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IMPORTANCE AND CULTIVATION PRACTICES OF ENDANGERED MEDICINAL PLANT –*Coleus Forskohlii*

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Importance

Coleus (*Coleus Forskohlii)* is a plant of Indian origin belonging to the mint family Lamiaceae and grows perennially over tropical and subtropical regions. In India, the crop is cultivated in the parts of Gujarat, Maharashtra, Rajasthan, Karnataka and Tamil Nadu and is being grown in an area of more than 2500 hectares for its tuberous roots. The common names of *Coleus* are Pashan Bhedi in Sanskrit, Patharchur in Hindi, Makandiberu in Kannada, Coleus in English, Garmalu in Gujarati, and Maimnul in Marathi. It is an important medicinal plant. Becauseof the continuous collection of its roots from wild sources, the plant has been included in the list ofendangered species (Boby and Bagyaraj, 2003).Forskolin is present in their roots. Because of the continuous collection of roots from wild sources, this plant has been included in the list of endangered species. The crop has great potential in future due to the expected increase in demand for forskolin. With the present annual production of about 100 tons from 700 ha in India, cultivation of *C.forskohlii* is picking up because of its economic potential is an important medicinal crop which contains forskolin in its roots. Because of the continuous collection of roots from wild sources, this plant has been included in the list of endangered species. The crop has great potential in future due to the expected increase in demand for forskolin which is widely used in glaucoma, cardiac problems, eczema, asthma, and hypertension and is also used in the treatment of certain types of cancers. With the present annual production of about 100 tons from 700 ha in India, the cultivation of *C.forskohlii* is picking up because of its economic potential. However, the crop has not become very popular among farmers because of its susceptibility to many diseases of which root- rot/wilt is the most important, causing serious losses affecting the tuber yield.

Medicinal properties and uses

- ✓ Dried tuberous roots are the economic part.
- ✓ Its tuberous roots are found to be a rich source of an alkaloid called Forskolin
- ✓ Forskolin is the important base for many drugs developed for hypertension, glaucoma, asthma, congestive heart failure, weight management and certaintypes of cancers.
- ✓ In addition, forskolin is reported to have been used in the preparation of
- ✓ Medicines prevent hair greying and restore grey hairs to their normal colour.
- ✓ Leaves are employed in treating intestinal disorders and used as a condiment.


Coleus plant


Coleus planting


Roots of coleus

Cultivation Practices

Soil and Climate : Well-drained red loamy soils are suited for cultivation. Water stagnation should be avoided. Crop thrives best in areas receiving 70 cm annual rainfall.

Seed and seed rate : For commercial plantings, the crop is propagated through terminal cuttings. For this purpose about 10-12 cm long cuttings comprising 3-4 pairs of leaves are preferred.

Season : Planting is done during June – July.

Planting : Planting is done at 60 x 45 cm spacing (37,030 plants/ha). In low fertile soils, planting is done at 60 x 30 cm which requires 55, 500 plants/ha.

Manuring : Incorporate 15 t/ha of FYM during the last ploughing. NPK at 30:60:50 kg/ha is applied in two split doses at 30 and 45 days after planting. Apply 10 kg $ZnSo_4$/ha to avoid micronutrient deficiency.

Irrigation and intercultural activities : The first irrigation is given immediately after transplanting if there is no rain.During the first two weeks after planting, the crop is irrigated once in three daysand thereafter weekly irrigation is enough to obtain good growth and yield.

Plant Protection

Root Knot Nematode control:

- ✓ Crop rotation with marigold, sorghum and maize
- ✓ Intercropping with marigold
- ✓ 200 kg of neem cake per acre before planting
- ✓ As a last option appliesCarbofuran granules at the rate of 20 kg per hectare underwet conditions near the root zone.

Major diseases:

Fusarium wilt control:

- ✓ Never allow water stagnation
- ✓ Dipping the terminal cuttings in Carbendazim solution (1 gram per litre) before planting
- ✓ Mix 5 kg of *Trichoderma viride*in 250 kg of compost and apply around theroots every 20 days interval

Bacterial wilt control:

- ✓ Streptocyclin 300 ppm solution around the roots
- ✓ Apply 2 kg of *Pseudomonas fluorescens*bio-control agent mixed with 300 kg ofcompost.

Harvesting

Crops can be harvested six months after planting. Before harvest, the top portion should be removed when sufficient moisture is in the soil. Roots are dug manually or by tractor-drawn harvester. The soil particles are removed and the tubers are cut into small bits using a motorised chopper to facilitate drying. The cut root bits are dried under the sun for 3-5 days with frequent turnings until the moisture drops to 6-8 per cent.

Yield:

Green roots: 15 – 20t/ha
Dry roots: 2 – 2.5 t/ha

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ELECTRONIC NATIONAL AGRICULTURE MARKETING (e-NAM): AN ONLINE TRADING PLATFORM

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Abstract
Electronic National Agricultural Market or e-NAM is a virtual trading platform where the farmers and traders meet through online and selling is also done through e-payment method. This scheme was launched in April, 2016under Digital India Flagship Programme, based on the concept of ReMS initiative in Karnataka. Initially it was started as a pilot basis in 21 mandis across 8 states covering only 24 commodities and till February, 2024 it has covered 1389 mandis all over the India with more than 1.77 Crores registered farmers, 2.5 lakhs registered traders. At present total 219 commodities are traded through e-NAM and in November, 2023 the total trade value through this platform was almost 3lakh Crores which is a great achievement.

Keywords : Electronic trading platform, APMC, FPO.

Introduction

The Economic Survey of India, 2014-2015 recommended the construction of a national-level electronic marketing platform for farmers to enable farmers to market their produce more efficiently and receive remunerative prices. The idea behind such a platform was to leverage technology to create a unified marketplace where farmers could connect with buyers from across the country, thereby expanding their market access and potentially improving their income Government of India had introduced e-NAM scheme on 14th April, 2016 after motivating by the concept and success of Rashtriya e-Market Service Scheme (ReMS) Model in Karnataka, 2012. NAM portal was designed to integrate the existing APMC (Agriculture Produce Market Committee)/RMC (Regulated Market Committee) market yards, sub-yards, unregulated markets and even the private markets all over the country to create a common online market platform throughout the nation. This platform enables farmers and traders to conduct online transactions for buying and selling produce, eliminating many of the traditional barriers and middlemen involved in the process.

Pre-requisites of e-NAM

The eligibility criteria for states and union territories (UTs) to receive assistance under the scheme include implementing some reforms in their Agricultural Produce Market Committee (APMC) Acts to meet three specific pre-requisites:

1. Single license valid across all mandis; states/UTs must ensure that a single license is sufficient for trading in all the mandis (markets) within the respective State/UT.
2. Single point levy of market fees; the market fees should be levied at a single point, typically at the first wholesale purchase from the farmer.
3. Provision for electronic trading; states/UTs are required to incorporate provisions for electronic trading within the mandis.

Importance of e-NAM

The major importance of the scheme e-NAM over the current APMCs or regulatory marketing system in India is as follows.

1. Electronic trading provision which involves incorporating online trading platforms into the process of price discovery for agricultural produce. This could facilitate transparent and efficient price discovery mechanisms.
2. This scheme is enabling online payment methods to streamline transactions and reduce the reliance on cash transactions, thereby enhancing the efficiency and security of the trading process.
3. Unified single trade licensing simplifies the regulatory process for traders, reducing bureaucratic hurdles and promoting interstate trade.
4. For states that currently lack regulation in agricultural produce trading (like non-APMC states), integrating with e-NAM and establishing a regulatory body can help standardize trading practices, ensure compliance with quality standards and provide a framework for dispute resolution.

Major stakeholders under e-NAM

The primary participants in this scheme are farmers, APMCs, traders, Mandi Boards, and FPOs. The list of current stakeholders is provided below.

Table 1: Breakup of different stakeholders under e-NAM as on 31st January, 2024

State and UTs	**27**
Traders	**253725**
Commission agents	111488
Service providers	79
Farmers	**17705211**
FPOs	**3510**
Total	**18074013**

Source: https://enam.gov.in/

Spread of e-NAM across the mandis over the years

Initially Government of India started this scheme in 21 pilot mandis across 8 states in 24 commodities in April, 2016. Gradually the number of registered mandis under this scheme has been increased over the years and on 31st March, 2018 total 585 mandis joined the scheme across 16 states and 2 UTs with 124 commodities traded through e-NAM; in May, 2020 the number of registered mandis were 1000 across 18 states and 3UTs with 193 commodities traded. At present the total number of registered mandis under this scheme is 1389 across 23 states and 4 UTs.

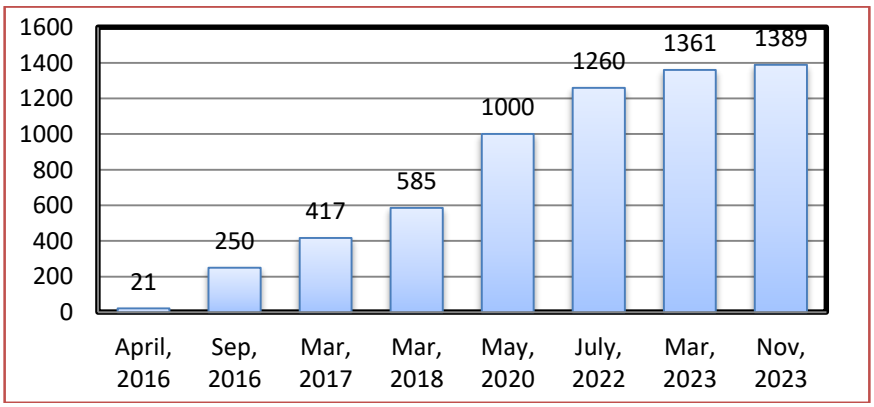


Fig 1 : No of APMC markets integrated with e-NAM over the years
Source : https://enam.gov.in/

State-wise number of registered mandis and traders under e-NAM as on 31stjanuar, 2024

