resistance to pests and diseases (Mishra et al., 2021).

The development of new crop protection measures is facilitated by the use of omics technologies, such as genomics, proteomics, and metabolomics, which offer comprehensive insights into the molecular mechanisms underpinning plant-pathogen interactions (Pandey et al., 2017). The synthesis of secondary metabolites and antimicrobial peptides derived from plants that have broad-spectrum antibacterial action and can be used as natural defence chemicals against pathogens and pests is also facilitated by biotechnology (Lee et al., 2019).

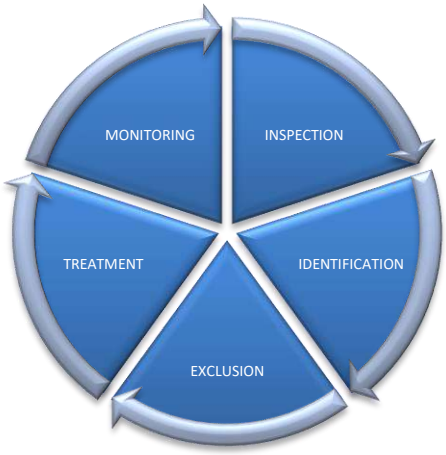
Application of Precision Agriculture:

By enabling real-time monitoring, precise interventions, and targeted resource allocation, precision agriculture, made possible by cutting-edge technologies and data analytics, has revolutionised crop protection practises (Gebbers and Adamchuk, 2010). The rapid and precise assessment of crop health, pest infestations, and disease outbreaks is made

possible by remote sensing technology, such as satellite imaging and airborne drones (Vangeyte et al., 2018).

Large amounts of data gathered from remote sensing can be processed by image analysis algorithms and machine learning techniques, which can also enable early identification of pest and disease symptoms, enabling timely interventions (Huang et al., 2021). The exact mapping and monitoring of pest and disease hotspots made possible by GPS and Geographic Information System (GIS) technology enables targeted interventions and reduces the need for pesticides (Sánchez-Hermosilla et al., 2019).

Application of Integrated Pest Management [IPM]:



IPM (Integrated Pest Management) is a cutting-edge and environmentally friendly method of crop protection that incorporates a number of techniques to efficiently manage pests while minimising the usage of chemical pesticides (van Lenteren, 2012). In order to achieve long-term pest management objectives, IPM emphasises the integration of a variety of pest control strategies, including biological control, cultural practises, monitoring, and targeted pesticide usage (Kogan, 1998). IPM emphasises the employment of numerous techniques, minimises pesticide use, promotes ecological balance, and lessens the development of pesticide resistance in order to provide an innovative and sustainable strategy to crop protection (Huang et al., 2016).

Conclusion and future aspects:

Innovative methods of crop protection, such biotechnology, precision farming, and integrated pest management (IPM), hold great promise for overcoming pest control difficulties while guaranteeing environmentally sound and sustainable agricultural practises. These methods give farmers practical tools and techniques to safeguard their crops against pests, diseases, and environmental challenges, which boosts output, decreases dependency on chemical pesticides, and reduces negative environmental effects.

- Crop types with increased resistance to pests and diseases will continue to develop as a result of biotechnology developments, including gene editing methods like CRISPR/Cas9 (Chen et al., 2018).

- Precision agriculture will be able to identify, monitor, and make decisions about pests with more accuracy and automation because to the integration of artificial intelligence (AI) and machine learning algorithms (Andjar et al., 2019).

- The application of nanotechnology in crop protection has a lot of promise, including the creation of formulations based on nanotechnology for controlled release systems and the targeted administration of pesticides (Raliya and Tarafdar, 2017).

- Predictive pest management systems that can foresee pest outbreaks and optimise control methods will be developed thanks to the adoption of data-driven methodologies, including big data analytics and predictive modelling (Andjar et al., 2019).

- Autonomous monitoring and intervention systems for effective and sustainable crop protection will be produced through the integration of several cutting-edge technologies, such as merging remote sensing, robotics, and AI (Li et al., 2020).

Overall, cutting-edge technology integration and advancement, together with the use of multidisciplinary strategies that take ecological, economic, and social concerns into account, are key to the future of innovative crop protection.

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The Emergence of Nano Fertilizers: Small Size, Big Impact

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ABSTRACT

Nano fertilizers (NFs) reduce fertilizer requirements in agriculture, enhance nutrient uptake efficiency, and reduce fertilizer loss due to runoff and leaching. Nano-fertilizers have shown great promise for long-term use in soil fertility and crop production while having little or no environmental impact. Nano-fertilizers have sub-microscopic diameters, a significant surface area-to-volume ratio, the ability to encapsulate nutrients, and better mobility, which may boost plant nutrient access and agricultural productivity. Nano-fertilizers are regarded as a deliverable 'smart system of nutrients' due to these qualities. However, the challenges in the agroecosystem go beyond current advances. Nutrient supply, for example, remains a difficulty due to differences in soil physicochemical characteristics, moisture, and other agroecological factors. Furthermore, NFs have demonstrated encouraging outcomes in a range of plant species when employed in soil or foliar treatments. The primary elements of nanomaterials include micro- and macronutrient precursors, as well as their nanoscale characteristics. This article discusses novel approaches to their use as a Nano Fertiliser, routes of application and the process of absorption in plant tissues. Furthermore, the analysis examines potential flaws and future issues for the commercial agricultural application of NFs.

INTRODUCTION

Farmers struggle mightily to feed the world's expanding population even though agriculture is the foundation of the global economy. In order to develop sustainable agriculture, soil fertility is essential. Fertilizers have long been used to

increase agricultural yield and soil fertility. On the other hand, traditional fertilizers have substantial drawbacks, such as nutrient losses due to leaching, volatilization, and runoff, which worsen the environment. To get over these limitations, researchers have created new types of nano fertilizers. Nano-enabled products, such as nano-insecticides, nano-pesticides, and nano-fertilizers, play an essential role in sustainable agriculture because of their smaller size (1-100 nm) and larger surface area (Raguraj et al. 2020). According to a recent study, nanoparticles could be utilized to control plant pests such as insects, fungi, and weeds (Ali. et al. 2020; Sood et al. 2021). It has been proposed that NFs could more effectively deliver nutrients to plants, hence greatly increasing crop productivity (Abdelmigid et al. 2022). Nanoscale fertilizers are substances that support plant growth and increase agricultural production. Nanoparticles with a size range of one to one hundred nanometres commonly make up these materials. Numerous methods, including foliar spraying, seed coating, and soil inclusion, can be used to apply them to plants.

Nano fertilizer Synthesis and Mechanism of Action:

Nano fertilizers are a form of fertilizer that contains nanoparticles, which can aid improve fertilization efficiency and effectiveness in plants. The following steps are commonly included in the synthesis of nano fertilizers:

- **Material selection for nanoparticles:**

The first step in creating nano fertilizers is to choose the proper nanoparticle material to serve as the fertilizer carrier. Titanium dioxide, iron oxide, and silica are examples of commonly used nanoparticle materials.

Nanoparticle suspension preparation: The selected nanoparticle material is next prepared as a suspension in water or another suitable solvent. This can be accomplished by dissolving the nanoparticles in a solvent and then sonicating or agitating the mixture to ensure that the nanoparticles are evenly distributed.

Fertilizer addition:

After preparing the nanoparticle suspension, the necessary fertilizer is applied to the mixture. The amount of fertilizer added will be determined by the required concentration as well as the type of fertilizer utilized.

Mixing and drying:

To ensure that the fertilizer is properly distributed throughout the nanoparticle suspension, the nanoparticle-fertilizer combination is vigorously mixed. After that, the mixture is dried using an appropriate drying method, such as freeze or spray drying.

Characterization:

Finally, the nano fertilizer is characterized using various analytical techniques such as scanning electron microscopy, X-ray diffraction, and Fourier transforms infrared spectroscopy to ensure that it has the desired properties and that the nanoparticles are well dispersed and stable.

Table-1 lists the many types of nano fertilizers currently on the market. Notably, synthesizing nano fertilizers necessitates knowledge and specialized equipment to ensure that the nanoparticles are correctly synthesized and disseminated. When handling nanoparticles, it is critical to follow adequate safety protocols because they might constitute a health danger if not handled appropriately.

Table 1. Different types of Nano fertilizer

Sl. no.	Type of Nano fertilizer	Composition	Particle Size	Potential Advantages
1	Nano-nitrogen	Nitrogen nanoparticles	10-100 nm	It promotes plant

	fertilizers			development, increases the effectiveness with which nitrogen is used, lowers leaching losses, and lessens environmental contamination
2	Nano-phosphorus fertilizers	Phosphorus nanoparticles	10-100nm	increases the availability of phosphorus, accelerates plant growth, improves root formation, and increases crop output.
3	Nano-potassium fertilizers	Potassium nanoparticles	20-200 nm	It stimulates photosynthesis, increases nutrient uptake, optimizes water consumption, and increases crop production.
4	Nano-iron fertilizers	Iron nanoparticles	10-100 nm	Improves plant growth, facilitates nutrient uptake, and boosts agricultural output by increasing photosynthesis and chlorophyll content.

Nano fertilizer Mechanism of Action:

1. **Increased Nutrient intake:**

Because nanoparticles are tiny in size, they can more easily penetrate plant cell walls, enhancing nutrient intake. Nano-sized zinc oxide particles, for example, have been demonstrated to improve zinc uptake by plants.

2. **Increased Plant Growth:**

Nano fertilizers can boost plant growth by boosting chlorophyll content, photosynthetic rate, and water use efficiency. Nano-sized silicon particles, for example, have been demonstrated to boost tomato plant growth and yield.

3. **Increased output:**

Nano fertilizers can boost output by increasing plant nutrient content and lowering nutrient loss through leaching. For example, nano-sized calcium carbonate particles have been proven to boost rice crop production.

The Advantages of Nano fertilizers:

Nano fertilizers have been widely researched for their potential agricultural applications. Here are some of the most promising nano fertilizer applications:

1. Improved nutrition delivery: By enhancing the solubility and uptake of critical nutrients, nano fertilizers can improve the efficiency of nutrient delivery to plants. For example, found that zinc oxide nanoparticles could boost plant phosphorus uptake.

2. Nutrient release control: Nano fertilizers can slowly release nutrients, eliminating the requirement for frequent fertilizer treatments. For example, found that slow-release urea nanoparticles could boost nitrogen uptake by plants while reducing fertilizer waste.

3. Increased crop yields: Nano fertilizers can boost crop yields by increasing nutrient uptake, decreasing nutrient waste, and promoting plant growth. For example, found that copper oxide nanoparticles could boost tomato plant growth and yield.

4. Pollution reduction: Nano fertilizers can help to minimize pollution by reducing the amount of fertilizer required and preventing nutrient runoff. For example, found that zinc

oxide nanoparticles could reduce nitrogen and phosphorus leakage from the soil.

5. Increased resilience to abiotic stress: Nano fertilizers can boost plant resistance to abiotic stresses including drought and excessive salinity. For example, found that titanium dioxide nanoparticles could improve wheat plant drought tolerance.

CRISPR/Cas9 gene editing and nanotechnology:

Nano fertilizers and CRISPR/Cas9 technology are both cutting-edge technologies with promising applications. Agriculture has the potential to revolutionize. Nano fertilizers are fertilizers that use nanotechnology to improve plant nutrient uptake, reduce fertilizer waste, and increase plant growth. Crop yields. These fertilizers are engineered to provide nutrients precisely where they are most required, allowing plants to grow more effectively. CRISPR/Cas9, on the other hand, is a potent gene-editing technique that enables scientists to make precise modifications to cell DNA sequences. This method has the potential to significantly increase crop production while also making plants more resistant to pests and illnesses. Plants with higher nutrient uptake and disease resistance can be created using these two technologies. For example, researchers at the University of Nebraska-Lincoln utilized CRISPR/Cas9 to change genes in plants to improve their ability to absorb iron from the soil and then used nano fertilizers to distribute iron precisely to the regions of the plant where it is most required. Another example comes from a study published in Nature Communications in which researchers utilized CRISPR/Cas9 to make wheat plants resistant to a severe fungal disease known as powdery mildew. They then employed micro fertilizers to give nutrients to the plants, resulting in a 20% increase in wheat yield when compared to untreated plants.

Problems and potential issues:

While nano fertilizers have numerous potential benefits for agriculture, they also pose a number of obstacles and potential dangers. Here are a few of the most important:

Environmental impact:

There are worries regarding nano fertilizer's possible environmental impact, specifically their ability to collect in soil and water and disrupt ecosystems. According to one study, silver nanoparticles in wastewater irrigation can concentrate in the soil and impact soil microbes, plant growth, and soil enzymes.

1. **Health concerns:**

Concerns have been raised concerning the potential health dangers connected with nano fertilizers, particularly for employees exposed to these particles during manufacture or application. A study found that exposing rats to silver nanoparticles caused lung inflammation and oxidative stress.

2. **Lack of regulatory direction:**

There is currently a lack of regulatory guidelines for the use of nano fertilizers in agriculture, which could lead to possible hazards and uncertainties. It is critical to create regulatory frameworks that address the possible dangers of these particles while also ensuring their safe and responsible use.

3. **Cost:**

The production of nano fertilizers can be costly, which may limit their application in specific areas or for some crops. To make nano fertilizers more affordable to farmers, production costs must be reduced.

4. **Toxicity:**

The toxicity of nano fertilizers is an important topic of research since there is the worry that their use may have harmful consequences on

human health, animal health, and the environment. Several research has been conducted to evaluate the cytotoxic behavior of various types of nano fertilizers, with variable results. According to one study published in the journal Environmental Science and Technology, using copper oxide nanoparticles as a fertilizing agent in soil had a negative impact on earthworms and soil microbes. According to the study, these detrimental effects were caused by the release of copper ions from the nanoparticles, which are poisonous to living creatures.

5. Limited research:

There has been little long-term research on the impact of nano fertilizers on plant growth, soil health, and ecosystem functioning. More research is required to properly comprehend the possible benefits and hazards of these particles.

CONCLUSION:

Nano fertilizers have the potential to revolutionize agriculture by providing a long-term answer to the issues that modern agriculture faces. Their use can boost crop yields, reduce fertilizer waste, and improve plant nutrient absorption while lowering agriculture's environmental effects. However, their safety and regulatory concerns must be addressed, and their costs must be decreased in order to make them more affordable to farmers in underdeveloped nations. More research and development are required to realize the full potential of nano fertilizers.