Table-2 : State-wise registered mandis and traders under e-NAM

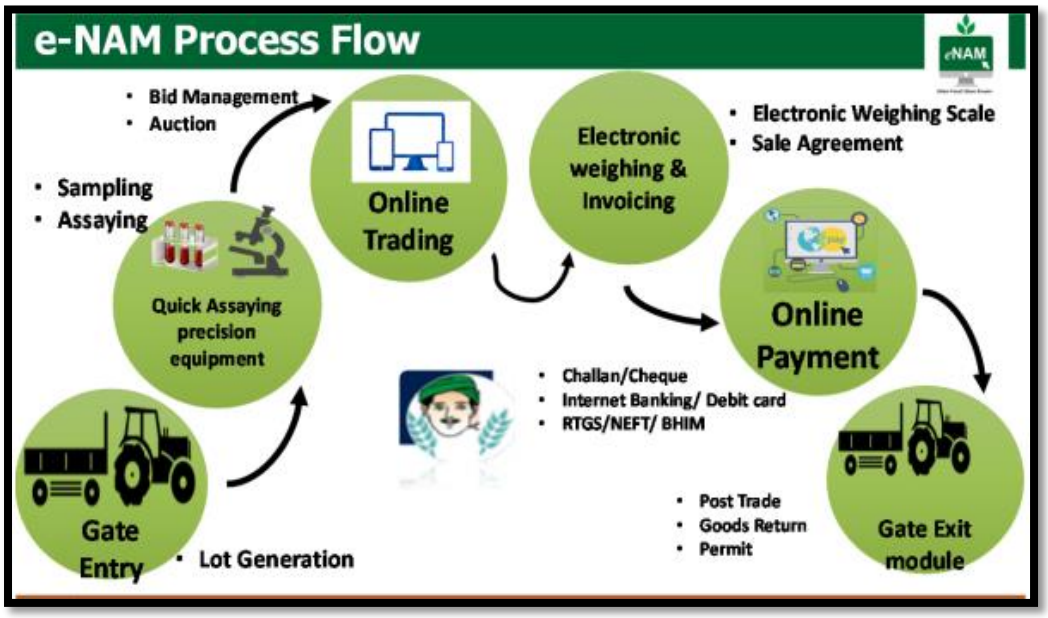
State/ UTs	Mandis registered under e-NAM	Registered traders under e-NAM
ANDAMAN and NICOBAR ISLAND	1	4
ANDHRA PRADESH	33	3749
ASSAM	3	8
BIHAR	20	195
CHANDIGARH	1	121
CHATTISGARH	20	3250
GOA	7	877
GUJARAT	144	10140
HARYANA	108	16787
HIMACHAL PRADESH	38	2260
JAMMU & KASHMIR	17	2640
JHARKHAND	19	2486
KARNATAKA	5	743
KERALA	6	430
MADHYA PRADESH	139	23775
MAHARASHTRA	133	22210
NAGALAND	19	94
ODISHA	66	9052
PUDUCHERRY	2	216
PUNJAB	79	2953
RAJASTHAN	145	84630
TAMIL NADU	157	10748
TELANGANA	57	6221
TRIPURA	7	22
UTTAR PRADESH	125	39268
UTTARAKHAND	20	5807
WEST BENGAL	18	4939
TOTAL	**1389**	**253725**

Source : https://enam.gov.in/

Process of selling through e-NAM

The farmers clean and grade their produce before bringing it to the registered mandis. When farmers register on e-NAM and enter their nearby mandi or marketplace, they are assigned a commission agent and provided with an identification number. Then, the lot is graded under the supervision of the grading officer in an assaying lab within the premises of the market where electronic trading facilities are available (assaying is not mandatory). After assaying the produce different quality products are displayed on the auction platform. Then, between 9:30 AM and 12:00 PM, the local vendors and other purchasers physically inspect the fruit before placing an online bid for each lot using a mobile app, an on-site computer, or both. Based on the produce's grade as listed online, traders and purchasers from other markets may also place bids. At 12:10

PM, the online auction closes. The computer system uses an automated price discovery technique to determine the highest offer for each lot using the English auction system. The market employee will identify the highest bidder for each lot, and the farmer will receive an SMS with the buyer's name and the bid amount. Both the commission agent and the buyer receive an SMS as well. The technology will create the sale bill if the farmer accepts the offer price and will use electronic weighing to ascertain the precise quantity of produce. After the trader's account is cleared of market fees and the like, funds are sent from an escrow account to the commission agent, who subsequently pays the farmer. Because these transactions take place on the same day as the trade, the farmers can depart the e-NAM with the sale by 12:30 PM with the sale proceeds.



Source : https://enam.gov.in/

Conclusions

The e-NAM scheme is gradually gaining momentum and recognition despite facing initial challenges. By providing farmers with access to a wider market and enabling fair pricing for their produce, e-NAM has the potential to significantly enhance farmer's income. The recognition and increase in trade value and volume through the e-NAM platform signify its growing acceptance and effectiveness. However, to fully unlock its potential, it's crucial for policymakers to address the issues that have slowed its progress and make necessary adjustments to ensure greater acceptability and wider coverage. With concerted efforts and strategic adjustments, e-NAM can emerge as a transformative force in strengthening the agricultural marketing sector and uplifting the livelihoods of farmers.

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RECENT ADVANCES IN PROPAGATION OF POTATO

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Introduction

Potato is scientifically known as *Solanum tuberosum* L. having chromosome number 2n=4x=48. It is an important world staple food crop and stands fourth position after rice, wheat and maize. It contains 20.6% of carbohydrate, 2.1% of protein and 0.3% of fat and also it is rich in vitamin B and C and some of the essential amino acids like leucine, isoleucine and tryptophan. It is cultivated as summer crop in hills and winter crop in plains. In the plateau regions of Maharashtra, Karnataka and Madhya Pradesh, potato is raised in rainy (June-July) and winter seasons (Sept-Oct).

In the current context of potato cultivation in India, with a total area of 2.16 million hectares and a productivity of 24.55 tons per hectare, the total production stands at 53.03 million tons, necessitating a seed rate of 2.5 to 3.0 tons per hectare. Consequently, the total seed requirement amounts to 6.15 million tons, representing 11.59% of the total production.

Various techniques are employed for multiplying seed potatoes throughout the world. These include traditional methods, tissue culture techniques of seed production and advanced hi-tech systems such as microplant, microtuber and aeroponics-based seed production.

Seed Plot Technique (SPT)

CPRI Shimla developed a technique for disease free quality seed production during low aphid population in sub-tropical North Indian plains, known as seed plot technique. This technique was developed by Dr. Pushkarnath during 1959.

Components of Seed Plot Technique

1. **Crop rotation and hot weather cultivation :** It is desirable to adopt 2–3 years of crop rotation preferably with cereal crops. Using of hot weather cultivation, the soil borne pathogens, insects and weed seeds can be killed by exposing soil to high temperature.
2. **Use of healthy seeds :** The seed tubers should be healthy for obtaining healthy seed tubers.
3. **Use of sprouted seeds :** Using pre-sprouted seed tubers will helps in obtaining larger size of seed tubers, ensures quick and uniform emergence and also results in early tuberization and maturation.
4. **Planting & use of systemic insecticides :** Planting will be done normally during 1st week of October. During planting or during earthing up period, use of systemic insecticide will be made for controlling sucking pests and white grubs.
5. **Rouging out :** Removal of off-types and diseased plants from the field called roughing out. For this, three investigations will be made: 20 to 25 days after transplanting; 40 to 45 days after transplanting and 3 to 4 days before dehaulming.
6. **Dehaulming :** The removal of plants from the ground level is called dehaulming. It will be done before vector crossing critical level *i.e.* 20 aphids/100 compound leaves.
7. **Harvesting:** Potatoes are normally harvested 10 to 15 days after dehaulming. After the harvest, tubers are kept under cool shady area for curing. After curing, the tubers are treated with 3% Boric acid for 30 minutes to avoid tuber infection during storage.

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8. **Cold storage:** The treated tubers are packed in bags, sealed and labelled and kept under cold storage at 4^0C temperature.

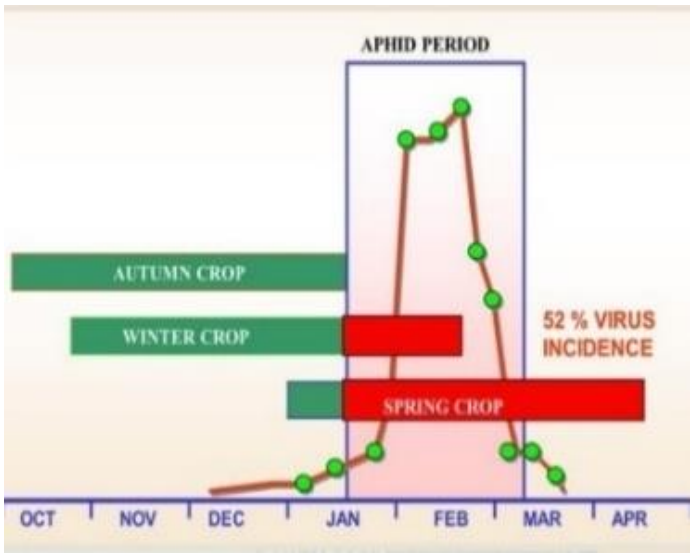

Fig. 1: Crop season vs aphid infestation period in Indian plains

Disadvantages of seed plot technique

- There will be low multiplication of the tubers *i.e.,* 1:6
- It requires specific season and area
- There will be a chance of accumulation of degenerative viral diseases will be more in seed tubers

True potato seeds (TPS) technology

True Potato Seed (TPS), the sexual or botanical seed of potatoes, emerges as a revolutionary alternative to traditional seed tubers for cultivating commercial potato crop. Each potato plant produces dozens of berries containing hundreds of these tiny seeds. TPS presents a range of advantages over seed tubers, addressing issues like low multiplication rates, high storage and transportation costs, pathogen carry-over and physiological degeneration.In contrast to seed tubers, TPS offers numerous benefits, including lower costs for planting materials, reduced transmission of pathogens and pests and simplified storage and transportation processes. Exceptional cases aside (e.g., potato spindle tuber viroid), TPS is generally free from most diseases, including systemically transmitted viruses.