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Introduction to Mushroom

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ABSTRACT

Mushrooms are of edible and poisonous appears either below ground (hypogeous) or above ground (epigeous) where they may be picked by hand. Edibility may be defined by criteria that include absence of poisonous effects on humans and desirable taste and aroma. Digestible mushrooms include many fungal species that are either harvested wild or cultivated, poisonous mushrooms contain a variety of toxins that can differ markedly in toxicity. The most common consequence of mushroom poisoning is simply gastrointestinal upset. Most "poisonous" mushrooms contain gastrointestinal irritants that cause vomiting and diarrhea. Toxins are of Alpha-Amanitin, orellanine, Monomethylhydrazine, Muscimol, Arabitol, Ergotamine, many investigations have recently reclassified some species of mushrooms from edible to poisonous has made older classifications insufficient at describing what now is known about the different species of fungi that are harmful to humans.

INTRODUCTION

Mushroom is a eukaryotic macro fungus, fleshy sporocarp (fruit), achlorophyllous; heterotrophic organism belongs to basidiomycotina sub division. Mushroom can play a significant role contributing to the livelihood of rural and urban dwellers, through income generation. Mushrooms can make a valuable dietary addition through protein and various micronutrients and, coupled with their medicinal properties, mushroom cultivation can represent a valuable small-scale enterprise

option. Around 1200 species of fungi that considered to mushrooms, with at least 200 species showing various amount of edibility (Chang, 1999). Twelve species are commonly grown for food and/or medicinal purposes, across tropical and temperate zones, counting the Common mushroom (Agaricus), Shiitake (Lentinus), Oyster (Pleurotus), Straw (Volvariella), Lion's Head or Pom Pom (Hericium), Ear (Auricularis), Ganoderma (Reishi), Maitake (Grifola frondosa), Winter (Flammulina), White jelly (Tremella), Nameko (Pholiota), and Shaggy Mane mushrooms (Coprinus). The viable market dominated by White button mushroom (Agaricus bisporus), Oyster mushroom (Pleurotus spp) and Tropical paddy straw mushroom (Volvariella spp.), recently cultivation of Milky mushroom (Calocybe indica) has been started (Rai et al., 2005).

Difference between edible and poisonous mushroom

Amanita phalloides group causes the most hazardous type of mushroom poisoning species; contain a variety of different toxins that can differ markedly in toxicity. The most common reason for this misidentification is close similarity in terms of color and morphology of the toxic mushroom species with. Mushroom with red cap, presence of white gills and ring at its stalk is considered as poisonous mushroom (eg. Amanita phalloides), edible mushroom with brown or white cap with brown gills without ring at its stalk.

Fig; 1. Poisonous mushroom (Amanita spp.) Fig: 2. Edible milky mushroom (Calocybe indica) Fig: 3. Edible oyster mushroom (Pleurotus ostreatus)

History of mushroom

Claudius Caesar was the 4th Roman emperor, verdict from AD 41 to 54. Claudius was murdered by his wife, Agrippina by severing him with poisonous mushroom Amanita phalloides. Psilocybin mushrooms, often known as magic mushroom. Prehistoric rock arts near Villar del Humo in Spain, suggest that Psilocybe hispanica was used in religious rituals 6,000 years ago. The hallucinogenic species of the Psilocybe genus have a record of use among the native peoples of Mesoamerica for religious communion, divination, and healing, from pre-Columbian times to the present day. Mushroom stones and motifs have been found in Guatemala.

Various Mushroom Stones (approx 1 ft tall - 1000 B.C. to 500 A.D.)

What is spawn?

Seed of mushroom is known as spawn, generally mushroom reproduces through spore, and spore germinate to produce germ tube followed by mycelium. Sorghum seed are more suitable for spawn preparation. 1 kg sorghum seeds are boiled at 1000C form minutes. Followed by addition of 20g hydrated lime to shade dried seeds. Seeds are filled 3/4th glass bottle closed with non-absorbable cotton plug and sterilized in autoclave at 1210C , 15 lbs pressure for 20 minutes. Inoculate mycelium of required mushroom aseptically under laminar air flow chamber and incubate at 280C for 15 days. White mycelium grows on surface of sorghum seed indicates that spawn is ready to use

Oyster mushroom

Oyster mushroom usually referred as 'Dhingri' in India, is basidiomycetes and belongs to the genus 'Pleurotus'. The name Pleurotus has its origin from Greek word, 'Pleuro' that means shaped laterally or lateral position of the stalk or stem

Procedure for cultivation of oyster mushroom

Requirements

1. Mushroom cultivation shed

<table>
<tr><td rowspan="2">Dark room</td><td rowspan="2">Light room</td><td>LAB</td><td>sale counter</td></tr>
<tr><td colspan="2">Straw store room</td></tr>
</table>

2. Spawn

3. Paddy straw

4. Polyenthene bags (30x 15 inch)

5. Carbendazium 7.5g

6. Formaldehyde 125 ml

Steps for cultivation of oyster mushroom

(i) Preparation or procurement of spawn

(ii) Substrate preparation

(iii) Spawning of substrate

(iv) Crop management

(i) Spawn Preparation

A pure culture of Pleurotus sp. is needed for inoculation on sterilized substrate. he mycelium color of Pleurotus florida, an oyster species, is purely white (Chitra etal., 2018) It takes 10-15 days for mycelial growth on cereal grains. It has been reported that sorghum and millet grains are superior over wheat grains.

(ii) Substrate Preparation

Oyster mushroom can be cultivated on a large number of agro-wastes having cellulose and lignin which helps in more enzyme production of cellulose that is correlated with more yield. These include straw of paddy, wheat and finger millet, stalk and leaves of maize, millets and cotton, used citronella leaf, sugarcane bagasse, saw dust, jute and cotton waste, de-hulled corncobs, pea nut shells, dried grasses, sunflower stalks, used tea leaf waste, discarded waste paper and synthetic compost of button mushrooms etc. It can also be cultivated by using industrial wastes like paper mill sludge's, coffee byproducts, tobacco waste, apple pomace etc (Uddin et al., 2011)..

The popular methods of substrate preparation are:

- Steam Pasteurization;
- Hot Water Treatment;
- Sterile Technique (Till method);
- Fermentation or Composting; and
- Chemical Sterilization.

(iii) Spawning of Substrate

Freshly prepared (20-30 days old) grain spawn is best for spawning. Old spawn (3-6 months) stored at room temperature (at 20-300 C) forms a very thick mat like structure due to mycelium aggregation and sometimes young pinheads and fruit bodies start developing in the spawn bottle itself. The spawning should be done in a pre-fumigated room (48hrs.with 2% formaldehyde).

(iv) Crop Management

(A) Incubation

Spawned bags, trays or boxes are arranged in a dark cropping room on raised platforms or shelves for mycelium colonization of the substrate. Although mycelium can grow from

10 to 330 C, but the optimum temperature for spawn running lies between 22 to 260 C. When the mycelium has fully colonized the substrate, the fungus is ready for fruiting.

(B) Fruiting

Contaminated bags with moulds may be discarded while bags with patchy mycelia growth may be left for few more days to complete mycelia growth. While various species require different temperature regimes all require high humidity (70-85%) during fruiting. Frequent spraying of water is required in the cropping room depending upon moister content available on the bed.

CONCLUSION

At this cutting era population is been increasing, need to be focused on food safety although production of quality food is reduced, moreover climate change and land transformation to buildings so there is much needed focus on terrace farming and mushroom cultivation is an alternative source for people in urban cities.

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Enriched Vermicompost Production- A Scope for Sustainable Agriculture

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Matheyarasu, R. and Rajarathinam, P.2023. Enriched Vermicompost Production- A Scope for Sustainable Agriculture. *Vigyan Varta* SP3: 59-62.

ABSTRACT

The indiscriminate usage of chemical fertilizers and pesticide has led to deleterious effects on the natural environment and residual effect in the food grains. Enriched vermicompost refers to organic manure (Vermicast). This is mixed with beneficial microbial inoculants such as Azotobacter, Phosphobacter, Azospirillum, Trichoderma, Pseudomonas and Beauveria. Enriched Vermicompost Technology (EVT) is an advanced concept for sustainable agriculture and that is gaining more importance in the current era, targeting conservative agriculture. Enriched vermicompost contain nitrogen (1.8-2.1 %), phosphorus (1.1-1.12%), potassium (1.15-1.40%) and CN ratio (14-20 %) and the recommendation for vegetable crops 500-1000 kg/acre, for fruit crops 8-10 kg/tree and flower crops 500 g/plant. Compared to the conventional method of chemical fertilizers and pesticides, Enriched vermicompost has benefits of eco-friendliness, disease - free crops, increased yields, ultimately quality improvement and more income.

INTRODUCTION

Vermicompost is organic manure bioprocessed by earthworms, which also consists of wormcastings including humus, live earthworms, their cocoons, and other microorganisms (Nagavallemma et al., 2004). Enriched vermicompost refers to organic manure (vermicast), enriched with beneficial microbial inoculants such as Azotobacter, Phosphobacter, Azospirillum, Trichoderma, Pseudomonas and Beauveria (Kumar and Singh., 2000). Enriched vermicompost is a

modern concept of utilization of locally available waste materials such as agricultural crop residues (maize, sorghum, cumbu / bajra), industrial waste, coirpith, animal waste, cow dung and water hyacinth (Eichhornia crassipes) as substrate for vermicomposting (Lindsey and Hirt, 1999). Among these substrates water hyacinth is a cheapest and easily available waste with richest sources of nutrients (especially potassium) (Lindsey and Hirt, 1999; Jafari. 2010). Water hyacinth is a serious threat to aquatic ecosystem and management of water hyacinth remains global need (Matheyarasu. 2010). Re-use of this plant plays a vital role in their management (Jafari. 2010). The profuse growth of water hyacinth has encouraged many to find an easiest way to manage. At a marginal level, water hyacinth can be used as a soil mulch material, substrate for producing organic manure (vermicompost & compost), mushroom, biogas, paper production, animal feed and wastewater and industrial effluent treatment (Lindsey and Hirt, 1999). Vermicomposting is an appropriate method for reutilizing the water hyacinth biomass or stubbles (Table-1) (Matheyarasu. 2010).

Enriched vermicompost production technology

Enriched vermicompost technology is an advanced concept of reutilization or recycling of water hyacinth waste. The harvested stubbles or biomass is considered as a valuable feedstock for enriched vermicompost (Gajalakshmi et al., 2001). This method can also help to enhance the chemical and biochemical properties of vermicompost prepared by deep tank system and enriched same with the liquid beneficial microbial inoculants. There are eleven steps involved in the production of enriched vermicompost from the water hyacinth waste, all the steps involved in enriched vermicompost technology as same as vermicompost except the enrichment before packaging (Figure-1) (Nagavallemma et al., 2004). The locally available waste material such as crop residues, water hyacinth, coirpith, animal wastes, and industrial waste are used as raw material for the production of enriched compost (Lindsey and Hirt, 1999). Among these water hyacinth is the cheapest and largely available waste. The selected composting sites needs to fulfill the following basic requirements such as, plenty of waste, electricity, road, transport, labour availability, water and shade (Gajalakshmi et al., 2001). The after harvested or collected biomass (water hyacinth) from the lakes, ponds and river can be used as a raw material for enriched vermicompost production. Water hyacinth waste is subjected to a process called pre-composting depending on the condition of the waste; the pre-composted (sun dry) waste materials are brown or dark in colour and reduced volume into half of original. Pre-composting is simple process mainly done to reduce the volume of wastes into half; In addition to volume reduction, pre-composting leads to partial breaks down of waste materials, enhancing microbial colonization, increases the composting efficiency and reduces the time for composting (Nair et al., 2006). Once these pre-composting is completed, waste used as a feed stock and it filled in the well prepared deep tank, up to 75% of their height (usually 5m×1m×1m), the size of the tank vary according to the availability of waste material. The preconditioned waste materials will be covered with farm yard manure and crop stubbles. In the next stage the waste covered with farm yard manure and crops stubbles and finally sprinkling of fresh cow dung slurry should be done immediately after the inoculation of earthworms (Eisenia foetida) and the top layer covered with the mulch material to avoid excessive moisture loss. In the maturation period watering twice a day is must. At maturation (after 120 days) the moisture content can be brought down by stopping the addition of water (Kumar and Singh. 2001).

This ensures drying of compost and migration of worms to the vermibed. The mature compost is a fine loose granular mass. After harvesting, sieving should be carried out with the harvested material. This process removes young worm population from vermicast. Addition of beneficial microbial inoculants to vermicast is called as enrichment. The harvested vermicompost enriched with beneficial microbial inoculants such as Azotobacter (provides nitrogen source and improve soil physical property), Phosphobacter (provides increased usage of phosphotic fertilizers applied in the soil). Azospirillum (improves growth of the plant and fixes nitrogen), Trichoderma, Pseudomonas (control wilt causing pathogens and nematodes) and Beauveria (controls soil grubs). Enrichment method mainly enhances the physio-chemical and bio-chemical properties of vermicompost. Table.2 describes the nutritional comparison between compost, vermicompost and enriched vermicompost. Enriched vermicompost contains nitrogen (1.8-2.1 %), phosphorus (1.1-1.125%), potassium (1.15-1.40%) and CN ratio of 14-20 %.The presence of humic acid, phosphatase enzyme activity, plant growth hormones and vitamin precursors from earthworm's excretion induce the growth and development of plants. One tonne of waste materials yield 750-850 kg of vermicompost. The recommended rate of application varies considerably from crop to crop (Table-3).

CONCLUSION

The present day food production largely depends on chemical fertilizers and pesticides. This indiscriminate use of chemicals leads to environmental degradation such as increased cost of production, pollution and global warming. Enriched vermicompost have the potential benefits over chemical fertilizer, which includes improvement in soil texture, enrichment of soil nutrients and consequently result in increased productivity, conservation of natural resources, improvements in crop yields (quantitatively and qualitatively). This enriched vermicompost can also act as a bio-pesticide, thereby conserving the beneficial biota of an ecosystem. Hence, enriched vermicompost is the most welcoming and sustainable alternative for the chemical fertilizers and farmer-friendly approach to protect our environmental resources for the future generation.

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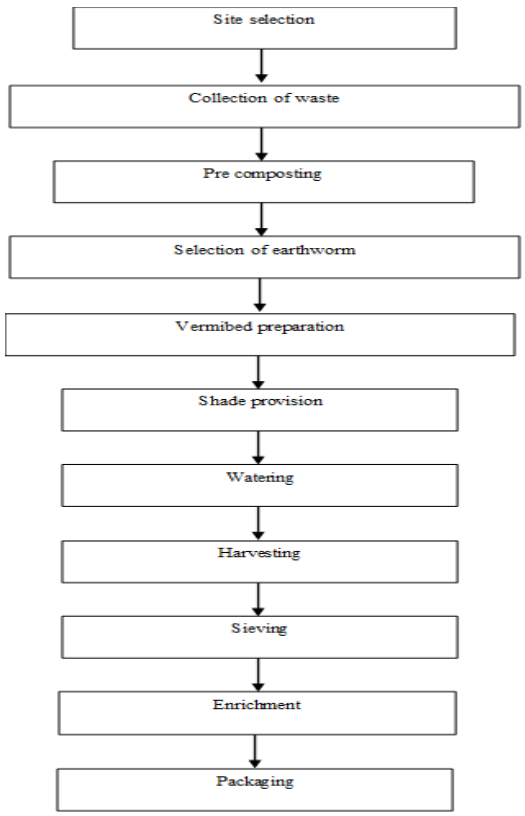
Figure captions

Figure: 1. Enriched vermicompost production flow-chart)



Tables

Table.1 Potential uses of water hyacinth in some selected region.

Region	Uses / Reuses	Region	Uses / Reuses
India	Vermicompost, Compost, Mulching	Bangladesh	Animal feed Yarn and rope Bio energy
China	Biogas production Animal feed Fertilizer Water purification	East Africa	Animal feed –pigs Fertilizer, Crafts and furniture Charcoal briquetting Hydroponics
References: Gajalakshmi et al., 2001. Jafari. 2010. Jianguing et al., 2001.Linddesy and Hirt. 1999.			

Table 2. Nutritional comparison of compost, vermicompost and enriched vermicompost (in %)

Nutrient	Vermicompost	Enriched vermicompost	Compost
Nitrogen	0.51-1.61	1.18-2.1	0.8
Phosphorus	0.19-1.02	1.1-1.25	0.35
Potassium	0.15-.0.73	1.15-1.40	0.48
Organic carbon	9.8-13.4	-	12.2
Source: Adapted from Nagavallamma et al., 2004.			

Table 3. Recommended dose of enriched vermicompost (vermicel)

Crop / Soil type	Recommended dose
Nursery beds	1.5-3 kg / sq.m
Main field	500-750 kg/acre
Potted plants / Indoor plants	100gms/plant
Kitchen gardens	5-10 kg/sq.ft
Lawn	0.5-1kg /10 sq.ft
Ornamental trees	5 kg/ tree
Land reclamation	2.5 mt /acre
Vegetable crops-Brinjal, cabbage, potato	500-100Kg/acre
Fruit crops - Mango, coconut, citrus, orange	8-10 kg/tree
Flower crops -Roja, Jasmine	500g/plant
Plantation crops-Coffee, banana, papaya	2-3kg/plant

Black Garlic: A Wonder Plant

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ABSTRACT

Garlic is important spice crop and used as a medicinal herb from time immemorial. It contains sulphur containing pungent compounds allicin, having antioxidant property and more health benefits. As scientific progress in garlic, the black garlic has been produced from fresh garlic by maillered reaction at high temperature of (40-60 °C) and high humidity (90 %) for period of 10 days. Result of fermentation, fresh garlic changes into black colour with less pungent of allicin, higher S-Allycysteine compound, antioxidant and medicinal value. So it is concluded that, black garlic can utilized as one of the functional food, food supplements, as well as medical purposes in our diet.

INTRODUCTION

Garlic has been used as a medicinal herb from time immemorial where its benefits have been observed and scientifically proven. Historical records indicate that garlic had been used as medicine as a diuretic, digestive aid, antibiotic, anti-parasitic, for colds, infections and a wide variety of other ailments. These benefits apply to White garlic however recently there has been a rise in popularity of Black Garlic.

Black garlic (BG) is simply fresh garlic (Allium sativum L.) that has been fermented for a period of time. The process turns garlic cloves dark, gives them a sweet taste, and alters their consistency to chewy and jelly-like texture that is free from odour and has a taste similar to figs. The duration of fermentation varies depending on cultures, manufacturers, and purposes. Exact origins of BG are unknown and controversial. However, BG has long been consumed in South Korea, Japan,

and Thailand for centuries, and was introduced into Taiwan and other countries around 10 years ago.

Procedure for black garlic

Black garlic (Allium sativum L.) is a fermented product of garlic made by treating fresh garlic for an average of 10 days at high temperatures (40 to 60 °C) and high humidity. It undergoes a Maillard reaction, which causes different compounds to form during the reaction. The reaction also darkens white garlic into a black colour. Processes vary widely across suppliers, with aging treatment ranging from 4 to 40 days. Some studies found that 21 days of treatment at 70 degrees and 90% relative humidity was best for black garlic's antioxidant abilities. When garlic undergoes treatment to turn into black garlic, allicin, the component that gives fresh garlic its notorious odour, is converted into a variety of antioxidant compounds.

Biochemical property

From a nutritional point of view, Black garlic has a much higher content of allicin, the active ingredient in White garlic that imparts its benefits, but without the odour. Additionally, Black garlic is rich in amino acids and has almost double the amount of antioxidants when compared to White garlic. The changes of physicochemical properties are the main reasons for enhanced bioactivity of BG compared with fresh garlic. Black garlic also contains an additional very specific compound called S-Allycysteine (SAC) in very high concentrations, compared to White garlic which is water soluble and thus absorbed easily within the body. S-Allylcysteine has been shown to assist with the absorption of allicin. This makes Black garlic much more effective than White garlic for all the benefits mentioned above and additionally it is well tolerated by the digestive system so the chance of gastric distress is completely minimised.

Mechanism of antioxidant action

Garlic contains a high abundance of hydrogen-sulphur donating compounds, which are very important for antioxidant properties to be possible. Allicin, an unstable component of garlic, is converted into organosulfur compounds, which are more stable and also contain hydrogen-sulphur donating capabilities. Hydrogen-sulphur donating compounds are vital to antioxidant effects, as they activate the Nfr-2 factor. Nfr-2 factors bind to antioxidant response elements, which trigger the release of various enzymes like Heme oxygenase-1, Superoxide dismutase, Catalase, Quinone-oxidoreductase-1 and Glutathione S-transferase. All of these enzymes are important because they become powerful antioxidants, transforming damaging oxygens and nitrogens into nonreactive states that can significantly harm cells in the human body.

Health benefits of Black garlic

1) **Anti-Cancer Properties:** Black garlic is toxic to cancer cells and can both stop their growth and division, and kill them.

2) **Benefits Heart:** Black garlic improves the cholesterol of patients with mildly high cholesterol levels. Black garlic's high levels of organosulfur compounds also relax blood vessels, which leads to lower blood pressure.

3) **Strong Antioxidant:** Black garlic decreases UV skin damage and reduces liver damage. Black garlic is 10 times more effective than fresh garlic in its antioxidant power.

4) **Reduce Inflammation:** Black garlic lowers the number of cells that cause inflammation and cell damage.

5) **Lowers Allergies:** Black garlic inhibits key allergy-promoting molecules

(prostaglandin E2, leukotriene B4, and cyclooxygenase-2), and prevents their signalling that can lead to cell attack by immune system cells called macrophages.

6) **Reduces Liver Damage:** Black garlic increases the normal activity and metabolism of the liver, also decreases fatty liver deposits and rebalances liver cell diameters to optimal size.

7) **Reduce Obesity:** Black garlic significantly decreases body weight, stomach fat, and fat cell (adipocyte) size. Also lowers triglyceride and LDL (bad) cholesterol levels and increased HDL (good) cholesterol levels.

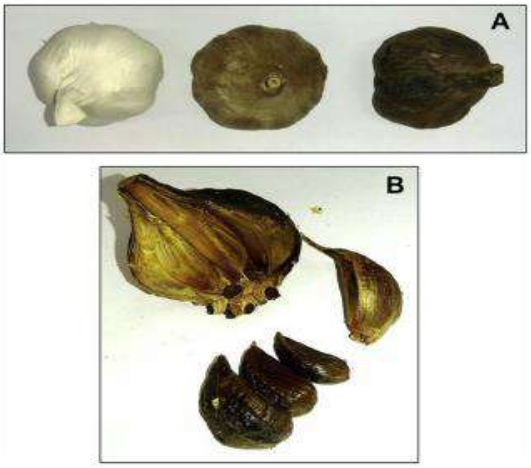

Fig. Garlic fermentation process (A) and Black garlic cloves (B) (Photo courtesy: Kimura et al., 2017)

Forms of supplementation

Black garlic is taken in tablet form as supplements, or in bulb form.

Difference between black garlic and fresh garlic

Black garlic has increased fructose and glucose content (due to Maillard reaction), explaining its sweet flavour. Black garlic is the optimal choice as an antioxidant for neutralizing reactive oxygen species. Fresh garlic, however, has stronger anti-inflammatory properties because of its lower sugar content.

CONCLUSION

Apparently, Black garlic exhibits several advantages when compared with fresh garlic. Since garlic has long been consumed in the human society and has been recognized as one of the safe food substances, there will be no constraints for further invention of Black garlic products for such functional food, food supplements, as well as medical purposes. A more systematic and efficient process for manufacturing Black garlic is important since it is crucial to control the changes in metabolite levels during the fermentation process for industrial-level mass production.

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Role of Forest Genetic Resources in Environmental Security

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ABSTRACT

Forest genetic resources play a critical role in environmental security by contributing to the conservation and sustainable use of forest ecosystems. These resources provide the genetic diversity necessary for forests to adapt to changing environmental conditions, such as climate change, pests, and diseases. By maintaining genetic diversity, forest genetic resources help to ensure the resilience of forest ecosystems and the services they provide, such as carbon sequestration, water regulation, and biodiversity conservation. Additionally, forest genetic resources can be used to develop new tree varieties with desirable traits, such as increased productivity or disease resistance, which can help to support sustainable forest management and contribute to livelihoods. Overall, the conservation and sustainable use of forest genetic resources are essential components of environmental security, as they help to maintain the health and resilience of forest ecosystems and the services they provide. This article discusses the importance of forest genetic resources in human livelihood and environmental security. The article concludes by emphasizing the need for concerted efforts to conserve forest genetic resources to ensure environmental security for present and future generations.

INTRODUCTION

The Forest Genetic Resources (FGR) constitute diversity at individual tree, between trees in a population and between populations in forest ecosystems which includes the variety of tree species and variation of morphology, tree products (pulp

wood, fuel wood, food, fodder, medicinal plants, etc) obtained from trees, that sustain the ecosystem structures, functions and processes in and around production systems, and that provide timber and non-timber forest products for utilization by people. FGR are the genetic variation in trees of present or potential benefit to humans; FAO, 1989) can play in responding to anthropogenic climate change

Climate change threatens the continued existence of species, populations, varieties, and breeds found in many parts of the world, and is changing the nature of the production systems in which these occur. At the same time, adaptation to climate change involves the increased use of the genetic diversity present in these resources to, inter alia, sustain agricultural production, support the continuing provision of ecosystem services, and maintain livelihoods under changing conditions. Loss of FGR or failure to use their full potential limits the capacity of humankind to adapt to climate change that contravenes environmental security.

Discussion

The indirect pathway to availability results from the fact that forests and trees provide ecosystem services that critically support agriculture. Forest and tree root systems, transporting deeper water and nutrient resources close to the soil surface and making them accessible for other crops, enhance agricultural productivity (Jose 2009; FAO 2010;).

Forests and trees also shelter a range of auxiliary species, including pollinators and natural pest enemies, which provide multiple benefits for availability at different scales, particularly in smallholder agricultural systems with no or little agrochemical use (Garibaldi et al. 2011; Ka; Foli et al. 2014; Reed et al. 2017). Besides water provision, pollination is probably one of the most important ecosystem services for global food production.

Trees possess the unique bulk capacity to remediate pollutants: wood offers a vast reservoir to safely allocate them; foliage, roots and living stem cells offer myriads of cells for degradation and/or sequestration in cell walls and vacuoles; and leaves present considerable surface for volatilization. Numerous assays conducted with Populus, Salix, Picea, Pinus, and other widely-planted trees (reviewed by Luo, He, Polle, & Rennenberg, 2016) confirm remarkable pollutant removals relative to background levels.

Mature tree species (1) are more efficient at reducing air pollution, (2) have higher capacity to intercept storm water runoff, and (3) can reduce energy consumption compared to young trees. Acacia tortilis was found to be the most efficient tree species for the above three environmental benefits as well as reducing air pollution levels through dry deposition, avoiding further pollution formation and CO2 removal. The primary benefit of younger trees is increased property values over time. Since younger trees tend to have lower initial costs and will grow into mature trees over time, the benefits of younger trees can still be substantial, particular if the needs for the environmental benefits are long term and not immediate . In many tropical countries there is a need to improve the capacity of stakeholders to identify trees that are suitable, in both environmental and livelihood terms, for use in mitigation schemes. For example, large-scale plantations of the gum arabic tree (Acacia senegal) are being promoted in Sahelian countries such as Burkina Faso, Mali, Niger and Senegal for climate change mitigation, reclamation of degraded land and income generation, even though knowledge as to whether the germplasm used can provide the required gum yield is limited.

When located near air pollution sources, trees and bushes can also increase air dispersion, improving local air quality, although some tree characteristics can also inhibit air flow and result in air pollution increases (Abhijith et al., 2017; Baldauf, 2017). Moreover, trees provide various ecosystem services in urban environments such as the regulation of temperature by providing shading, thermal comfort and the removal of other gaseous pollutants (Logan, 1989; Amorim et al., 2013; Selmi et al., 2016).

Fruit, vegetable or seed production from 87 of the world's most important food crops, representing 35 percent of global food production, depend to some extent upon animal pollination, (Klein et al. 2007). Large-scale land conversion to specialized and intensive monoculture systems, excessive pesticide application, as well as emerging predators and diseases (e.g., Asian hornet or varroa) have been associated with the recent massive decline of domesticated honey bee populations and the increase of colonies collapse disorder (CDD) (Klein et al. 2014). This raised a renewed interest in native wild bees and wild pollinators able to sustain crop yield Garibaldi et al. 2011;).