Disadvantages of TPS

- TPS cultivation demands significant labor inputs and continual monitoring, making it vulnerable to damage from climate fluctuations such as high temperatures, heavy rainfall and drought, more than crops grown from seed tubers.
- TPS crop also require approximately 20-25 additional days to reach maturity compared to conventional potato crops grown from seed tubers.
- Limited availability of hybrid TPS populations, restricting choice for farmers.
- Due to its segregating nature, TPS lacks the uniformity seen in conventional potato crops, resulting in lower market value.

Advances in Potato Seed Production

1. **Tissue culture-based systems**
   a. **Micro propagation**

   Steps in micropropagation of potato

   - **MS Media Preparation :** The MS media is prepared and kept for autoclaving for sterilization and it is kept for 1-2 days for media solidification.
   - **Inoculation :** 7-8 single node cuttings are inoculated into the bottle jar containing MS media.
   - **Incubation :** After inoculation the bottle jars are kept in incubation chamber for 15 days.
   - **Sub-culturing :** The bottle jars after incubation will be taken for sub-culturing.
   - **Placing under growth chamber :** After sub-culturing, the bottle jars are kept under growth chamber for growth of the plant.

   b. **Micro-tuber production from micro-plants**

   Micro-tubers are also called as miniature tubers. Sprouts and shoot tips of the micro plants are taken as explant and these are sub-cultured in bottle jars. 20-25 days after sub-culturing, micro-tubers will start developing. The micro-tubers100-200 mg weight will be harvested.

2. **Mini-tuber production in soil**

   Both microplants and microtuber are taken as planting material. These planting materials are transplanted into net house. Approximately 10-20 minitubers are produced from single microplant. The obtained minitubers are multiplied in three subsequent generations before supplying to farmers as seed. The yield of minituber from microtubers is less than the microplants.

   Advantages of mini tubers over micro plant

   - Minitubers are hardier than the microplants.
   - They are easy to handle and transport.
   - Require less care during planting, post-planting operations.

   Disadvantages of mini tubers over micro plant

   - It takes 2-3 additional months time in the laboratory for the production of mini tubers.
   - It requires cold storage for breaking dormancy.

3. **Aeroponics**

   Aeroponics is a plant culture technique in which mechanically supported plant roots are either continuously or periodically misted with nutrient solution. *In vitro* grown 15-21 days old microplants are hardened before shifting to this system. Hardened plantlets of about 15 cm height are planted in holes of aeroponic grow boxes. All essential nutrient elements supplied by pump. 100% relative humidity is maintained inside the root zone.

   Roots, stolons and tubers develop inside the chamber and leaves are exposed to light. Nutrient solution is replenished from time to time with an interval of 2-3 weeks with maintaining pH of 6.0. Sequential picking is done at regular interval and tubers are harvested when they attain desired size of 3-10 g. The aeroponic minitubers are harvested and are called as generation-0 (G-0) planted under net house at a spacing of 30 cm x 15 cm for obtaining

Generation-1 (G-1) seed tubers. These minitubers are taken for commercial potato production.

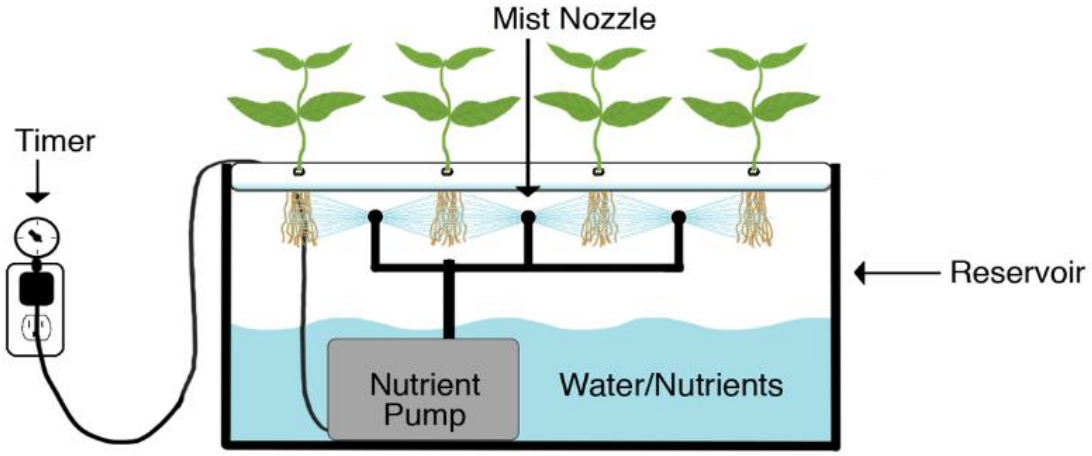

Fig. 2 : Aeroponics model

4. Apical Rooted Cuttings

The steps involved in Apical Rooted Cuttings are

Disease Free Mother Cultures (CPRI): The disease-free mother tubers are taken from CPRI, Shimla

⬇

***In vitro* Multiplication in TC Lab:** These mother cultures are multiplied in *In vitro* for obtaining mother plants under tissue culture

⬇

Mother plants multiplication in polyhouse: The mother microplants are multiplied on nursery bed under polyhouse

⬇

ARC Production (Seedlings) in polyhouse: From the mother microplant, apical stem cuttings are taken and transplanted into the pro-trays

⬇

Seed Production (Season 01)in open field: The ARC are transplanted into the open field for obtaining G0 seed tubers This will be called as season 1

⬇

Seed Production (Season 02) in open field: The obtained G0 seed tubers are again transplanted to the open field for production of G1 seed tubers

⬇

Commercial potato production: These G1 seed tubers are taken for commercial potato production

Fig.3 : Healthy ARC plant

Comparison Conventional v/s ARC Seed production system

Particulars	Conventional Seed Production	ARC Seed Production
Investment	High cost	Low cost
Technology	Complicated	Simple
Suitability	For only large-holdings resource rich formers	Even small- holders can become seed producers
Gestation Period	At least 6 seasons are required	Only two seasons
Risk	High	Low
Seed System	Centralised	De-centralised

Conclusion

Recent advancements in potato seed production techniques have revolutionized the way farmers cultivate this essential crop. Traditional methods like the Seed Plot Technique (SPT) have paved the way for more sophisticated approaches such as True Potato Seeds (TPS) technology, tissue culture-based systems and aeroponics. These innovations offer numerous benefits, including reduced costs, enhanced storage and transportation efficiency and year-round availability of quality seed tubers. Moreover, the emergence of techniques like mini-tuber production and apical rooted cuttings (ARC) has popularized seed production, making it accessible even to small-scale farmers. By reducing the gestation period and minimizing risks, these modern methods empower farmers to improve their yields and contribute to food security. While each technique has its advantages and limitations, collectively, they signify a transformation towards sustainable and efficient potato cultivation practices. By embracing these advancements and fostering innovation, the agricultural sector can meet the growing demand for potatoes while ensuring long-term environmental and economic sustainability.

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FUNCTION OF BRAIN AND OVARIAN TYPE AROMATASES IN FISHES WITH AQUACULTURE APPLICATIONS

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Aromatase in Fishes

Aromatase (CYP19A1) is a monooxygenase from the family of cytochrome P450 that plays role in the androgens to estrogens conversion and aromatase inhibitors prohibit the aromatase enzyme function (Korani *et al*., 2023).Estrogen and androgen are important to female and male differentiation, respectively. Estradiol (E2), the most effective endogenous estrogen, is biosynthesized from androgen by cytochrome P450 aromatase mainly encoded by *cyp19a1a/b* in fish (Zhang *et al*., 2014; Chen *et al*., 2020). P450 aromatase coded by the gene that exists in two forms: ovarian type and brain type (Mishra and Chaube, 2016).Both brain-type and ovarian-type aromatase play a regulatory role in the gonadal development of fish (Guo *et al*., 2024). Since cultured fish exhibit different form of reproductive dysfunction in captivity, understanding the function of brain and ovarian type aromatases is critical in developing the methods for controlling reproduction in captivity.

Unlike that of mammals, the brain of teleost fish exhibits an intense aromatase activity due to the strong expression of one of two aromatase genes (aromatase A or *cyp19a1a* and aromatase B or *cyp19a1b) (Diotel et al., 2010)*. Teleost fishes are unique as aromatase B enzyme is expressed exclusively in radial glial cells (RGCs), which represent pluripotent cells in the brain of all vertebrates (Coumailleau *et al*., 2015). RGCs persist throughout life and act as progenitors in the brain of both developing and adult teleost fish. In-situ hybridization and immunocytochemical studies in teleost fish have revealed that aromatase Bpositive RGCs are most concentrated in the preoptic area and the hypothalamus. Also, they are observed throughout the entire central nervous system and spinal cord (*Diotel et al., 2010;* Coumailleau *et al*., 2015). Aromatase A enzyme is expressed mainly in granulosa cells of the ovary, which are involved in the conversion of testosterone to estradiol. Expression of aromatase in the brain of fish is also strongly stimulated by estrogens and androgens. It is essential to understand the function of brain and ovarian type aromatases as they are involved in sexual differentiation and control of seasonal reproductive cycle.

Use of Aromatase Inhibitors for Aquaculture Applications

Aromatase inhibitors (AIs) are a class of medicines that work by blocking the enzyme aromatase, the enzyme that converts androgens into estrogen in finfish and shellfish.Two major classes of aromatase inhibitors are available in the market. Type I steroidal medicines include formestane and exemestane; they are androgen substrate analogues that bind competitively but irreversibly to the enzyme and are marketed as inactivators. Type II nonsteroidal inhibitors such as anastrozole and letrozole are triazoles; they bind reversibly to the enzyme and fit into the substrate binding site, such that azole nitrogens interact with the heme prosthetic group (Miller, 2003).