Numerous studies have demonstrated strong relationships, both in tropical and temperate ecosystems, between proximity of forest, forest strips and fragments; bee abundance and pollination rates; and agricultural productivity (Hawkins 1965). Therefore, an ecosystem approach to the management of agriculture, forestry and aquatic food production in the face of climate change will be essential. Effective ecosystem approach in the context of climate change includes identification of appropriate Forest genetic resources for use in climate change-affected production systems, understanding these resources and how to manage them, and ensuring that they – and their associated knowledge – are available to those who need them. Also, important will be to build greater resilience into production systems – improving their capacity to continue functioning and producing in the face of changes and shocks. Diverse genetic resources can play an important role in this. F Crops, livestock, forest trees and aquatic organisms that can survive and produce in future climates will be essential in future production systems. Identifying and utilizing species and populations with phenotypically plastic individuals may be an important element in climate change adaptation strategies, especially in regions where the climate is expected to become more variable.

CONCLUSION

Tree-based landscapes inter face with human food and nutritional systems. In particular places, and for specific groups of people (and individuals), these landscapes provide goods, services and livelihood options that can be critical for avoiding the worst forms of hunger, malnutrition, and destitution. Environmentally-induced and anthropogenic changes affecting forest cover imply both direct and indirect consequences for food security and nutrition: direct consequences result from changes in the avail ability and quality of food and nutrition, while indirect consequences result from changes in income and livelihoods related to forest products Research into adaptive traits that may be of use in climate change adaptation and mitigation needs to be strengthened. The adaptive, stress-resistant, and life-history traits of the majority of tree species, particularly in the tropics and sub-tropical, have not been well documented.

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Remote Sensing for Precise Nutrient Management in Agriculture

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ABSTRACT

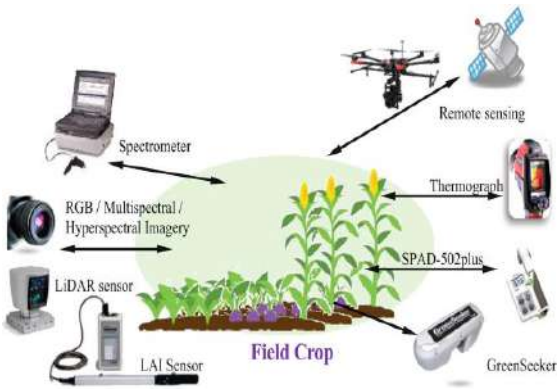
Over the past several years, there has been a substantial rise in interest in the application of remote sensing technologies in agricultural operations. This is due to the fact that these technologies have the potential to completely transform the way farming is carried out. This increase in interest can be attributed to the fact that remote sensing technologies have the ability to completely revolutionise the way farming is done. This is one of the reasons why there has been such a surge in interest in these technologies. The use of remote sensing provides a technique that is not only non-intrusive but also cost-effective when it comes to the acquisition of essential information on the state of health of crops and the nutrients that they contain. This information is critical for agricultural purposes. This article explores the role that remote sensing plays in the process of precise nutrient management in agricultural operations and provides examples of how this function might be applied. The potential benefits, uses, difficulties, and openings that lie ahead for this area of research are the focus of a lot of the attention that is dedicated to this topic. Farmers are able to make better-informed decisions about the application of nutrients thanks to the use of remote sensing techniques, which in turn lead to improved crop yields, decreased negative effects on the environment, and agricultural practises that are more sustainable.

INTRODUCTION

Agriculture feeds the expanding world population. Traditional agricultural nutrient management generally overuses or underuses fertilisers, causing economic losses and environmental deterioration. Remote sensing technologies have improved nutrient management by revealing crop health and needs.

This article examines how remote sensing improves agricultural nutrient management. This article examines remote sensing's benefits, applications, problems, and future potential to change farming practises. It will also advise farmers, researchers, and politicians on remote sensing for better nutrient management.

Remote Sensing in Agriculture



Definition and Overview

Remote sensing collects data without direct interaction. Remote sensing sensors on satellites, aircraft, drones, or ground platforms collect data on crops, soil, and environmental elements in agriculture. This data helps monitor crop health, diagnose nutrient deficits, and optimise fertiliser use.

Types of Remote Sensing Systems

Agriculture uses passive and active remote sensing devices. Active systems emit energy and measure backscattered energy, while passive systems measure Earth's inherent energy. Agriculture uses multispectral sensors, hyperspectral imaging, LiDAR, and thermal imaging.

Nutrient Management in Agriculture

Importance of Nutrient Management

Nutrient management is essential for crop growth, productivity, and environmental sustainability. Nutrient balance ensures crops have enough nitrogen, phosphate, and potassium. However, poor fertiliser management can cause nutrient imbalances, agricultural losses, water contamination, and greenhouse gas emissions.

Challenges in Nutrient Management

Soil sampling and hand nutrient application are laborious, time-consuming, and inaccurate. Nutrient needs vary across a field, making uniform application inefficient. Weather, crop growth stage, and soil qualities affect fertiliser uptake, making optimal nutrient treatment rates difficult to estimate.

Role of Remote Sensing in Nutrient Management

Crop Health Monitoring

Normalized Difference Vegetation Index (NDVI) data from remote sensing allows crop health monitoring. Farmers can recognise stress, nutrient deficits, and timely corrections by analysing vegetation indices over time.

Nutrient Deficiency Detection

Remote sensing can detect crop nutrient deficits by analysing spectral signatures of nutrient stress symptoms. Remote sensing can detect nutrient deficits before they are visible by analysing crop reflectance patterns. Early detection facilitates quick correction.

Precision Nutrient Application

Farmers can use precision agriculture and remote sensing data to apply nutrients accurately. Remote sensing data optimises nutrient distribution in variable rate application systems, minimising waste and maximising plant nutrition. Targeted approaches improve efficiency, cost, and environmental sustainability.

Remote Sensing Techniques for Nutrient Management

Spectral Reflectance

Spectral reflectance measures plant electromagnetic radiation at different wavelengths. Chlorophyll, leaf area index, and nitrogen concentration are revealed by this data. Multispectral sensors collect wavelength-specific spectral reflectance data.

Hyperspectral Imaging

Hyper-spectral imaging allows crop analysis in hundreds of small and contiguous spectral bands. This method identifies slight nutrient deficits and plant species. Hyperspectral imaging sensors on drones or satellites can give high-resolution nutrient management data.

Light Detection and Ranging (LiDAR)

LiDAR technology creates 3D crop canopy models by measuring the sensor-target distance with laser pulses. LiDAR data can assess plant height, biomass, and canopy structure—nutrient status indicators. Orchard and tree crop nutrient management benefits from LiDAR-based remote sensing.

Thermal Imaging

Thermal imaging monitors crop energy emitted by physiological state and water stress. Farmers can detect water and nutrient stress, pinpoint poor irrigation, and optimise nutrient uptake by using temperature data.

Data Analysis and Interpretation

Image Processing and Analysis

Processing and analysing remote sensing data yields useful information. Image registration, normalisation, and categorization improve remote sensing data. Data is interpreted and actionable using statistical studies, machine learning algorithms, and data mining.

Machine Learning and Data Mining

Machine learning algorithms derive useful information from remote sensing data. These algorithms can detect and forecast nutritional shortage by learning to recognise patterns and correlations between spectral data and nutrient levels. Predictive nutrient management models can be created by mining big databases for hidden trends.

Benefits of Remote Sensing for Nutrient Management

Enhanced Crop Yield and Quality

Remote sensing lets farmers optimise fertiliser application with real-time crop health and nutrient status data. Improved crop yields and product quality ensure economic viability and market competitiveness.

Reduced Environmental Impact

Remote sensing helps regulate nutrients to reduce water pollution and eutrophication. Avoiding excessive fertiliser use reduces nutrient leaching, greenhouse gas emissions, and soil damage.

Cost and Time Savings

Remote sensing saves farmers time and labour. Farmers may save fertiliser expenses and boost profits by focusing nutrient application. Remote sensing also permits early

interventions to avert nutrient-related yield losses and economic losses.

Challenges and Limitations

Sensor Resolution and Accuracy

Remote sensing sensor accuracy and spatial resolution affect nutrient management decisions. Sensor calibration errors and low-resolution sensors may miss field variability. **These issues require sensor technology breakthroughs.**

Data Interpretation and Calibration

Remote sensing data interpretation involves data analysis and agronomy skills. Crop types, growth phases, and environmental factors affect spectral reflectance and nutrient levels. Remote sensing data must be calibrated and validated with ground-truth observations to estimate nutritional status.

Infrastructure and Accessibility

Remote sensing demands infrastructure and technical resources. High-quality sensors, computing equipment, and image processing software may cost farmers. In some areas, internet connectivity and data analysis and interpretation experts are scarce.

Future Perspectives and Emerging Technologies

Integration with Precision Agriculture Systems

Remote sensing combined with GPS, UAVs, and variable rate application systems can optimise nutrient management. Real-time data, decision-making, and sub-field nutrient application are possible with this interface.

Advancements in Sensor Technology

Remote sensing for nutrition management will increase when sensor technology improves spatial and spectral resolutions, accuracy, and affordability. Miniaturised sensors, lightweight drones, and satellite constellations should improve data accessibility.

Artificial Intelligence and Big Data Analytics

AI and big data analytics will help mine remote sensing data for insights. AI systems can estimate nutrient needs, optimise fertiliser recommendations, and discover nutrient deficiencies using historical data. Advanced data analytics will aid farmer decision support systems.

Case Studies and Success Stories

Applications in Different Crops

Remote sensing for precise nutrient management works well for cereals, oilseeds, fruits, vegetables, and vineyards. Remote sensing case studies can help farmers adopt these practises.

Real-World Examples of Improved Nutrient Management

Remote sensing for accurate nutrient management has yielded meaningful results for farmers and organisations. These examples can demonstrate increased yields, reduced fertiliser use, crop quality, and environmental sustainability, encouraging others to adopt this technology.

Adoption and Implementation

Considerations for Farmers

Farmers contemplating remote sensing for accurate nutrient management should evaluate their needs, resources, and technology. When choosing remote sensing equipment and data analysis methods, consider farm size, crop kind, budget, and technical knowledge.

Policy and Regulatory Support

Government policies and laws can boost agricultural remote sensing usage. Financial incentives, supportive structures, and research and development can help integrate remote sensing into nutrient management.

Training and Education

Farmers should learn about remote sensing and nutrient management through training and education. Hands-on workshops, online courses, and knowledge-sharing platforms can help farmers and agronomists make nutrient management decisions.

CONCLUSION

The use of remote sensing technology in agriculture has enormous promise for accurate nutrient management. Remote sensing can support sustainable agriculture practises, increased yields, and decreased environmental impact by enabling real-time crop health monitoring, identifying nutrient deficits, and facilitating targeted nutrient administration. For widespread implementation, it will be essential to resolve issues with sensor resolution, data interpretation, and accessibility. The future of remote sensing in nutrient management is bright as sensor technology, artificial intelligence, and big data analytics continue to progress, paving the way for a more effective and sustainable agriculture industry.

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Surprising Health Benefits of Papaya

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ABSTRACT

The papaya is a tropical fruit that is well-known for its numerous health advantages. Consumption of papaya, which is high in vital nutrients, enzymes, and antioxidants, has been linked to a variety of health benefits. This article discusses the possible health advantages of eating papaya, emphasising its nutritional composition, which includes vitamins A and C, folate, and dietary fibre. Papain, the fruit's enzyme, assists in protein digestion and may have anti-inflammatory qualities. Furthermore, the high antioxidant content of papaya, such as beta-carotene and lycopene, helps to reduce oxidative stress and battle chronic illnesses. It has been associated to better digestion, skin health, and immunological function. Furthermore, papaya is being studied for its possible anti-cancer qualities as well as its capacity to boost heart health by controlling blood pressure and cholesterol levels. However, further studies are needed to fully elucidate the mechanisms underlying these health benefits and to establish optimal consumption recommendations. In conclusion, incorporating papaya into one's diet presents a promising approach to promoting overall health and well-being.

INTRODUCTION

Papaya plant is actually an overgrown herb, known as an herbaceous perennial. Eventually, it grows to 10 to 20 feet, producing melon-like oval fruits six to 20 inches long. The plant spread relatively easily throughout the tropics, and has become naturalized in several regions, especially those abundant with water and fertile soils. It is believed papaya is a native to tropical America, in a region that goes from the Andes of South America to Southern Mexico. It was taken by the Spaniards to Manila in the mid-16th century and gradually spread to all tropical and subtropical countries. It is now

widely cultivated in India, China, Sri Lanka, Malaya, Mexico, Brazil, Peru, Venezuela, Central and South Africa, Philippines, Australia and on most of the Pacific islands. In Florida, during the early 1900, there was a small papaya industry, but it was rapidly destroyed by viral diseases (such as papaya ring spot virus) that are still threatening papayas in other areas: the Hawaii and industry underwent a decline recently for this reason. “Papaya” is recommended to be one such pick from the group of Yellow and orange fruits, which promises abundant health benefits. It is a melon like fruit with yellow-orange flesh with dozens of small black seeds enclosed in skin that ranges in color from green to orange. It is a large, fleshy. Hollow berry up to 50-60 cm. in diameter and usually weighs from 1/2 kg to 2 kg. It is cylindrical or pear-shaped. The central cavity is surrounded by hundreds of small seeds, though sometimes seedless varieties of the fruit are also found. The fruit has a thin smooth skin. It is dark green in color at first, but as the papaya ripens, it changes to bright yellowish or orange. Inside, the thick juicy flesh has a soft melting quality, and may be yellow or pink. It has a delicate aroma and delicious flavor. The fruit, as well as the other parts of the papaya tree, contain papain, an enzyme that helps digest proteins. This enzyme is especially concentrated in the fruit when it is unripe. Papain is extracted to make digestive enzyme dietary supplements and is also used as an ingredient in some chewing gums.

Health benefits of papaya

Papayas offer not only the luscious taste and sunlit color of the tropics, but are rich sources of antioxidant nutrients such as carotenes, vitamin C and flavonoids; the B vitamins, folate and pantothenic acid; and the minerals, potassium and magnesium; and fiber. Together, these nutrients promote the health of the cardiovascular system and also provide protection against colon cancer. In addition, papaya contains the digestive enzyme, papain, which is used like bromelain, a similar enzyme found in pineapple, to treat sports injuries, other causes of trauma, and allergies.