Ccommercially available synthetic AI like anastrozole, letrozole, fadrozole, and exemestane are used to achieve all male population in finfish and shellfish hatcheries. In addition to all male fish population production, aromatase inhibitors are also used to induce sex reversal in fishes. Several studies have reported successful use of aromatase inhibitors in sex reversal and seed production of different species of groupers (Nakamura *et al*., 2022). With AI treatment, Nakamura and his research group have successfully induced precociousmale development in the honeycomb grouper. These males mated with females and successfully fertilized eggs (Bhandari *et al*., 2004, 2005; Alam *et al*., 2006).Later, this group reported that AI treatments effectively induce precocious and functional sex change in females of various species of groupers (Li et al. 2006; Hur et al. 2012; Garcia et al. 2013; Wu *et al*., 2015; Evliyaoğlu *et al*., 2019).Aromatase inhibitor induces sex reversal in the protogynous hermaphroditic rice field eel (*Monopterus albus*) (Jiang *et al*., 2022). This study reported an artificial method for producing functional males through the oral administration of an aromatase inhibitor (letrozole @ 300 mg/kg feed) in juvenile fish.Similar methods can be applied for the sex reversal and seed production of tiger grouper and other species of groupers in India. Also, this method can be applied for inducing sex reversal in coral reef fishes exhibiting hermaphroditism.

Afonso *et al*., (2001) examined the efficacy of a potent nonsteroidal aromatase inhibitor (Fadrozole) incorporated into the food, on sex reversal of Nile tilapia (*Oreochromis niloticus*) larvae. All experimental fishes were fed with diets containing different amounts of the aromatase inhibitor Fadrozole (0, 50, 75 and 100 mg/kg) during 15 and 30 days, starting 9 days after hatching and the study found that treatment with the highest doses (75 and 100 mg/kg) for 30 days produced 100% males.An aromatase inhibitor (fadrozole) was administered to developing Japanese fugu *(Takifugu rubripes)* from the 'first feeding' till the 100th day after hatching. This study observed that ovarian cavity formation was inhibited by fadrozole at doses of 500 and 1000 µg/g diet, which was followed by testicular differentiation in all treatedd fish (Rashid *et al*., 2007). Use of aromatase inhibitors (AIs) could direct juvenile zebrafish sex differentiation to male and even induce ovary-to-testis reversal in adult zebrafish (Chen *et al*., 2020). In this study, zebrafish treated with AI exemestane (EM) for 32 days induced sex reversal. The potential of tamoxifen, a non-steroidal aromatase inhibitor, for all-male production in Nile tilapia was reported by Pandit Narayan et al. (2016 & 2017). The authors reported that nine days post hatch fry fed with tamoxifen @ 150, 200 and 250 mg/kg diet for 30 and 40 days induced sex reversal. The percentage for males in tamoxifen @ 250 mg/kg diet were significantly higher than control and lower dose treatments.

Babiak et al. (2012) evaluated the efficiency of an aromatase inhibitor, Fadrozole, to induce masculinisation in Atlantic halibut. Three doses of Fadrozole were tested: 100, 500 and 700 mg/kg of feed, applied for 42–60 days to weaned halibut fry of 26–30 mm TL. The study found development of testes in up to 97% of examined individuals in all tested doses. Lal *et al*., (2023) reported the use of 17α-methyltestosterone (MT) and letrozole (LET) as potential AIs for all male production of rosy barb (*Pethia conchonius*).The AIs were supplemented with a gel-based feed (LET: 50, 100, 150 and MT: 12.5, 25, 37.5 mg/kg feed) in Rosy barbfry. The experimental fishes were mainatined in a 45-L glass tank using AI treated gel-based feed for 3 months. The authors found that use of MTat 25 mg/kg gel-based feed exhibited superior result in terms of all male population.

These studies clearly indicate that aromatase inhibitors are important class of compounds for controlling sex ratio in fish hatcheries. The dose for particular target species need to be standardized in the hatchery. In recent years, there are several studies suggesting the use of plant based ingredients containing the property of aromatse inhibitor, which can be used in fish hatcheries. Aromatase inhibtors can be incorporated in the feed and given to fish for inducing sexual differentiation and all male population. Also, it can be injected to adult fish exhibiting hermaphroditism to induce sex reversal in fish hatchery. In aquariculture, aromatase inhibitors can be incorporated in feed and fed to induce all male fish population in hatcheries as male population fetch higher price in the market. Further research is needed to understand to the distinct function of brain and ovarian type aromatases in fishes.

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INFINITE ADVANTAGES OF INSECTS AND EXPLORING VARIED CONSERVATION APPROACHES

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Abstract
Despite their small size, the six-legged creatures play a vital role in our ecosystem. They are instrumental in maintaining the delicate balance of the food chain, serving as alternate food sources, aiding in bio decomposition, and acting as bioindicators. Additionally, they contribute to pollination, crucial for the survival of numerous plant species. Certain insects also serve as natural predators, effectively controlling agricultural pests. Despite their importance, beneficial insects face numerous threats stemming from human activities and climate change. Hence, there is an urgent need to conserve these invaluable creatures. To achieve this, various actions can be undertaken, such as implementing habitat preservation measures, reducing pesticide usage, promoting sustainable agriculture practices, and raising awareness about the importance of insect conservation. Through concerted efforts, we can ensure the survival and well-being of our six-legged friends, safeguarding the health and stability of our ecosystems.

Keywords : Insects, Conservation, Life on land, Endangered species

Introduction

Insects, being the most diverse organisms on Earth, fulfill various vital roles within ecosystems. They contribute significantly to the food chain, serving as prey for numerous species including bats, birds, and freshwater fish. In addition, many flowering plants rely on insects for pollination, crucial for their reproductive success, while insects also aid in nutrient recycling by consuming waste materials. Insects also serve as bioindicators, reflecting the health of ecosystems through their presence, abundance, and diversity. Changes in insect populations can signal environmental disturbances, such as pollution or habitat degradation, providing early warnings of ecosystem imbalances. Insects also serve as a sustainable and nutritious food source for humans and animals alike. Rich in protein, vitamins, and minerals, they offer a viable alternative to traditional livestock farming. In many cultures, insects are consumed as delicacies, providing a valuable source of nutrition while requiring fewer resources and generating lower greenhouse gas emissions compared to conventional meat production. Integrating insects into our diets could help alleviate food insecurity and reduce the environmental impact of food production. Insects face numerous threats that contribute to their endangerment. One of the primary contributors to the decline of insect populations is the widespread adoption of intensive farming practices, which rely heavily on the use of pesticides and fertilizers. This form of agriculture accounts for 16.4% of the factors contributing to the crisis faced by insects. Additionally, biological factors, such as the spread of diseases and the disruption of natural ecosystems, also play a significant role, contributing 16.4% to the overall decline. Another major factor is the ongoing process of development, which has led to the destruction and fragmentation of many natural habitats, accounting for 10.7% of the problem. Deforestation, a consequence of human activities, has also had a profound impact on insect populations, contributing 8.8% to the overall decline. Furthermore, the disturbance of rivers and wetlands, another by-product of human activity, has added to the woes of insects,

accounting for 6.3% of the factors. Unidentified factors, which are not yet fully understood, also play a role, contributing an additional 6.3% to the crisis. Lastly, climate change, a global phenomenon, has also had a significant impact on insect populations, accounting for 5% of the factors contributing to their decline (Fenoglio et al., 2021).According to a study by the Biological Conservation journal, insects are disappearing at a rate eight times faster than mammals, birds, and reptiles, which poses a significant threat to ecosystem functioning and more than 40% of insect species are at risk of extinction in the coming decades. To address these challenges and prevent further endangerment or extinction of insects, effective conservation strategies must be implemented, and safeguarding insect populations is essential not only for their inherent worth but also for monitoring and sustaining the overall health of ecosystems. This article provides information on the several applications of insects as well as the various conservation tactics.

2. Uses of insects

Insects, far from being just tiny creatures obsessed with stinging and biting us and buzzing around our food, infesting crops, and gardens, have endless benefits for humans and for the planet:

i. **As pollinators** : Most plants, whether wild or cultivated, rely on insects for pollination, including butterflies, beetles, flies, and notably, honeybees.

ii. **Soil maintenance and waste management :** Several insects, such as beetles, are vital for breaking down organic material, like how scavenger birds operate, thus preventing the spread of diseases and enhancing soil fertility. Additionally, insects contribute to organic waste management by consuming organic matter. For instance, the larvae of black soldier flies are capable of decomposing organic waste, resulting in the production of insect frass, which then serves as a biofertilizer.

iii. **As food :** Insects serve as a significant food source for various animals, including humans. Insects are known to be rich in both macro nutrients and micronutrients and they offer an array of flavors and textures. By promoting the consumption of insects, we can reduce the environmental impact associated with conventional livestock production, including deforestation, water pollution, and biodiversity loss.

iv. **Economic importance :** Certain insects contribute to various sectors of the economy by producing valuable substances. For instance, the honey and wax industries rely on products derived from honeybees. Shellac resin is obtained from the secretions of the lac insect

v. **As predators** : Insect predators play a crucial role in pest control by consuming multiple prey species throughout their development. For example, Coccinellid beetles target various insect pests, including aphids, mealybugs, scale insects, mites, whiteflies, and other soft-bodied insects, effectively helping to manage pest populations.

vi. **As bioindicators :** Insects, particularly from orders like Coleoptera, Diptera, Hymenoptera, Isoptera, Lepidoptera, and Hemiptera, serve as valuable environmental bioindicators due to their complex biology and diverse species. Their presence, behavior, and population dynamics can signal changes in microclimates, foraging patterns, nesting habitats, and food availability, as well as interactions influenced by factors such as agrochemical use (Chowdhury et al., 2023).

3. List of endangered insects

The majority of India's plant and animal life is endangered because of a number of issues. A list of India's endangered insects may be found in Table 1.Table 1: List of the endangered species in India (Source: Glenn, 2006)

Scientific name	Insect name
Euploea andamanensis	Andaman crow
Graphium epaminondas	Andamans Swordtail
Pheidole lanuginosa	Red headed ants
Haematopinus oliveri	Pygmy hog-sucking louse
Epiophlebia laidlawi	Himalayan Relict Dragonfly
Euploeas cherzeri	Nicobar Crow
Cephal aeschna acutifrons	Dragon fly
Monomorium effractor	Ant
Burmagomphus sivalikensis	Dragon fly
Pheidole spp	Big headed ants

4. Strategies to conserve insects

Conserving insect populations is crucial for maintaining ecosystem balance and supporting various ecosystem services. Several strategies are employed to safeguard insect populations and their habitats, ensuring their vital contributions to biodiversity and human well-being. The strategies outlined below provide practical approaches to conserve insect populations.

i. **Transform Grass into Biodiverse Havens**: Transforming traditional lawns into diverse natural habitats can greatly benefit insect conservation efforts. This shift not only aids insect populations but also reduces maintenance costs and promotes biodiversity. Initiatives like Germany's "Thousands of Gardens – Thousands of Species" project serve as models for this transformative approach(Kawahara et al., 2021)

ii. **Nurturing Indigenous Flora**: Growing native plants can significantly benefit native insects due to their long-standing ecological relationships. These plants serve as vital food sources and nesting sites for a variety of insect species, which in turn support the broader ecosystem by providing prey for birds and other wildlife. Native plants are also better adapted to local climates and easier to maintain. Even if native plants are not available, cultivating a diverse range of non-native species, particularly those that produce nectar, can still support insect populations. Additionally, native plants can be incorporated into urban environments, such as balconies or city landscapes. Prioritizing the diversity of native plants over traditional lawn maintenance can enhance the beauty and ecological value of outdoor spaces.

iii. **Reduce pesticide/ herbicide usage**: Reducing the use of pesticides and herbicides is crucial for preserving natural insect populations. These chemicals often harm unintended insect species and can even spread beyond their intended application areas. By minimizing pesticide use, beneficial arthropods can thrive, contributing to ecosystem balance. Promoting the use of biopesticides can be useful as they target only on the pest but not beneficial insects.

iv. **Restrict Outdoor Illumination**: To protect nocturnal insect populations, it's essential to minimize night-time light pollution, which has significantly increased since the 1990s. Artificial lights act as traps for nocturnal insects, leading to exhaustion or increased predation. This phenomenon has been linked to declines in nocturnal moth populations, affecting their reproductive success. To mitigate these effects, individuals can turn off

unnecessary lights, dim existing ones, use motion-activated lighting, shield bulbs, and opt for amber- or red-coloured bulbs, which are less attractive to insects. For many fireflies, there is a painful lack of data on even baseline populations. While some species remain abundant, overall, we risk the loss of firefly biodiversity due to light pollution. Despite the threats, no firefly species is protected under the Endangered Species Act. The U.S. Fish and Wildlife Service is considering petitions to safeguard five species, including the Bethany Beach firefly.

v. **By increasing awareness**: To foster appreciation and understanding of insects, efforts are needed to counter negative perceptions and highlight their benefits. Educational initiatives like blogs, social media posts, and smartphone photography can engage the public and showcase the importance of insects in ecosystems. Supporting insect-focused public activities, like insect fairs and butterfly houses, provides hands-on learning experiences. Cultivating positive portrayals of insects in popular media and advocating for approachable common names can also enhance public perception and appreciation of these vital creatures.

vi. **Become a representative/educator**: Individuals can play a crucial role in insect conservation by becoming educators, ambassadors, and advocates for these vital creatures. Engaging children in outdoor activities and educational programs fosters an early appreciation for insects and nature, shaping them into future stewards of the environment. Professional researchers can contribute by providing interactive insect-themed activities in schools and through online platforms and similar opportunities should be created by entomological societies worldwide.

vii. **Engage in local politics**: Engaging in local politics and supporting evidence-based policies is essential for advancing insect conservation efforts. Advocacy at the local level can lead to environmentally friendly landscaping requirements and conservation planning in urban landscapes. Ultimately, public opinion is a powerful tool for conservation, urging decision-makers to take action to protect insects and their habitats.

Conclusion

While some insects pose risks, others offer valuable benefits, such as being a food source or supporting our economy. However, human activities have pushed many insect species to the brink of extinction. It's imperative to recognize the crucial roles insects play in ecosystems and human well-being. Bees, for instance, are vital pollinators essential for plant reproduction, yet they face threats from pesticides and urbanization. Therefore, it's crucial for young enthusiasts like us, who have a passion for insects (entomophilia), to take the initiative in educating others about the importance of insect conservation. Instead of instinctively harming insects when we encounter them, we should strive to promote understanding and respect for their role in our ecosystems. By raising awareness and advocating for their protection, we can inspire others to appreciate and preserve these valuable creatures for the benefit of present and future generations.

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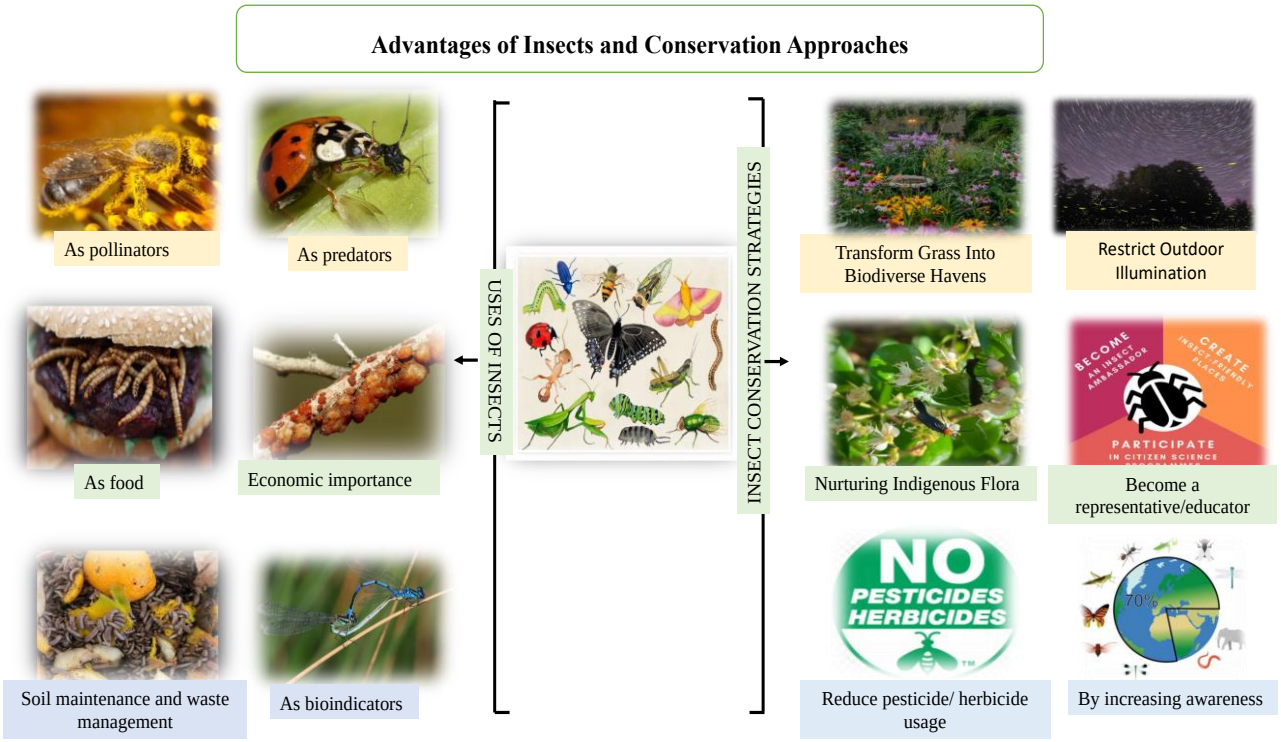

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MARICULTURE: CULTIVATING A SUSTAINABLE OCEAN HARVEST

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Abstract
Mariculture, the cultivation of marine organisms in coastal environments, is poised to become a vital source of aquatic food, employment, and income for coastal communities. This sector has the potential to enhance coastal environmental health when managed properly. However, the expansion of mariculture faces challenges from increasing population pressures and competition for coastal resources. Effective environmental management, sustainable technologies, and robust policy and planning strategies are essential to address these challenges and ensure the sustainable growth of mariculture.

Introduction
The global fish production volume reached 186.6 million metric tons in 2023, an increase from 184.6 million metric tons in 2022. Seaweed mariculture is believed to have started during the Tokugawa (or Edo) Era in Japan. With the world projected to require a 50% increase in food production by 2050 due to population growth and resource constraints, aquaculture has emerged as the fastest-growing sector in food production, achieving an annual growth rate of over 6% for the past two decades.

The first scientific attempt at developing various mariculture technologies was initiated in India during the 1960s by the ICAR-Central Marine Fisheries Research Institute (CMFRI). In 2020, mariculture contributed 33.0 million tonnes of food fish, accounting for about 27% of global food fish aquaculture production. In this regard, ICAR-CMFRI has developed an innovative decision support model for identifying potential mariculture sites by using the Geographical Information System (Divu et al., 2020). Including seaweeds, total mariculture production reached 68.1 million tonnes, which is 55.6% of the world's total aquaculture output.

India, facing increasing seafood demand, recognizes the insufficiency of capture fisheries alone to meet this demand. The National Policy on Marine Fisheries (NPMF, 2017) highlights the importance of mariculture in boosting fish production from coastal waters.

Mariculture and its genesis in India
In 2020, mariculture contributed 33 million tons of food fish, accounting for about 27% of global food fish aquaculture production. Mariculture production, including seaweed, reached 68.1 million tons, representing 55.6% of global aquaculture production. The National Policy on Marine Fisheries (NPMF, 2017) highlights the pivotal role of mariculture in enhancing fish production from coastal waters.

Mariculture systems
Mariculture, or marine aquaculture, encompasses several prominent systems such as sea cage farming, Integrated Multitrophic Aquaculture (IMTA), Recirculating Aquaculture Systems (RAS), seaweed culture, and bivalve farming.

Sea Cage Farming

Sea cage farming has become a significant method for intensive finfish production along India's coast since 2007. This method has advanced in terms of cage design, mooring systems, and the variety of species farmed. The Indian Council of Agricultural Research-Central Marine Fisheries Research Institute (ICAR-CMFRI) has been instrumental in developing and standardizing guidelines and best practices for sea cage farming. Economic returns range from Rs. 1.5 to 2.5 lakh per crop, making sea cage farming a successful venture in states like Maharashtra, Tamil Nadu, Kerala, Karnataka, and Odisha.