Asthma prevention

Papaya contains several unique protein-digesting enzymes including papain and chymopapain. These enzymes have been shown to help lower inflammation and to improve healing from burns. In addition, the antioxidant nutrients found in papaya, including vitamin C, vitamin E, and beta carotene, is also very good at reducing inflammation. This may explain why people with diseases that are worsened by inflammation, such as asthma, osteoarthritis.

Protection against Heart Disease

Papaya’s may be very helpful for the prevention of atherosclerosis and diabetic heart disease. Papayas are an excellent source of vitamin C as well as a good source of vitamin E and vitamin A, three very powerful antioxidants. These nutrients help prevent the oxidation of cholesterol. Only when cholesterol becomes oxidized it is able to stick to and build up in blood vessel walls, forming dangerous plaques that can eventually cause heart attacks or strokes. One way in which dietary vitamin E and vitamin C may exert this effect is through their suggested association with a compound called Paraoxonase, an enzyme that inhibits LDL cholesterol and HDL cholesterol oxidation. Papayas are also a good source of fiber, which has been shown to lower high cholesterol levels. The folic acid found in papayas is needed for the conversion of a substance called homocysteine into benign amino acids such as cysteine or methionine. If unconverted, homocysteine can directly damage blood vessel walls and, if levels get too high, is considered a significant risk factor for a heart attack or stroke.

Immune Support

Vitamin C and vitamin A, which is made in the body from the beta-carotene in papaya, are both needed for the proper function of a healthy immune system. Papaya may therefore be a healthy fruit choice for preventing such illnesses as recurrent ear infections, colds and flu.

Protection against Macular Degeneration

Mother's especially mentions to children that taking carrots would keep your eyes bright as a child, but as an adult, it looks like fruit is even more important for keeping your sight. Data reported in a study published in the Archives of Ophthalmology indicates that eating 3 or more servings of fruit per day may lower your risk of age-related macular degeneration (ARMD), the primary cause of vision loss in older adults, by 36%, compared to persons who consume less than 1.5 servings of fruit daily. Its reported already which involved over 110,000 women and men, researchers evaluated the effect of study participants consumption of fruits; vegetables; the antioxidant vitamins A, C, and E; and carotenoids on the development of early ARMD or neovascular ARMD, a more severe form of the illness associated with vision loss. While, surprisingly, intakes of vegetables, antioxidant vitamins and carotenoids were not strongly related to incidence of either form of ARMD, fruit intake was definitely protective against the severe form of this vision-destroying disease. Three servings of fruit may sound like a lot to eat each day, but papaya can help you reach this goal. Add slices of fresh papaya to your morning cereal, lunch time yogurt or green salads. Cut a papaya in half and fill with cottage cheese, crab, and shrimp or tuna salad. For an elegant meal, place slices of fresh papaya over any broiled fish.

Protection against Rheumatoid Arthritis

While studies suggested that high doses of supplemental vitamin C makes osteoarthritis, a type of degenerative arthritis that occurs with aging, worse in laboratory animals, another indicates that vitamin C-rich foods, such as papaya, provide humans with protection against inflammatory polyarthritis, a form of rheumatoid arthritis involving two or more joints. The findings, presented in the Annals of the Rheumatic Diseases were drawn from a study of more than 20,000 subjects and focused on subjects who developed inflammatory polyarthritis and similar subjects who remained arthritis-free during the follow-up period. Subjects who consumed the lowest amounts of vitamin C-rich foods were more than three times more likely to develop arthritis than those who consumed the highest amounts.

Promote Lung Health

Apart from the high antioxidant level, papaya has several vitamins and minerals that make it a great immunity booster, which further helps in building resistance against several virus, bacteria and pathogen attacks. In fact, the presence of vitamin C, E and antioxidants like beta carotene, papaya can also help in easing the air passage and reduce congestion in lungs and nasal cavity. Moreover, the anti-inflammatory properties help in reducing inflammation caused due to cold, sore throat and flu.

Papaya and Green Tea Team Up to Prevent Prostate Cancer

Choosing to regularly eat lycopene-rich fruits, such as papaya, and drink green tea may greatly reduce a man›s risk of developing prostate cancer. Regular consumption of both green tea and foods rich in lycopene resulted in a synergistic protective effect.

Diabetes

People with type 1 diabetes who consume high-fiber diets have lower blood glucose levels, and people with type 2 diabetes may have improved blood sugar, lipid, and insulin levels. One small papaya provides about 3 grams of fiber, which is equivalent to just 17 grams of carbohydrates.

Digestion

Papayas contain an enzyme called papain that aids digestion; in fact, it can be used as a meat tenderizer. Papaya is also high in fiber and water content, both of which help to prevent constipation and promote regularity and a healthy digestive tract.

Inflammation

Choline is a very important and versatile nutrient found in papayas that aids our bodies in sleep, muscle movement, learning, and memory. Choline also helps to maintain the structure of cellular membranes, aids in the transmission of nerve impulses, assists in the absorption of fat, and reduces chronic inflammation.

Skin and healing

When used topically, mashed papaya appears to be beneficial for promoting wound healing and preventing infection of burned areas. Researchers believe that the proteolytic enzymes chymopapain and papain in papaya are responsible for their beneficial effects. Ointments containing the papain enzyme have also been used to treat decubitus ulcers (bedsores).

Hair health

Papaya is also great for hair because it contains vitamin A, a nutrient required for sebum production, which keeps hair moisturized. Vitamin A is also necessary for the growth of all bodily tissues, including skin and hair. Adequate intake of vitamin C, which papaya can provide, is needed for the building and maintenance of collagen, which provides structure to skin.

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An Overview of Biofertilizers, Biopesticides and their Importance in Sustainable Agriculture

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ABSTRACT

Modern agriculture is characterised by widespread cultivation, the use of chemical fertilizers, the use of high-yielding varieties that are nutrient-responsive, and the increasing use of plant protection agents and their applications. Therefore, for sustainable agriculture, utilise minimal inputs like fertilizers and pesticides by adopting technologies that promote natural reactions without upsetting the ecological balance by maintaining the balance of the soil, plants, animals, and microbes. The major microorganisms used as biofertilizer are Rhizobium, Rhizobium, Azotobacter, Cyanobacteria, Azolla, Mycorrhiza and Plant Growth Promoting Rhizobacteria (PGPR). Microorganisms known as biofertilizers increase the amount of nutrients available to plants, which promotes plant growth. A biopesticide is a product made from naturally occurring compounds that manages pests through non-toxic and environmentally favourable approaches. Biopesticides can come from a variety of sources, such as living things (natural enemies), animals (such as nematodes), plants (such as Chrysanthemum and Azadirachta), and microorganisms (such as B. thuringiensis, Trichoderma, and nucleopolyhedrosis virus). However, biopesticides are preferable and sustainable strategies for disease management because they are non-target species and typically less hazardous to users.

INTRODUCTION

Biofertilizers are substances that contain living cells of powerful strains of various microorganisms that have the capacity to mobilise nutritionally significant materials from an immobilised state to an accessible state through biological processes.

Types of Biofertilizers:

A. Nitrogen fixing microorganism:

Nitrogenase is an enzyme complex that Nitrogen-fixing microorganisms employ to transform atmospheric nitrogen into ammonia. Symbiotic and non-symbiotic nitrogen fixers are distinguished. Symbiotic organisms are the Rhizobiaceae members that form symbiotic partnerships with leguminous plants. On the other side, non-symbiotic microbes include free-living and endophytic species like Cyanobacteria, Azospirillum, Azotobacter, etc. (Fatimah et al. 2021).

1) Symbiotic Nitrogen Fixer – Rhizobium, Azospirillum

2) Non-Symbiotic Nitrogen Fixer – Azotobacter, Acetobacter.

3) Azolla Symbiont Nitrogen Fixer with Anabaena azollae, Azolla pinnata.

4) Blue Green Algae (Cyanobacteria) – free living organism Nostoc and Anabaena.

B. Phosphate solubilising microorganisms:

Phosphate anion, also known as orthophosphate, is a soluble form of phosphorus. Rhizospheric bacteria, which aid in plant nutrition, make it easier for plants to absorb orthophosphate. Different microbes can dissolve the remaining unavailable form of phosphate into an available form by producing organic acid, which lowers the pH of the soil, causes the phosphate compounds to dissolve, and makes them available for the plant's nutrition (Mahanty et al., 2017).

1) **Bacteria –** Pseudomonas striata, Bacillus megatarium var. phosphaticum Bacillus polymyzxa.

2) **Fungi –** Aspergillus awamari, Penicillium digitatum, Vesicular Arbuscular Mycorrhiza (VAM) fungi like Glomus and Gigaspora species.

3) **Actinomycetes –** Streptomyces spp. and Nocardia spp.

C. Potash Solubilizing microorganism:

Potassium is found in silicate minerals such illite, orthoclase, biotite, illite, and feldspar in immobilised forms. Both bacteria and fungi can solubilize potash, and the main process for doing so is acidification, which involves the production of organic acids (Chaudhary et al., 2022).

Examples of potassium solubilizing bacteria include Bacillus mucilaginous, B. edaphicus, B. circulans, Acidithiobacillus ferrooxidans, Frateuria aurantia.

D. Sulphur Oxidizers: Thiobacillus thiooxidans

Biopesticides: Biopesticides is a population of pathogenic microorganisms that are antagonistic to particular pest and provide natural control are called Biopesticides or Microbial Pesticides.

Types of Biopesticides:

A. Microbial pesticides – Microbial pesticides are composed of microscopic living organisms (viruses, bacteria, fungi, protozoa and nematodes) or toxin produced by these organisms. Microbial bio-pesticides are

formerly known as biocontrol agents (Meena and Mishra, 2020).

Bacterial Pesticides:

Bacillus thuringiensis var. kurstaki – Cotton Bollworms, Fruit Borer of Brinjal and Tomato.

Bacillus papillae – Coleoptera insect – white grub.

Agrobacterium radiobacter – used to treat roots during transplanting that checks crown gall disease. they produce an antibiotic, agrocin that is toxic to A. tumefaciens.

Pseudomonas fluorescens (Phenazine) – it is used to control damping off caused by Pythium sp., Rhizoctonia solani, etc.

Fungal Pesticides: -

Beauveria bassiana – control of Colorado potato beetle and Sugarcane / Maize Stalk Borer.

Metarhizium anisopliae – control of Sugarcane pyrilla.

Verticillium lecani – used for Aphids, Whiteflies and Mealy bugs of Cotton, Papaya.

Trichoderma – It is effective against soil borne diseases such as root rot.

Viral Pesticides: - Nuclear Polyhedrosis Virus (NPV) – They develop in insect's cell nuclei and control pest like tobacco budworm and cotton bollworm.

Cytoplasmic Polyhedrosis Virus (CPV) – They develop in the insect's cell cytoplasm and control pests like caterpillar.

Granulosis Virus (GV) – They develop either in nuclei or cytoplasm of insect's cell and control pests like sugarcane shoot borer.

A. Botanical pesticides – Botanical bio-pesticides are obtained from any plant part or the whole plant body, which can neutralize or kill the harmful pests and/or control of the weeds. Applications of plant-based bio-pesticides for defence against insect pests and other harm-causing forms have become commonplace in both new and conventional agricultural practises, such as organic farming (Meena and Mishra, 2020).

Ex. Azadirachtin, Nicotinoids, Natural Pyrethrums, Rotenoids etc.

B. Biochemical pesticides – Biochemical insecticides include compounds known as insect sex pheromones, which disrupt mating and draw pest insects to traps.

C. Biotic agents (Natural enemies) –

Predators - Predators capture and eat other organisms such as insects or mites.

1. **Cryptolaemus:** Mealy Bugs, Lady Bird Beetles had feed on Aphids and White flies.

2. **Chrysoperla:** Jassids and Lacewing larva, White flies and syrphid maggot feeds on aphids.

3. **Zygogramma**: Parthenium weeds,

Parasitoids – Parasitoids are insects that parasitize other insects. Parasitoids may attack all stages of their host (eggs, larvae, pupae, adults). Egg parasitoids: Trichogramma jopanicum – Rice Leaf Folder, Trichogramma chilonis – Root Borer, Trichogramma minutum – Sugarcane Borer.

Role of Biofertilizers, Biopesticides in Agriculture and Soil fertility

- Biofertilizers contribute in the development and expansion of trees and crop plants.

- The use of biofertilizers promotes root growth, vegetative growth, nitrogen

fixation, and increased mineral and water intake.

- Some Biofertilizers (eg, Rhizobium, BGA, Azotobacter sp.) stimulate production of growth promoting substance like vitamin B complex, IAA and Gibberellic acids etc.
- Under ideal agronomic and pest-free conditions, they can at best avoid using more chemical fertilisers than 40 to 50 kg N/ha.
- They increase biomass yield and production by 10% to 20%.
- They function as antagonists, which reduces the prevalence of soil-borne plant infections and helps in disease bio-control.
- They improve soil fertility and soil productivity.
- Biocontrol is exercised in a wide range of area and is safe for human and animal health.
- The bioagents continue to exist in nature as long as the pest is common, and when the pest is not there, they take self-precautions in the environment.
- The degradation/decomposition of organic matter in soil as well as the rate of decomposition in compost pits are both accelerated by bio-inoculants containing cellulolytic and lignolytic microorganisms.

CONCLUSION:

Biofertilizer have great role in increasing the crop production and they improve the soil health status and provide different growth promoting hormones and phytohormones to the plant. Hence the use of biofertilizer could be the proper option for sustainable agriculture. Biofertilizer will be crucial in the future for enhancing crop availability of nutrients and nutrient sources. Biopesticides are typically microbial biological pest controls that are applied similarly to chemical pesticides and are also used to manage soil-borne and seed-borne fungal infections. The biofertilizers Acetobacter, Azotobacter, and Azospirillum are crucial for fixing nitrogen, whereas Bacillus sp. and Aspergillus sp. are crucial for phosphate solubilization and other soil mineral nutrients. The adoption of biofertilizers in India would not only have an effect on the economic growth of sustainable agriculture, but it will also help the nation's ecosystem and overall well-being.

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Pesticides: A Threat to Soil Health

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ABSTRACT

The indiscriminate use of pesticides in agriculture has had a negative impact on soil properties, biodiversity, and human health. Pesticides can degrade soil structure, reduce soil fertility, and kill beneficial soil organisms. They can also pollute water and air, and pose a risk to human health. Organic farming is a more sustainable alternative to conventional agriculture that does not use pesticides.