Pen culture

Pen culture is a method of fish farming where fish are raised in a designated volume of water that is enclosed on all sides except the bottom. Typically, shallow regions along shores and banks of lakes and reservoirs are used to create these pens, utilizing materials such as nets or wooden structures.

Integrated Multitrophic Aquaculture (IMTA)

IMTA integrates the cultivation of multiple species from different trophic levels within the same system. This method aims to create a balanced ecosystem by allowing the waste from one species to be utilized as nutrients for another. For example, finfish farming can be combined with seaweed and bivalve farming, where the waste produced by finfish provides nutrients for seaweed and bivalves, thereby reducing environmental impact and enhancing productivity.

Recirculating Aquaculture Systems (RAS)

RAS are highly controlled, closed-loop systems where water is continuously recycled and filtered. These systems allow for high-density fish farming with minimal water use, reducing the environmental footprint. RAS technology is particularly beneficial for inland aquaculture, where access to large water bodies is limited.

Seaweed Culture

The cultivation of seaweeds offers numerous environmental benefits, including carbon sequestration, nutrient absorption, and habitat provision for marine life. Seaweed farming is also a source of various commercial products, such as food, fertilizers, and biofuels.

Seaweed culture method

Long line system

Longline systems are aquaculture setups where a length of rope is suspended horizontally in the water column. This rope is anchored at both ends to maintain its position, and flotation devices are attached to ensure it remains buoyant. Seaweed seeds or shellfish culture systems, such as those for mussels or oysters, are then hung from this main rope, allowing them to grow and be cultivated in the aquatic environment.

Raft system

Sources by floating bamboo raft method Seaweed research gate.com. The raft is constructed with bamboo forming a mainframe that is 12 feet by 12 feet. The raft includes diagonal supports that measure 4 feet by 4 feet. Around 150 – 200 grams of seaweed fragments are tied at a spacing of 15 cm along the length of the rope. *Alvarezii* is the only commercially cultivated species, accounting for 30% of the market. The remaining 70% is composed of *Gracilariasp, Gelidiellasp, and Sargassum sp.*

Bivalve Farming

Bivalve farming, which includes the cultivation of species such as mussels, oysters, and clams, is renowned for its minimal environmental impact. Bivalves are filter feeders, meaning they clean the water by filtering out plankton and other particles, thus enhancing water quality. This form of aquaculture is sustainable and provides a high-quality protein source without the need for feed input.

Advantages of Mariculture

1. **Increased Food Production :** Mariculture helps meet the growing demand for seafood, reducing pressure on wild fish stocks.
2. **Economic Benefits :** It provides employment opportunities and stimulates local economies, especially in coastal regions.
3. **Quality Control :** Mariculture allows for better monitoring and control of water quality, leading to healthier and safer seafood products.
4. **Diversification of Food Sources :** Mariculture broadens the range of available seafood options, promoting dietary diversity and potentially improving food security.
5. **Preservation of Wild Populations :** By reducing pressure on wild fish stocks, mariculture helps conserve biodiversity in oceans and coastal ecosystems. Disadvantage of Mariculture

While mariculture has many advantages, it also comes with several disadvantages:

Challenges and Considerations of Mariculture

1. **Environmental Impact :** Intensive mariculture operations can lead to pollution from excess nutrients, chemicals, and waste, which can harm local ecosystems and water quality.
2. **Disease and Parasite Spread :** High-density farming conditions can facilitate the spread of diseases and parasites among farmed species, which can also affect wild populations.
3. **Habitat Destruction :** The establishment of mariculture facilities can lead to the destruction of important coastal habitats, such as mangroves, sea grasses, and coral reefs.
4. **Resource Use :** Mariculture can be resource-intensive, requiring significant inputs of feed, water, and energy. The production of feed, often derived from wild-caught fish, can exert additional pressure on marine resources.
5. **Invasive Species :** Non-native species used in mariculture can become invasive, outcompeting local species and altering ecosystem dynamics.
6. **Market Dependency and Economic Risk :** Mariculture operations can be highly dependent on market conditions and susceptible to economic risks such as price fluctuations and trade barriers.

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AN INTRODUCTION TO BIG DATA

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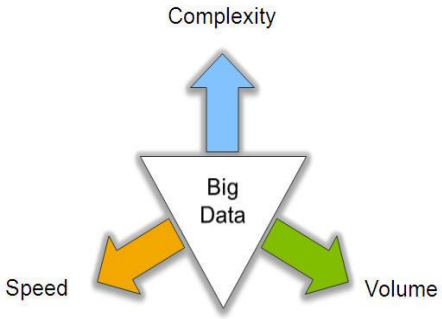
Definition

Big data refers to massive, complex datasets that are difficult to store, process, and analyze using traditional methods. This data comes from a variety of sources, including social media, sensors, and machines.



Challenges include analysis, capture, data curation, search, sharing, storage, transfer, visualization, querying, updating and information privacy.Analysis of data sets can find new correlations to "spot business trends, prevent diseases, combat crime and so on."

Big Data Characteristics: Big data is characterized by three V. They are

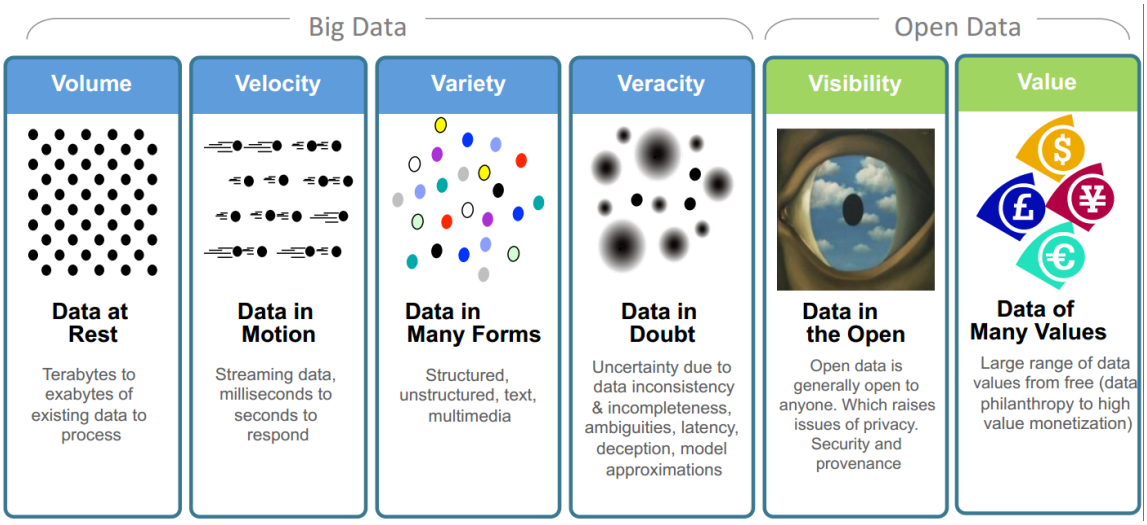
a. **Volume:** The amount of data is massive and ever-growing
b. **Variety:** The data comes in many different formats, including structured, semi-structured, and unstructured data. Structured data is organized in a predefined format, such as rows and columns in a spreadsheet. Semi-structured data has some organization, but it doesn't follow a strict format. Unstructured data is completely free-form, such as text, images, and videos.Different Types:
   - Relational Data (Tables/ Transaction/ Legacy Data)
   - Text Data (Web)
   - Semi-structured Data (XML)
   - Graph Data: Social Network, Semantic Web (RDF), …
   - Streaming Data : You can only scan the data once
   - A single application can be generating/collecting many types of data
c. **Velocity:** The data is generated and collected at a very high speed.
   Examples
   - **E-Promotions:** Based on your current location, your purchase history, what you like ➔ send promotions right now for store next to you
   - **Healthcare monitoring:** sensors monitoring your activities and body ➔ any abnormal measurements require immediate reaction
   - **Disaster management and response**

Extended Big Data Characteristics: 6V

a. **Volume** : In a big data environment, the amounts of data collected and processed are much larger than those stored in typical relational databases.
b. **Variety** : Big data consists of a rich variety of data types.

c. **Velocity :** Big data arrives to the organization at high speeds and from multiple sources simultaneously.
d. **Veracity :** Data quality issues are particularly challenging in a big data context. *Data = quantity + quality*.
e. **Visibility/Visualization :** After big data being processed, we need a way of presenting the data in a manner that's readable and accessible. Big Data – visibility = Black Hole
f. **Value:** Ultimately, big data is meaningless if it does not provide value toward some meaningful goal.

Big Data: 6V in Summary



Why Study Big Data Technologies?

- The hottest topic in both research and industry
- Highly demanded in real world
- A promising future career
  - Research and development of big data systems: Distributed systems (eg, Hadoop), visualization tools, data warehouse, OLAP, data integration, data quality control
  - Big data applications: social marketing, healthcare etc
  - Data analysis: to get values out of big data, discovering and applying patterns, predictive analysis, business intelligence, privacy and security etc

Importance of Big Data

Big data plays a crucial role in today's world, driving innovation and shaping various industries. Here's a breakdown of its importance:

1. **Informed Decisions:** Big data analytics allow organizations to analyze massive datasets, uncovering trends and patterns invisible to the naked eye. This empowers them to make data-driven decisions, reducing risks and maximizing success.
2. **Enhanced Customer Experience:** Businesses can leverage big data to understand customer behavior and preferences. This enables them to personalize marketing campaigns, provide targeted recommendations, and improve customer service, leading to higher satisfaction and loyalty.
3. **Product Development & Innovation:** By analyzing customer feedback and market trends, big data helps identify unmet needs and opportunities for new products or services. Companies can use this knowledge to develop innovative solutions that resonate with their target audience.
4. **Operational Efficiency:** Big data can optimize internal processes by pinpointing inefficiencies in areas like supply chain management or resource allocation. This translates to cost savings and improved overall operational efficiency.
5. **Competitive Advantage:** In a data-driven world, companies that effectively utilize big data gain a significant edge. They can make faster, more informed decisions, develop superior products, and deliver a personalized customer experience, all of which contribute to a competitive advantage.
6. **Beyond Businesses:** Big data's impact extends beyond businesses. It's used in scientific research, healthcare, and social good initiatives. For instance, big data can analyze weather patterns to predict natural disasters or track disease outbreaks to facilitate faster responses.