INTRODUCTION

The dynamic increase in India's population especially after the independence has led to the intensive development of agriculture to meet our food sufficiency and be self-dependent for food requirements to the people of the country. This development was not just intended to meet food requirements but to eventually commercialize the largest engaged sector by the people of the country. To ensure food safety around the country, it was important to build up all necessary measures to boost crop production. This opens an opportunity and need for commercial introduction of High Yielding Varieties and Pesticides in India which came under the Green Revolution during the 1960s. At that time there was lack of knowledge and technical know-how in the farmer's community which resulted in an indiscriminate use of pesticides for decades throughout the nation. These practices resulted in various types of harmful effects on living organisms, environment as well as soil. Pesticides can also linger in the soil for years or decades after they are applied, continuing to harm soil health. The term Pesticide includes

all of the following; herbicide, insecticide, nematicides, acaricide, rodenticide, bactericide, fungicide, insect repellent, disinfectant and so on.

Pesticide companies claim their products are needed to feed the world's growing population, the reality point in the opposite direction. The continued use of toxic chemicals to grow our food undermines the healthy soil ecosystems that sustainable food production depends on. Pesticide properties like solubility in water, proclivity to adsorb to the soil, pesticide perseverance and soil properties like sand, silt, clay and organic matter are important in regulating the fate of the chemicals in the ecosystem. Direct application of pesticides to the soil to manage soil pests, spray drift during foliage treatment, wash off of treated foliage, release from granules, or release from treated seeds all cause pesticides to reach the soil.

Effect of Pesticides on Soil Properties

Scoop up a shovelful of healthy soil, and you'll likely be holding more living organisms than there are people on Earth. Like citizens of an underground city that never sleeps, tens of thousands of subterranean species of invertebrates, nematodes, bacteria and fungi are constantly filtering our water, recycling nutrients and helping to regulate the planet's temperature. (Muzafar et,al)

Pesticides are impacted by a number of factors after coming into contact with the soil, including adsorption rate, organic matter, soil texture, microorganisms, and the availability of moisture. The propensity for pesticides to be adsorbed varies with the proportion of clay and organic matter in the soil, the greater the number of adsorption sites as clay and inorganic matter increase the binding because they have more positive and negative charge sites. This influences pesticide persistence and leaching. Additionally, it lessens the likelihood that a pesticide will penetrate the soil, causing the residues to remain in the soil for extended periods of time without moving. In soils with a lot of organic matter and clay, pesticides often last longer. Once pesticides are present, the soil serves as a reservoir from which they can travel into invertebrate bodies, be absorbed by plants, pass into the air or water, or decompose. Pesticide residues have a negative impact on the beneficial soil microorganisms and the biotransformation that goes along with it in the soils.

Pesticides residue effects on soil fauna

Insect populations decline as a result of extensive pesticide use. The ecosystems and biodiversity that support all life forms on Earth, including crop production methods that provide food for people, are seriously threatened by these eradications. The most intricate and diverse ecosystems are found in soil, where roughly a quarter of all organisms can be found. 10 to 100 million organisms can be found in a little amount of soil. These organisms provide essential ecosystem services such as the cycling of nutrients that plants require to grow, the decomposition of dead plants and animals to nourish new life, and the control of pests and diseases. (Ghosal et,al)

Effect of pesticides on soil biological properties

Effects on arthropods: Whether sprayed directly or indirectly, pesticides operate as a

sink or reservoir in the soil. Earthworms improve soil aeration, aid in the breakdown of organic matter, and raise the amount of nutrients in the top layer of soil. Earthworms contribute to the preservation of human health by consuming decaying trash and serving as a bio indicator in the case of soil fertility. Some pesticides kill earthworms, and by eliminating the vegetation that the worms feed on, they may indirectly reduce population. In the rice-maize cropping system, imidacloprid, chlorpyrifos, and phorate all had a detrimental effect on earthworms.

Effect on soil microorganisms

For the fertility of the soil, the micro flora is crucial. The primary source of "N" for plant growth is the conversion of organic "N" by microbes into inorganic forms, together with bacterial fixation of atmospheric "N." The breakdown of carbonaceous organic matter is aided by the soil microorganisms. The development, activity, and enzyme of the soil microflora are negatively impacted by pesticides, which in turn impair soil fertility and soil health. Fipronil, chlorpyrifos, Chlorantraniliprole, and Cartap hydrochloride had no appreciable negative impact on the collembola population, whereas plots treated with carbofuran and phorate saw reductions of 27.65% and 13.47% in the rice-maize cropping scheme. Numerous tiny soil arthropods, such as tiny ants, beetles, and soil oribatid mites, did not exhibit any discernible harmful effects from pseudo scorpions. The majority of OP insecticides, carbamate biocides (such as aldicarb, carbofuran), and OC insecticides (such as DDT, endosulfan, aldrin, chlordane, and heptachlor) have a deleterious impact on predatory mites. The objective for which the pesticide is administered may not be solved, but the enhancement of pesticides degrading microbial population has practical implications for maintaining soil health by permitting decomposition and consequent removal of the pesticides and hazardous residues. (Ahemad et,al)

Effect on snails and slugs: Snails and slugs can acquire insecticides and concentrate them on their bodies, such as carbamates and organophosphates. As these substances are water soluble, high levels of diazinon, phorate, and carbofuran were discovered in their bodies. They are not negatively impacted by the insecticides, but predatory birds that eat these snails and slugs will suffer adverse effects and perished.

Pesticides' Impact on the Chemical Properties of Soil

Pesticides adversely affect the soil and its composition, texture, as well as its chemical properties and its response to the plant's growth and development. For example the dimethoated soil prevents the production of methane in rice fields, the mineralization of organic C was accelerated by HCH, phorate, and fenvalerate and the root nitrogen, shoot nitrogen, root phosphorus, shoot phosphorus, seed production, and grain protein of pea plants were all reduced by pyriproxyfen and fipronil.

CONCLUSION

Farmers' indiscriminate use of pesticides and disregard for safety precautions when applying pesticides to the soil results in a variety of soil properties being degraded as well as the development of several diseases that affect human health, polluting our land first before polluting the air and water. As a result, the environment and biodiversity are harmed. Due to the fact that a significant section of the population depends on agriculture for survival, pesticides are employed extensively in agricultural areas to improve productivity by defending the harvests from potential danger. Adequate measures must be taken to protect human life and the environment from the hazardous effects of pesticides. It is now

widely accepted that the most important thing we can do for our mother earth is to take care of her by choosing an organic farming method. Organic farming, an environmentally beneficial agriculture strategy that ultimately promotes good human health, is a solution to this mayhem. A step towards sustainability is practicing organic agriculture, which is a return to our ancestors' way of life.

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The Ecological Impact of Oil Spills on Soil Health

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ABSTRACT

Oil spills have the potential to cause significant environmental damage, including detrimental effects on soil ecology. This review aims to evaluate the impact of oil spills on soil ecosystems by summarizing and analyzing relevant scientific studies published in the past decade. The assessment encompasses the various mechanisms through which oil spills affect soil quality, nutrient cycling, microbial communities, and plant growth. The release of crude oil into the environment introduces toxic compounds, such as polycyclic aromatic hydrocarbons (PAHs), heavy metals, and volatile organic compounds, which can persist in soils long after the initial spill event. These contaminants can alter soil physical properties, impeding water infiltration and reducing soil porosity. Oil penetration into the soil matrix can lead to the formation of hydrophobic layers, exacerbating issues related to water retention and affecting the availability of nutrients to plants. To mitigate the impacts of oil spills on soil ecology, several remediation strategies have been employed, such as the use of bioremediation techniques, soil amendments, and phyto-remediation. These approaches aim to enhance the natural degradation of oil pollutants, restore soil fertility, and promote the recovery of affected ecosystems.

INTRODUCTION

Oil spills are regrettably common around the world. An oil spill is the release of a liquid petroleum hydrocarbon into the environment, especially the marine ecosystem, due to human activity, and is a form of pollution. The term is usually

given to marine oil spills, where oil is released into the ocean or coastal waters, but spills may also occur on land. Oil spills may be due to releases of crude oil from tankers, offshore platforms, drilling rigs and wells, as well as spills of refined petroleum products (such as gasoline, diesel) and their by-products, heavier fuels used by large ships such as bunker fuel, or the spill of any oily refuse or waste oil Adelana, et al (2011).

Oil spills originate in oil platforms, refineries, or oil tankers that have an accident or that 'clean' their tanks in the ocean. The oil reaching the coast in this manner affects different ecosystems – open and protected sandy beaches, estuaries, and rocky shores – or remains in the water to be finally deposited on the sea bottom in deep or shallow waters.

Sources of oil spills

Oil spills may be due to release of crude oil from tankers, pipelines, railcars, offshore platforms, drilling rigs and wells, as well as spills of refined petroleum products and their byproducts, heavy fuels used by large ships such as bunker fuel, or the spill of any oily refuse or waste oil. Spilled oil can penetrate into the structure of the plumage of birds and the fur of mammals, reducing their insulating ability and making them more vulnerable to temperature fluctuations and much less buoyant in the water Oil tankers are just one of the many sources of oil spills.

Figure 1&2: Most vulnerable species and first victims of oil spills.

As mentioned above, sea birds and mammals are among the most vulnerable components of marine ecosystems in relation to oil pollution. Even short-term contact with spilled crude oil affects the insulating functions of feathery or hairy coats and results in quick death. The biological consequences of oil spills depend primarily on the population traits of different species. Abundant populations with a high reproductive potential are the least susceptible to population stresses. At the same time, adverse impacts for the less abundant species with longer life spans are usually more serious and protracted.

Figure 3: Affected soil from the oil spills.

Impact of Oil Spill on Soil

The evaluation of oil impact on soil ecology involves assessing the effects of oil contamination on the various components of the soil ecosystem, including plants, microorganisms, and invertebrates Song, et al (2017). Here are some key aspects to consider when evaluating the impact of oil on soil ecology:

- **Physical and chemical properties:** Oil contamination can alter the physical and chemical properties of soil. It can lead to changes in soil texture, compaction, and water-holding capacity. Additionally, oil contains toxic compounds that can increase soil acidity, affect nutrient availability, and disrupt soil pH levels.

- **Microbial communities**: Soil microorganisms play a crucial role in nutrient cycling, decomposition of

organic matter, and maintaining overall soil health. Oil contamination can significantly impact microbial communities. Certain microorganisms possess the ability to degrade hydrocarbons present in oil, while others may be sensitive or even killed by its toxic components. Consequently, the overall microbial diversity and activity can be affected, leading to disruptions in important soil processes.

- **Invertebrates:** Soil invertebrates, including earthworms, insects, and mites, contribute to soil structure formation, organic matter decomposition, and nutrient cycling. Oil spills can have direct toxic effects on these organisms, leading to reduced populations and altered community structures. In turn, this can disrupt soil processes and negatively impact the overall ecosystem functioning.

- **Soil food web:** The interactions between plants, microorganisms, and invertebrates form a complex soil food web. Disruptions in any component of the food web due to oil contamination can have cascading effects on the entire ecosystem. For example, reduced plant biomass can impact herbivores, which can then affect predators higher up the food chain.

- **Long-term effects and recovery:** Oil spills can have long-lasting effects on soil ecology, persisting for years or even decades. The persistence of oil compounds in soil can continue to exert toxic effects on plants and organisms. The recovery of soil ecology after an oil spill depends on factors such as the extent of contamination, type of oil, soil properties, and remediation efforts undertaken.

Remedies of Oil Spill in Ecosystem

Oil spills can have a detrimental impact on soil ecology, but there are several remedies that can be employed to mitigate the damage and protect the soil Ossai, et al (2020). Here are some effective measures:

Containment and Removal:

- Establish containment barriers such as booms and absorbent materials to prevent the spread of oil.
- Use vacuum trucks or skimmers to remove oil from the soil surface.
- Excavate and remove heavily contaminated soil for proper treatment or disposal.

Bioremediation:

- Utilize bioremediation techniques to enhance the natural degradation of oil by microorganisms.
- Introduce oil-eating bacteria or fungi to the contaminated area to accelerate the breakdown of hydrocarbons.
- Enhance the conditions for microbial activity by adjusting temperature, oxygen levels, and nutrient availability.

Soil Aeration:

- Promote aeration by tilling or ploughing the soil to increase oxygen supply, which supports the growth of aerobic microorganisms that break down the oil.
- Avoid excessive compaction of soil, as it restricts oxygen penetration.

Soil Amendments:

- Apply organic amendments like compost or activated carbon to bind with the oil, reducing its availability to plants and soil organisms.
- Utilize Biochar, a form of charcoal, to improve soil structure and absorb oil.

Phytoremediation:

- Plant native vegetation with strong root systems to stabilize the soil and facilitate the uptake and degradation of contaminants.
- Certain plants, such as willows, poplars, and grasses, have the ability to absorb and metabolize hydrocarbons effectively.

Monitoring and Evaluation:

- Regularly monitor the soil and surrounding ecosystem to assess the progress of remediation efforts.
- Conduct soil tests to determine the presence of contaminants and adjust the remediation approach accordingly

Environmental Protection Measures:

- Implement erosion control measures to prevent oil-contaminated soil from being washed away during rainfall or runoff.
- Implement sediment control devices such as silt fences or sediment basins to trap sediment and prevent further contamination.

CONCLUSION

The observed impacts on soil microbial diversity and activity are particularly concerning, as microbes play fundamental roles in nutrient cycling, decomposition of organic matter, and maintaining soil structure. When these vital processes are disrupted, the entire soil ecosystem faces significant degradation, hindering plant growth and soil fertility. The evaluation of oil spill impact on soil ecology serves as a stark reminder of the fragility of our ecosystems and the urgent need for responsible environmental stewardship. By recognizing the far-reaching consequences of oil spills on soil health and implementing effective mitigation and restoration efforts, we can work towards preserving our precious natural resources for future generations.

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Nanoremediation Applications for Soil-Water Pollution

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ABSTRACT

The human activities include the agricultural, industrial and other activities. The agricultural sector is considered the main source for our life's supplies. However, the agricultural activities or practices might result many pollutants such as applied mineral fertilizers, pesticides, effluents from domestic and industrial sewages and vehicular emissions. Therefore, a remediation to remove or decrease the pollutants in soil and water is needed for the environment protection. This remediation has several classic strategies several years ago, but a promising and new approaches have been established particularly nano-remediation. This nano-remediation depends on the applied nanomaterials in removing pollutants from soils and water through nano-bioremediation and nano-phytoremediation. The most important nanomaterials that have potential in removing pollutants from contaminated soils and water are nano-silica, nano-zero-valent of iron, nano-sized iron sulfide particles, nano-ZnO and others. However, many challenges or open questions are still needing a justification because using nanomaterials in higher concentrations are toxic to plants and agro-environment.