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A TRADITIONAL BLACK RICE

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Abstract:
Black rice, also known as forbidden rice or purple rice, has garnered significant attention globally due to its rich nutritional content and historical significance. This article explores the multifaceted aspects of traditional black rice, examining its historical roots, botanical characteristics, geographical distribution, nutritional value and increasing demand in modern times. Historically, black rice holds a prestigious place, particularly in ancient China where it was exclusively reserved for royalty, symbolizing wealth, health and longevity. Its cultivation and consumption were not limited to China but extended to other Asian regions like India, Indonesia and Thailand where it carried cultural significance and culinary traditions. Botanically, black rice is characterized by its medium grain texture, rich mineral and antioxidant content and preference for warm climates with ample sunlight and water. The demand for black rice has surged in recent years, fueled by its recognized health benefits, culinary versatility, and cultural significance. Its antioxidant properties, along with phenolic compounds, contribute to its potential in preventing various diseases.

Keywords : Black rice, nutrient content and health benefits

Introduction

More than half of the world's population depends mostly on rice which is a major grain crop belonging to Poaceae family. There are thousands of varieties of rice farmed worldwide, demonstrating its great genetic diversity. "Black Rice" is one of the pigmented rice variants that has drawn the most attention because of its high nutritional content and overall advantageous health attributes (Mazumdar *et al.,* 2022).Black rice, also known as forbidden rice or purple rice, is an ancient grain that has captivated the culinary world with its striking appearance, unique flavor, and impressive health benefits. The endosperm of black rice is covered in black bran. However, due to its typical color and sweet, nutty flavor, black rice has gained popularity in many Asian nations for use in sweet snacks and sweets. The color of black rice is caused by anthocyanins, specifically cyanidin 3-glucosidase and peonidin 3-glucosidase. Additionally, black rice is a good source of fiber, vitamins, and minerals, making it a wholesome and nutritious choice for health-conscious individuals. Throughout history, black rice has been revered as a symbol of luxury and exclusivity. In ancient China, it was known as "forbidden rice" because it was reserved exclusively for royalty and nobility, while commoners were prohibited from consuming it. In recent times, Korea has created several rice types with pericarps that are blackish purple, including Heukgwangbyeo, Heukjinjubyeo, and Heuknambyeo. This essay examines the historical background, botanical description, nutritional value, health advantages and other topics pertaining to black rice.

Historical Aspects

Ancient China: Black rice holds a significant place in Chinese history, where it was cultivated as early as 10,000 years ago. It was reserved for royalty and nobility due to its rarity and purported

health benefits. Legend has it that consuming black rice could extend life and bring good fortune. The rice's deep color was considered a sign of its superior nutritional value.

Other Regions: While black rice was most closely associated with China, it was also cultivated and consumed in other parts of Asia, such as India, Indonesia and Thailand. Its use varied across cultures, but it generally remained a symbol of wealth, prestige and health.

History of Black Rice in India

In India, black rice has been cultivated for centuries, particularly in the northeastern states of Manipur and Assam, where it is known as “Chak-Hao”. It was not only prized for its distinct flavor but also for its cultural significance. In Manipuri culture, black rice is associated with religious rituals and traditional ceremonies.

Culinary Traditions: Black rice has been a part of Indian culinary traditions, where it is used in various dishes, including desserts, savory dishes and traditional sweets. In some regions, black rice is ground into flour and used to make bread or cakes.

Modern Resurgence: In recent years, there has been a resurgence of interest in black rice in India, driven by growing awareness of its health benefits and culinary versatility. It has gained popularity as a nutritious alternative to white rice and is increasingly used in gourmet cooking and health-conscious diets.

Overall, black rice has a rich and storied history both globally and in India, where it has been cherished for its cultural significance, nutritional value, and distinctive flavor. Its journey from an exclusive luxury reserved for royalty to a beloved ingredient in modern cuisine reflects its enduring appeal and versatility.

Geographical Distribution

China is a prominent producer of black rice, with Sri Lanka, Indonesia, India, Philippines and other countries following suit. Thailand is ranked eighth in the world for growing black rice. China is the country that produces 62% of the world's black rice and it has produced over 54 contemporary black rice varieties with excellent yield attributes and several resistances. Nonetheless, certain varieties are grown in multiple nations, including as Bangladesh, Korea, Japan, and the Philippines (Goswami *et al.,* 2023).

Botanical Description

This rice has a medium grain texture and is rich in minerals and antioxidants. Warm areas with lengthy growing seasons of at least three to six months are preferred. With plenty of water and full sun, black rice grows well. It needs at least 21 degrees Celsius to germinate. It is referred to as "Kavuni" in Tamil, and it is a traditional rice that has anti-diabetic properties. It is not an often-farmed variety due to its reputation as a long-lasting, poorly tillering, and photosensitive cultivars. Black rice grains that have been dehusked range in color from dark brown to black, while polished grains are light brown (Valarmathi *et al.,* 2015). It has medium to high (16.03-27.14%) amylose content. The percentages of total dietary proteins and fiber were determined to be 7–24% and 21–52%, respectively. Furthermore, a greater amount of lutein (95–96%) and beta-cartene (26–65%) was discovered. There is little ash (0.54%). Iron (20–30%), calcium (33–45%), copper (9–14%), sodium (21-38%), potassium (7–15), and magnesium (9–26%) are all greater in it (Zhang *et al.,* 2022). Black rice plants typically grow to a height of around 2 to 4 feet (60 to 120 centimeters), although this can vary depending on the specific variety and growing conditions. The leaves of

black rice are long, slender and lance shaped. The flowering structure of black rice consists of branched clusters called panicles, which emerge from the top of the plant.

Demand for Black Rice

Black rice contains antioxidants and phenolic compounds which have numerous biological actions. Phenolic compounds work as reducing agents and hydrogen donors. Additionally, phenolic compounds function as hydrogen donors for free radicals and single oxygen quenchers. As a result, phenolic compounds shield cell components from oxidative damage. Epidemiological studies have demonstrated the potential of phenolics' antioxidant properties to avert neurological, cancerous, and cardiovascular disorders.

The demand for black rice has been steadily increasing in recent years, driven by several factors including its nutritional benefits, unique flavor, and culinary versatility. Some key reasons contributing to the growing demand for black rice are nutritional value culinary value, cultural significance, health consciousness, antioxidants, fiber, protein, vitamins and mineral content, low glycemic index and naturally gluten free.

In summary, black rice is not only visually striking but also has nutritional value, offering a range of health-promoting compounds and essential nutrients. Incorporating black rice into diet can contribute to overall health and well-being providing a delicious and nutritious alternative to other types of rice and grains.

Conclusion

In conclusion, black rice offers a multitude of health benefits, making it a valuable addition to any diet. Its rich nutritional profile, highlighted by antioxidants like anthocyanins, contributes to improved heart health, digestive function, weight management and brain health. Additionally, black rice provides essential nutrients, supports detoxification, promotes skin and eye health and helps regulate blood sugar levels. With its delicious flavor, striking appearance and diverse culinary uses, black rice stands out as a nutritious and versatile grain that can enhance overall health and well-being. Incorporating black rice into diet can be a simple yet effective way to reap its numerous health benefits and support a vibrant and balanced lifestyle.

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FRUIT CANOPY MANAGEMENT

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Abstract

A key component of orchard design and cultivation, fruit crop canopy management affects fruit quality, production, and spatial efficiency. In order to maximize fruit development, nutritional uptake, and solar energy utilization, this paper examines the concepts, methods, and instruments used in canopy management. The importance of controlling canopy geometry is emphasized in order to optimize light interception, manage tree vigor, and lessen the influence of environmental influences on quality and production. Important techniques like training and pruning are covered, emphasizing how they affect canopy architecture and increase fruit yield. The review also looks at how canopy management affects light dispersion in various canopy types and clarifies how this affects orchard productivity as a whole. This abstract emphasizes the significance of optimal canopy management strategies in optimizing fruit output and quality while guaranteeing efficient resource consumption through a thorough evaluation of the body of research and literature.

Introduction

Fruit crop canopy management is essential for orchard design, fruit quality, productivity, and tree density per unit area, all of which have an impact on overall fruit production and productivity. One of the key practices in perennial fruit crops for optimizing solar energy utilization is canopy management, which makes use of soil nutrients, moisture, and space. Globally, fruit-producing nations are actively utilizing canopy management techniques to manipulate tree growth and spacing to support a higher density of plants per unit area. To regulate the size and shape of the tree, thus controlling its growth and preserving its high fruit yield of the appropriate Caliber. The physical structure of a fruit tree, which includes the stem, branches, shoots, and leaves, is referred to as the canopy. The quantity, length, and direction of branches and shoots define the canopy. Fruit tree canopy management pertains to the growth and upkeep of the tree's structure in relation to size and form in order to maximize quality production. Canopy management necessitates an awareness of the bearing habits of fruit tree species and the impact of environmental conditions. Making the greatest use of the area and available resources to boost output is the fundamental tenet of fruit crop canopy management.

The fruit is physically supported by the canopy, which has a major impact on both productivity and quality. The orchard production system, which consists of the following components: variety, rootstock, tree spacing, and training system, has a significant impact on the canopy configuration. Canopy shape has seen improvements in recent years. A significant change in the production system has been brought about by the introduction of new systems like the bed system, Lincoln, and Tatura trellis forms of the canopy. The purpose of canopy management is to maximize assimilation production and conversion to economic yield. It is based on tree size, number of trees per hectare, and cutting techniques.

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The Fundamentals of Canopy Management

Fruit output and quality are impacted by tree canopy management because it changes light interception. It is important to regulate the canopy geometry to maximize light intercept. A 1.5–2.0 m shallow canopy is required for a high-density planting scheme in order to maximize the effectiveness of capturing solar energy through leaves and directing metabolites for high-quality fruit development that yields a decent return. The goal of canopy management is to maximize the amount of light and temperature that trees receive, control their vigor, and minimize the negative effects of weather on productivity and quality.