INTRODUCTION

Agriculture is considered one of the most important human activities, which represents the main source for food, feed, fuel and fiber. This activity may result a lot of environmental problems particularly under the excessive use of pesticides and mineral fertilizers. Hence, the agricultural pollution may refer to different agricultural practices, which result in the degradation or pollution of the agro-ecosystems and cause a damage to the human health. Different sources of agro-pollution could be considered ranging from a single discharge point (point source pollution) to nonpoint source pollution (from more diffuse and landscape-level sources). Concerning the nanomaterials, already used in soil and water remediation, they may include nanophytoremediation, nano-bioremediation, nano-Fe3 O4, nano-FeS coated humic acid complex, nano zero-valent iron, nano-hydroxyapatite, nano zeolite, nano zero-valent iron, ZnO-nanoparticles, nano-TiO2, stabilized nanoparticles.

APPLICATIONS OF NANO-REMEDIATION

The remediation of soil and water based on the nanomaterials through the plants (phytonano-remediation) or the biological agents (Nano bioremediation) may depend on different factors including depth of pollution and the kind of pollutants, pH, temperature, soil or water properties, and metal or pollutant species. The nano-remediation is a remediation method in which nanomaterials could be included in presence of plants or biological agents. Therefore, there is a need for a complete knowledge of plant physiology, biochemistry and degradation of pollutants as well as a suitable assessment of probable collaborative impacts. The nanotechnology could be used for in situ remediation of polluted soils through the following mechanisms immobilization, Fenton and Fenton-like oxidation, photocatalytic degradation, reduction reaction and various combinations. Concerning the applications of nanoparticles in environmental remediation, researchers have shown great concern in the utilization of nanotechnology in environmental remediation. There is a crucial importance for using the green synthesis of nanoparticles in this remediation due to it stability to provide a clean, environment friendly method, nontoxic and producing nanoparticles by eliminating toxic by-products and toxic precursors as well as it actsas an effective and sustainable technique for environmental remediation.

In general, the most important applications of nanomaterials in remediation may include detecting and removing heavy metals from soil and water, degradation of dyes in the industrial wastewater, and degradation and removing hydrocarbons. Guerra et al. (2018) classified the nanomaterials used for environmental remediation into three main categories to include inorganic (metal and metal oxide-based nanomaterials like Ag-NPs, TiO2 -NPs, iron-based nanoparticles), carbon-based (fullerene C60, fullerene C540, graphene, single-walled nanotubes and multiwalled nanotubes), polymeric-based materials (e.g., amphiphilic polyurethane NPs, polyamine-modified cellulose and polymer nanocomposites) and silica nanomaterials or silica-graphene porous nanocomposites. Important nanomaterials used in soil and water remediation include nano-silica and zero-valent iron nanoparticle.

4.1 Nano-silica

Silica nanoparticles or nano-silica (SiO2 -NPs) have become one of the most important nanoparticles, already used as nano-structuring, optical imaging agents and drug delivery as well as in environment cleanup due

to its immensely stable and less toxic. Silica nanoparticles also have been applied for the environmental remediation from pollutants like to reduce the radioactive compounds and heavy metals into soil and water, removing of nonmetals,metalsand radioactive elements as well as water purification. In an incubation Lab experiment, surface-modified nano-silica was used to stabilize Cd in polluted soils, and the maximum stabilization efficiency of Cd reached 91.21% under control both of moisture of soil and particle size. Nano-silica could be used as a new type of silicon fertilizer and as a carrier material, which has good environmental compatibility with soil. Some case studies for phyto- and bio-nano remediation of nano-silica are listed in Table 1.

TABLE 1. Some studies on the role of nano-silica in removingpollutants from soil and water

Plant species	Experiment type	Pollutants	Nanomaterials	Reference
------	Farm soil	As, Cd and Pb in soil	Ferroussulfate-modified nano-silica	Cao et al. (2020)
Maize and wheat	Field experiment	Cd in soil	Surface-modified nano-silica	Wang et al. (2020a)
Wheat-maize rotation for 3 years	Field experiment	Cd in soil	Mercapto-functionalized nano-silica	Wang et al. (2020b)
---------	Lab experiment	Cd in soil	Surface-modified nano-silica	Wang et al. (2020c)
Mountain rye or secale	Pot experiment	Pb and Cd in soil	Nano-silicaand municipal solid waste compost	Moameri and Khalaki (2019)
---------	Lab experiment	Ni in agri-wastewater	Nano-silica synthesized from barley and wheatgrass	Akhayere et al. (2019)
Wheat seedling	Pot experiment	Cd in soil	Mercapto-functionalized nano-silica	Wang et al. (2019b)

4.2 Nano-zero-valent iron

The nano-zero-valent of some metals could be used in removing pollutants from soil and water such as thallium (Tl) removal by nano-zero-valent Mn, lead (Pb) by nano-zero-valent Sn, antibiotics by nano-zero-valent tungsten, antibiotic sulfamethazine by nanosized zerovalent copper and uranium (U-VI) by nano zero-valent iron. The nano-zero-valent iron (nZVI) or iron nanoparticles is a promising remediator material could be used in environmental remediation. Iron nanoparticles are a type of iron-based materials have distinguished characterization including low toxicity, high iron source availability, high reactivity and attractive magnetic properties (magnetic adsorbents), which may support the adsorption through remediation (Fig. 1).

Fig. 1. Production of nano zero-valent iron (nZVI) by the reductive precipitation process using borohydride as a reducing agent, neon gas was used to keep the reductive environment. Precipitated nZVI was dried at 50 C° then kept under a thin layer of ethanol to prevent oxidation

TABLE 2. Some studies on the role of nano-zero-valent iron in removing pollutants

Plant species	Experiment type	Pollutants	Nanomaterials	Reference
----------	Batch experiment	Organic contaminants	Porous silicate supported micro-nano zero-valent iron	Gao et al. (2021)
----------	Batch experiment	Cr(VI) in water	Zero-valent iron nanoparticles	Wu et al. (2021)
----------	Batch experiments	Chlorophenol and Cr(VI)	Modified nanoscalezero-valent iron	Xie et al. (2021)
----------	Batch sorption experiments	U-VI in sewage water	Activated biochar-loaded nano zero-valent iron	Zhang et al. (2021)
Seeds of watercress (*Nasturtium officinale*)	batch experiment, petri dishes	As-polluted soils	Zero-valent iron and goethite nanoparticles	Baragaño et al. (2020)
Rice (*Oryza sativa*) seedlings	Pot experiment	Cd in soil	Nanoscalezero-valent iron	Guha et al. (2020)
----------	Lab work in a balloon flask	Organic As- pollutants	SiO_2-coated nano-zero-valent iron	Lv et al. (2020)
----------	Batch experiment	As(III)	Nanoscalezero-valent iron-encapsulated in porous zeolite-TiO_2	Madan et al. (2020)
----------	Granulation experiment	Cr(VI) in soil	Nanoscalezero-valent iron supported on vinegar residue	Pei et al. (2020)
Blackmangrove (*Avicennia germinans*)	Lab system for remediation	As, Cd and Pb in soil	Nano-zero-valent iron	Soto-Hidalgo et al. (2020)
----------	Batch experiment	Cr(VI) in wastewater	Nano zero-valentiron/carbon/alginate composite gel	Wen et al. (2020)
Rice (*Oryza sativa*) seedlings	Batch experiment, petri dishes	Cr(VI)	Polyethyleneglycol-stabilized nano zero-valent iron supported by biochar	Wu et al. (2020)
----------	Lab system for reclaimed water	Fluoroglucocorticoids	Nanozero-valent iron-modified biochar	Xiang et al. (2020)

The nZVI also could achieve both the adsorption of pollutants and reduction or oxidation through the induction of reactive oxygen species generated in aqueous solution. Some case studies for phyto- and bio-nano-remediation of nanozero-valent of iron are listed in Table 2.

CONCLUSIONS

To address the goals of increasing sustainable agriculture, the agro-pollutants should be remediated using different techniques or approaches. A wide range of these techniques could be employed in soil and water remediation, including the use of nano

particles in phytoremediation and bioremediation and nanotechnology, which produce the nano-phytoremediation and nano-bioremediation has also become popular in recent years. However, the new approaches within each of these technologies still also need to be explored in order to overcome the issues of each existing methodology. The methods of nano-bioremediation and nano-phytoremediation are still having several key challenges, such as the acceptable cost, biodegradability, non-toxicity, recyclability, high transformation/elimination capacity of the target compounds, ease of synthesis from a green chemistry perspective, and the potential for recovery after use or regeneration.

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Importance of Biosensors in Agriculture

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ABSTRACT

The development of biosensors has been the focus of research during the last few decades. Biosensors can serve as very efficient, inexpensive instruments for this purpose in addition to being employed in other widespread applications. Especially in third-world countries, it is evident that agricultural produce needs to be checked for quality and food safety. This problem can be tackled more precisely, conveniently, and sensitively by employing biosensors than by using conventional techniques. In-situ evaluations of fertiliser management, the detection of soil and water quality, the measurement of pesticide residues, and the monitoring of waste water are some of the essential components for crop growth and, as a result, for ensuring food security. The development of a broad transducer lineup was facilitated by the gradual blending of biosensors and nanotechnology, and expanded the sensing mechanism.

INTRODUCTION

Biosensors are analytical instruments that can convert biological reactions into electrical signals. Biosensors ought to be extremely accurate, reusable, and unaffected by external factors like pH and temperature.

A biosensor is a small analytical tool that uses an electric current to analyse, find, and record biological data. Either a discrete or continuous digital electrical signal can be produced by it. The primary purpose of this apparatus is to ascertain concentration of chemical and other biological components in food production and agricultural fields are specifically utilised in this device, they also occur in the biosensors. Leland C. Clark Jr. is known as the "Father of

Biosensors" since in 1956 he created the first real biosensor for oxygen detection.

Biosensors in Agriculture

Agriculture includes both the raising of crops and the keeping of animals. These elements play a significant role in our daily life. These products have historically been thrown away due to deterioration from diseases and pest infestations. Early detection is crucial in the agricultural field because crop diseases, insect damage, weed infestations, water shortages or surpluses, managing floods, assessing crop nutrition, and other issues are all preventable. There is cause for concern since herbicide, pesticide, and heavy metal concentrations are increasing in agricultural areas. Biosensors can be used to measure the levels of pesticides, herbicides, and heavy metals in the soil and groundwater. With the development of technology, biosensors can now be used to anticipate the probable emergence of soil disease. Using a biosensor for biological soil diagnostics allows for more effective early prevention and purification of soil illness.

Components of Biosensors

In essence, a biosensor is made up of two types of components: biological and physical. Biological component is constituted by biological substance that reacts with biological analyte (biological molecules, presence or concentration of which is to be detected) and physical components are comprised of three parts:

(a) A component of the biosensor that recognizes the signal caused by the interaction of the biological biosensor component and the analytic,

(b) Component responsible for transducing the known biochemical or biophysical signal into an electrical signal;

(c) Biosensor's part that reads the transduced signal (the part called reader device) and gives either analog or digital output inferable by the experimenter/observer.

Types

Biosensors are classified into following broad types:

(a) Electrochemical Biosensors.

(b) Immunosensors

(c) Acoustic biosensors

(d) Amperometric biosensors

(e) Calorimetric biosensors

(f) Potentiometric

(g) Optical biosensor

(h) Conduct Metric Biosensors

Uses and role of biosensors in agriculture

(a) Biosensors in detection of crop diseases

(b) Detection of pathogens in plants

(c) Biosensors used in agronomy and soil chemistry

(d) Biosensors in pesticides and its residues detection

(e) Biosensors for detection of Herbicides

(f) Biosensors used for quantification of Nitrates in plants

(g) Biosensors for detection of food pathogens and mycotoxins

(h) Linking with nanofertilizers: an agent to promote sustainable agriculture

(i) Biosensors for pre-harvest agriculture

Advantages and Disadvantages of Biosensors

Biosensors are portable, incredibly reliable, and fairly priced. They also offer a wide linear range of sensor response. Because they have improved selectivity towards targeted ions and ppb level detection, sensor-based responses eliminate the cost of onsite monitoring involved with collecting, separating, packaging, and transporting the sample to be analyzed. As a potential standard technology, it does have a number of issues that need to be resolved. Lack of heat sterilization, which denatures the biological component of the biosensor, high development costs, decreased enzyme and antibody stability, lack of reproducibility, lack of reusability, cell poisoning, etc. are a few of the drawbacks mentioned in the literature. Numerous authors from various fields emphasize ways to address shortcomings. To get at a better answer, though, it needs a common platform because it is a multidisciplinary strategy.

CONCLUSION AND FUTURE ROLE

In conclusion, despite the many advantages of biosensors and bio sensing tools like nanoparticles/nanomaterials, polymers, and microbes built biosensors in addressing some of the challenges in agricultural activities with regard to environmental sustainability, there is still a need to significantly assimilate multi-faceted methods in developing biosensors that can potentially be used for diverse applications in climate smart organic/biological agriculture for enhanced environmental sustainability. Therefore, it is proposed that effective development of comprehensive and influential biosensors for contemporary future contributions to knowledge in the field of biosensor machinery in climate smart organic/biological agriculture for environmental sustainability would require the appropriate combination of bio sensing as well as bio-fabrication with non-natural/synthetic biology methods by applying either/both electrochemical, optical, and bio-electronic moralities

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Impact of Microplastics on Soil Bio-physical Environment and Crop Production

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ABSTRACT

Microplastics (MPs) are fragments of any type of plastic less than 5 mm in length. Microplastics are ubiquitous in nature, high specific surface area and strong hydrophobicity. Plastic residues found in the soil because of mulching operations are converted into MPs by the passage of time and environmental actions. MPs play an important role in the transportation of toxic chemicals such as plasticisers, polycyclic aromatic hydrocarbons (PAHs), antibiotics, and potentially toxic elements (PTEs). The accumulation of residual MPs in field soil can cause negative impacts on crop production because they: (1) destroy the soil structure, alter the physico-chemical properties of soil, and affect nutrients mobility and moisture diffusion in soil; (2) reduce the availability of nutrients, alter microbial activities, affect crop development and growth, reduce seed germination (3) slow down development of roots during germination; and (4) influence greenhouse gas emissions. The existence of residual MPs hinder the sowing and growth of plants in the soil environment. MPs in the soil affect the soil physical characteristics like soil aggregation, water holding capacity (WHC), infiltration rate, microbial activity, enzyme activity as well as soil flora and fauna and terrestrial organisms. The use of biodegradable plastic material (e.g., polyhydroxy butyrate (PHB), polybutylene succinate, polycaprolactone (PCL), polyhydroxy alkanoate (PHA), polybutylene adipate-co-terephthalate (PBAT), polylactic acid (PLA), polyglycolide, and starch-based blends)in mulching can be mitigate the adverse effect of MPs on soil as well as plant health.

INTRODUCTION

One of the most popular materials in use today is plastic. Its strength and adaptability have made it a popular option for a variety of uses, including food packaging, household goods, and electronic equipment. The production of plastics worldwide has expanded significantly over the past 20 years, nearly doubling, and will produce 460 million tonnes (Mt) in 2019. This is due to the rapid population development. Even though plastics are recyclable, only 9% of them are recycled, leaving the majority in the environment where they are broken down into tiny fragments and particles known as microplastics by a variety of biotic and abiotic agents. Microplastics are microscopic plastic flecks that are no larger than five millimetres. Researchers and decision-makers are paying closer attention to the environmental issue of microplastic pollution in soil.

Sources and Pathways of microplastics in soil

Through a number of channels, including the direct disposal of plastic debris, the use of plastic mulch in agriculture, and the spreading of sewage sludge on soil, microplastics can penetrate soil ecosystems. Although the consequences of microplastics in soil are not fully understood, there is mounting evidence that they may be detrimental to the health of the soil and the larger ecosystem. Numerous services, including carbon sequestration, biogeochemical cycling, and biodiversity enhancement, are mediated by soils. The activity of soil bacteria, which catalyses many of the biogeochemical processes that provide human societal goods, such as enhancing food security, is a significant underlying engine powering most of these services. In turn, the physical and chemical environments to which these organisms are exposed have a significant impact on how these microorganisms function. For instance, it is known that pore space structure, hydrological characteristics, and the arrangement of soils into different functional aggregates all have an impact on how quickly microbes break down organic matter.

Soil processes and function depend on fundamental characteristics of the soil biophysical environment. With a baseline level of up to 0.002% of soil dry weight, microplastics have been discovered in soils from nonurban natural reserves, including mountainous and populated locations. Microplastics can be successfully integrated into the soil matrix via bioturbation, for example, after they reach the soil surface. Microplastics can migrate in both horizontal and vertical directions, and their distribution is regulated by a number of variables, including the soil biota, soil characteristics (such as soil macropores, soil aggregation, and soil cracking), and agronomic practises (such as plough and harvesting). Plant processes including root growth and uprooting as well as contributions from various animals (larvae, earthworms, vertebrates, etc.) could be considered biotic factors for the dispersion of microplastics. Through the transmission of contaminants throughout their growth phase, fungus mycelia may also aid in the migration of microplastics. Microplastics can be spread laterally by Epigeic earthworms, mosquito larva, mites, collembola, moles, and other organisms.

Impact of Microplastics on Soil Bio-physical Environment and Crop Production

(a) Impact of Microplastics on Soil Bio-physical Environment

In soil, nutrients are primarily produced through the breakdown of minerals and organic matter, and enzymes play a key role in controlling nutrient cycles as a measure of soil fertility. Microplastics alter the physical, chemical, and biological characteristics of soil.

Recent studies reveal that microplastics affect how dissolved organic matter (DOM) cycles carbon and nutrients. In contrast to studies that illustrate the impact of biodegradable mulch on soil chemistry and discovered that microplastics raise soil pH, microplastics modify soil pH through interactions with numerous organic and inorganic components, including cations and protons. This demonstrates how pH is changed by microplastics in various soil types. Microplastics may alter soil porosity, speeding up evaporation and causing soil to split. The primary determinant of soil structure, porosity, and stability is the composition of the soil aggregates. Since over 72% of the microplastics in soil considerably impair soil water aggregates, it is troublesome that microplastics may decrease biological activity and function.

In addition, the combination of microplastics and cadmium decreases growth rates and mortality of earthworms etc. Microplastics can potentially affect the soil food webs. Soil biota, such as predators, prey, and decomposers, interact in intricate networks known as soil food webs. Microplastics can alter the availability of soil organic matter, which can have an effect on soil nutrient cycling and the health of the soil ecosystem. In the end, this can result in less fertility and production of the soil. According to a study, soil nutrient availability was decreased because microplastics decreased soil microbial biomass and activity.

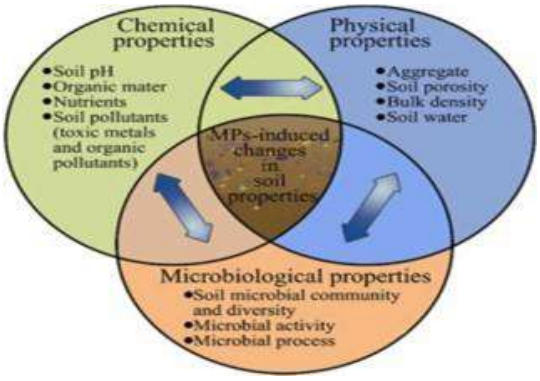

Figure: Microplastics effect on soil properties

(b) Impact of Microplastics on crop production

The presence of microplastics affect not just growth but also plant physiology .Photosynthesis is extremely critical to plant growth and a number of microplastics affect photosynthesis by reduction in leave chlorophyll .This impair mitosis and have an overall effect on plant health and quality due to a reduction of the mitotic index . Microplastics effect the both vegetative and reproductive phase of crops. There is a cluster formation of microplastics around the roots which prohibits the uptake of nutrients.

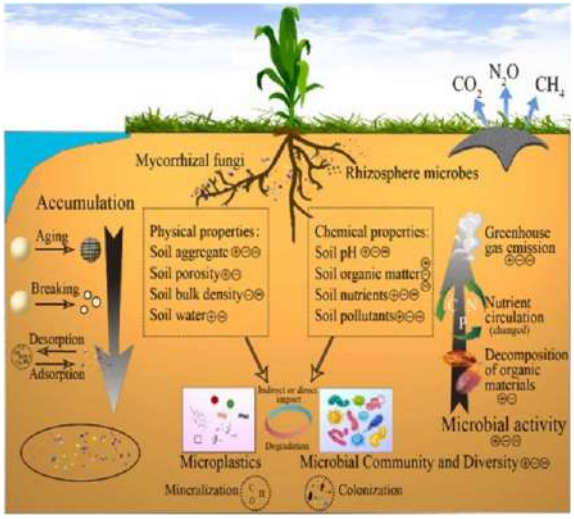

Figure: Effects of Microplastics on soil properties

CONCLUSION

Emerging contaminants known as microplastics inflict specific harm to soils, animals, plants, and humans. They enter terrestrial ecosystems in a variety of ways, build up in soils, and accumulate there. Microplastic contamination is spreading around the globe, and the significant hazards it poses to terrestrial soils must receive proper attention. Microplastic pollution affects physicochemical properties, soil microorganism, plant growth and physiology, and human-caused environmental dangers. Microplastic contamination is found in a range of soils, plants, and humans.

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The Mighty Millets: Addressing Nature's Powerhouse of Nutrients

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ABSTRACT

Millets are the group of small-seeded annual grasses that are grown as grain crops primarily on marginal land in dry areas and belong to the Poaceae family. Millets are the ancient food grains first domesticated for food and grown in 131 countries. Millets are the traditional food for 59 crore people in Asia and Africa. It has now been proposed to enlarge the food basket and include millets like Jowar, Bajra, Ragi etc. in the Public Distribution System. The major millets are Sorghum, Pearl Millet and Finger Millet covering 95% of the total millet growing area in India and the rest 5% are Little Millet, Foxtail Millet, Barnyard Millet, Proso Millet, Kodo Millet, and Brown top Millet. Millets are rich sources of minerals like calcium, iron, zinc, phosphorus, magnesium, and potassium. Millets are gluten free grains hence, used for celiac disease patients. It also contains appreciable amounts of dietary fiber and vitamins such as folic acid, vitamin B6, β- Carotene, and niacin. They are hardy crops that have low carbon & water, the root system of foxtail millet is reduced and enhance in response to low nitrogen and phosphate levels in the soil. It can sustain drought and even 350-400 mm of rainfall is sufficient for millets. Millets are dual-purpose crops. It is cultivated both as food & fodder, thus providing food/livelihood security to millions of households and contributing to the economic efficiency of farming. Millets are termed as the 'miracle grains' or 'crops of the future' as they can not only grow under harsh circumstances but are

drought-resistant crops that require fewer external inputs. India is the highest producer of millets in the globe and the 5th largest exporter of millets. Millets are addressing the need for fuel and feeds.

INTRODUCTION

Recently, millets have gained attention and efforts are underway to obtain their convenient and value-added processed products. It has now been proposed to enlarge the food basket and include millets like Jowar, Bajra, Ragi etc. in the Public Distribution System.

Government has recognized the role of millets in the food chain. Under the National Food Security Mission – NFSM of the preliminary targets for enhancing food grain production by an additional 25 million Tones, the share allocated for millets is 2 million Tones i.e., 8% of the enhanced food grain production.

Importance of Millets in India:

Millets are the group of small-seeded annual grasses that are grown as grain crops primarily on marginal land in dry areas and belong to the Poaceae family. Millets are the ancient food grains first domesticated for food and grown in 131 countries. Millets are the traditional food for 59 crore people in Asia and Africa. The major millets are Sorghum, Pearl Millet and Finger Millet covering 95% of the total millet growing area in India and the rest 5% are Little Millet, Foxtail Millet, Barnyard Millet, Proso Millet, Kodo Millet, and Brown top Millet.

Health benefits of Millets:

Millets are rich sources of minerals like calcium, iron, zinc, phosphorus, magnesium, and potassium. Millets are gluten free grains hence, used for celiac disease patients. It also contains appreciable amounts of dietary fiber and vitamins such as folic acid, vitamin B6, β-Carotene, and niacin. The availability of high amounts of lecithin is useful for strengthening the nervous system. Kodo Millet contains high dietary fiber that is 3 times more than wheat and maize and 10 times more than rice therefore, regular consumption of millets can help to overcome malnutrition. It is also rich in Zinc and Folic acid and is recommended for pregnant women. Pearl Millet contains 2 times more protein than milk (Hasemi et al. 2022).

Importance of Millets in the Indian Agriculture Sector:

Apart from health benefits, millets are resilient to climate change as they are adapted to a wide range of temperatures, and moisture regimes, and demand less input to grow. They are hardy crops that have low carbon & water, the root system of foxtail millet is reduced and enhance in response to low nitrogen and phosphate levels in the soil. It can sustain drought and even 350-400 mm of rainfall is sufficient for millets.

Millet production in the world:

Millets have served as a traditional staple for hundreds of millions of people in Sub-Saharan Africa and Asia (particularly in India, China, and Nigeria) for 7000 years and are now cultivated across the world. Estimates show that more than 90 million people in Africa and Asia depend on millets in their diets.

Africa accounts for more than 55 percent of global millet production, followed by Asia with nearly 40 percent, while Europe represents around three percent of the world market. In recent years, their production has gradually declined due to market distortions, a lack of appreciation of the benefits of millets

and policies that have favoured the production of the so-called Big Three cereals – rice, wheat and maize. Farmers have switched to cultivate more remunerative crops grown to sell for profit. They moved away from subsistence agriculture responding to changing consumer preferences and markets inputs (UNRIC, 2023).

Advantages of Millet production:

Millets have often been called the coarse grains, however, because of their nutritional contributions they are now being referred to as 'nutria-millets or nutria-cereals'. Given below are some of the advantages of Production of Millets in India.

1. Millets are termed as the 'miracle grains' or 'crops of the future' as they can not only grow under harsh circumstances but are drought-resistant crops that require fewer external inputs.

2. Millets are remarkable in their nutritive value be it vitamins, minerals, dietary fiber or other nutrients. It is nearly 3 to 5 times nutritionally superior to wheat and rice. Sorghum is an important source of polyphenols, antioxidants, and cholesterol-lowering waxes.

3. Millets help in curbing obesity, lowers the risk of hypertension, CVDs, T2DM, cancers as well as helps in preventing constipation due to their high dietary fiber content coupled with low glycemic index.

4. Production of millets does not depend on the use of chemical fertilizers. The millet crops do not attract pests and are not affected by storage.

5. Millets contribute to mitigating climate change as it helps reduce the atmospheric carbon pressure CO2. On the contrary, Wheat being a thermally sensitive crop and Paddy is a major contributor to climate change through methane emission.

6. Millets are dual-purpose crops. It is cultivated both as food & fodder, thus providing food/livelihood security to millions of households and contributing to the economic efficiency of farming.

Economic Importance of Millets:

India is the highest producer of millets in the globe and the 5th largest exporter of millets. Millets are addressing the need for fuel and feeds. It has the potential to produce biofuel. Millet Market size was over USD 9 billion in 2018 and will witness more than 4.5% CAGR during the forecast timespan (2018-2025) and the value projected is more than USD 12 billion (Lokesh et al. 2022).

CONCLUSION:

Millets are easily accessible and inexpensive. This is primarily due to a lack of awareness and information among the general public about the various types of food available, particularly little millets. The majority of developing countries grow millets to suit their food and nutrition needs, whereas affluent countries feed animals with them. Minerals, vitamins, protein, carbs, and amino acids all abundant in these foods. When compared to cereals, they play a vital role in sustainability because they consume less water. They can be cultivated with less pesticide and fertilizer in locations where main crops are not grown. Millets are a rich source of dietary fiber, protein, and minerals that can be added to people's daily diets as they have wide health benefits such as preventing diabetes, cardio-vascular diseases, obesity, gastro-intestinal problems, and cancer, among other things, as the population grows and they consume fast foods and eat an unbalanced diet. They contain anti-oxidants and provide energy throughout the day by digesting slowly. Therefore, to ensure food and nutrition security for our

country, it is important to increase the production of these crops and simultaneously revert the control of production, distribution and consumption back to the people.

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