According to Shikhamany (2001), the fundamentals of canopy management are (i) making the most use of light and (ii) preventing the development of a microclimate that is conducive to the spread of disease and pests. (iii) ease of doing cultural procedures; (iv) optimizing output and quality; (v) cost-effectiveness in acquiring the necessary canopy architecture. According to a report, controlling the suitable and effective canopy design of the short-statured tree has been shown to boost fruit output by 15-20% in several fruit crops (Nath and Pongener, 2017).

Tools for canopy management

The genetic makeup of a tree is naturally expressed in its canopy architecture. Size and shape of the canopy differ between genotypes. Nonetheless, there are a number of ways to adjust the canopy's dimensions and form.

Training

An ancient method of maximizing light and ventilation is to train perennial trees to grow toward the center of an open vase. In essence, the training could be used as a tool to control the canopy architecture of a weak-stemmed plant, such as the grapevine. Worldwide research has shown that the Bower training approach performs best in tropical climates. To fully utilize the productive potential of grapevines in tropical regions where apical dominance is more prominent, an expensive training system is necessary, despite the reduced light and temperature in the vine canopy, increased humidity, and increased incidence of disease.

Up to 10 shoots/m^2 can be produced by splitting the apices of plants that grow in horizontal plains. There is no way to enhance the number of fruiting units per unit area in vertical canopies, which aim to maximize light usage and minimize the accumulation of excessive humidity in the vine canopy. Developing diageotropic canopies and increasing bud fruitfulness, which in turn increases the cluster-to-cane ratio, is the best method for managing the canopy of grape vines.

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Pruning

By cutting off an unproductive branch from a tree, pruning can help control the growth and structure of the tree and create the ideal canopy architecture. Pruning also helps to lower the density of foliage on a tree.

The timing of pruning is determined by the goals of the pruning; in newly planted areas, trimming is done to create a well-organized framework. Branches that are sick, dried out, overlapping, or damaged need to be pruned. Pruning is typically done during the plant's dormant phase or right before a new growth spurt. Aids in branch selection during dormancy. While summer pruning reduces growth, excess growth, etc., dormant pruning is done to energize the plant. Winter harm might result from pruning too early in the season. While newly planted young trees in the orchard need to be pruned early in the winter, elder trees must be pruned later. Pruning triggers the beginning of flowering buds. Trees with delayed blossoming should be pruned before those with early blooms. To lessen excessive vigor and upright growth, pruning during the summer, or active growth phase, should be restricted to the removal of thinning-out cuts.

Light distribution in different canopy forms

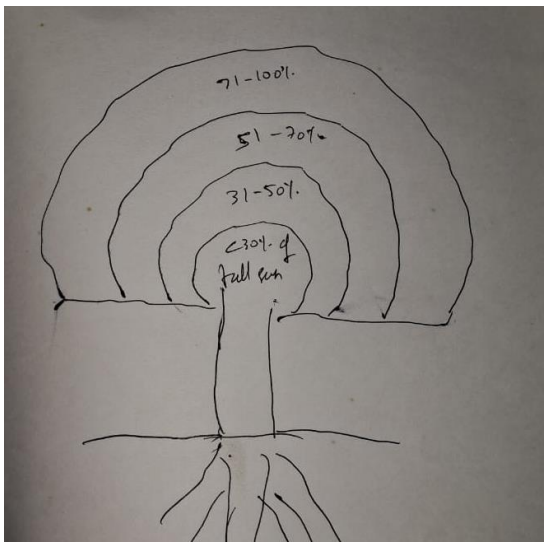

Fig:1

Three categories can be distinguished based on how much sunshine the canopy profile receives: i) a well-exposed zone with a light intensity greater than 50% of full sunlight ii) a zone with minimal exposure; light level of 30–50% iii) a well-lit area with less than 30% light. Light interception increased with tree height, especially for the triangle area of the tree.

Because of seasonal variations in development, the inner microclimate of central leader training systems rapidly reduces the amount of light in the inner canopy.

Conclusion

To sum up, fruit crop canopy management is an essential component of contemporary orchard management that has a big impact on the quantity and quality of fruit produced. Growers may increase fruit yield, improve fruit quality, and make the most efficient use of resources like soil nutrients and space by optimizing canopy structure and light interception. Tree growth can be manipulated to produce desired results in terms of tree density, spatial efficiency, and fruit development by implementing canopy management techniques, such as training and pruning.

Furthermore, with cutting-edge techniques like the introduction of novel trellis shapes and training methods, developments in canopy management aid in the growth of orchard production systems. Effective canopy management techniques are critical as environmental conditions and market demands continue to pose obstacles to fruit output. To further maximize orchard productivity, sustainability, and resilience in the face of changing agricultural landscapes, further research and innovation in this area are necessary.

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LIFE STAGES OFCOMMON MORMON (*Papilio polytes* Linnaeus) ON SWEET LEMONUNDER CAPTIVITY

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Introduction

The world's agricultural economies, as well as those of India, rely heavily on the cultivation of citrus fruits. Citrus fruits are grown in several states in India, with Maharashtra in the top list with 6,92,000 tonnes production annually, followed by Andhra Pradesh, Assam, Rajasthan, Meghalaya, Karnataka, West Bengal, Telangana, Madhya Pradesh, and Punjab being other citrus production regions. Through domestic sales, exports, and processing into value-added products like juices, essential oils, and by-products like pectin, the citrus industry generates a significant amount of money. Citrus is one of the most important perennial fruit crops grown in more than 150 countries globally, with 53 of these countries cultivating citrus economically. India occupies third position globally in terms of citrus production after banana and mango, following Brazil and China. India's share of the world's citrus production is approximately 7-8%. Total area under citrus cultivation in India is 923.2 thousand ha with an average production of about 8607.7 thousand MT.

Various citrus varieties have been found to be infested by 250 distinct species of insects and mites in India. These pests play a major role in the decline of citrus production. Among the major insect pests of citrus, swallow tails or citrus butterflies (*Papilio* sp.) are considered as the significant pest of citrus plants. Papilionidae, encompassing over 550 species distributed across every continent except Antarctica, stands as one of the most diverse families within the order Lepidoptera. The larvae of*Papilio polytes* (Linnaeus), common Mormon, or a citrus butterfly species is considered as the main damaging stage and is thought to be a significant citrus pest, particularly in nurseries, as they feed on citrus leaves voraciously. Excess infestation can lead to complete defoliation of the plant resulting in decreasing plant growth and ultimately yield. The climate, geographic location, and kind of plant they are feeding on, all have an impact on their biology and developmental phases. Understanding the biology and morphometrics of citrus butterflies on sweet lemons can help develop effective management strategies to combat these pests. Therefore, a study was conducted to determine the duration of developmental stages. The samples of larvae in their 4^{th} instar were collected from Tarakeswar, Hooghly district, West Bengal, India and reared on Bengal sweet lemon leaves.

Observations on Life stages of *Papilio polytes*

i. **Egg stage :** Eggs are singly laid and globular in shape with a pale-yellow colour that turns light brown later. Adults lay their eggs on the underside of leaves. This distinguishes the eggs of common Mormon butterfly and common lime butterfly where the latter lay eggs on the axial part of leaf, stem, or on the thorns. Total egg stage usually lasts for 2.8 days.
ii. **Larval stage :** The larvahashypognathous head with primary setae, along with well-developed biting and chewing type of mouthparts. It is a polypod larva with 3 thoracic and 5 abdominal

legs or pseudo legs or false legs or unsegmented legs. Abdominal legs are present on 3rd, 4th, 5th, 6th and 10th abdominal segments. Body is light brown in colour with white splotches which makes it look like bird droppings from 1st to 4th instars thus providing themselves with good camouflage. On the fourth and fifth dorsal segments, there is a transverse black band with an eye-spot on either side. On the 9th segment, there are 2 dorsal setae same as that present on the head. The larvae possess a forked or "Y" shaped red coloured fleshy eversible organ called as osmeterium on the head which everts when they are threatened. It also acts as a chemical defense by emitting noxious chemicals to ward off predators. When the larva reaches 5th instar, the colour turns into light green and a broad raised stripe appears near its head. At this stage, the ecdysial line becomes prominent. The total larva period is about 17 days. 5th instar turns to pre-pupal stage within 6 days. Length of 4th instar and 5th instar larvae are around 2.5cm and 3.9cm, respectively.

4th instar with hypognathous head

Osmeterium

5th instar (Time period 6 days)

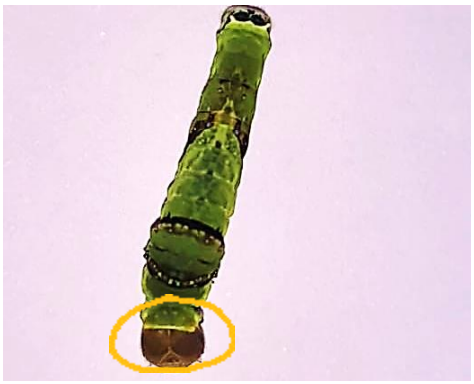

Fig. Ecdysial line/ Epicranial suture

iii. **Pupal stage :** It is a holometabolous insect thus pupal stage is present. Pupa is light green in colour. At the end of larval stage, the caterpillar stops feeding and starts moving towards the edge of container in which it was kept. It starts shrinking; body becomes stiff and curves itself to form a half-moon shaped structure, which indicates the pre-pupal stage lasting for a day. During pupation, if it is surrounded by green leaves, it prepares itself as green pupa otherwise they form brown pupa if formed around brown twig or stem. Being a lepidopteran, it form sobtect type of naked pupa known as chrysalis, where the appendages are glued to the body. At the later stages, the pupa turns brown before adult emergence. Length of pre-pupa is around 2.7 cm

and width 0.75cm. Length and width of pupa are around 2.9 cm and 0.9 cm, respectively. Total pupal period lasts for about 10 days.


Early Pre- pupa


Early pupal stage


Pupal stage after eclosion

iv. Adult stage : The adult emerges out by spitting the pupa dorsally. Emergence (eclosion from pupa) takes about 18 to 20 minutes. Newly emerged butterfly cannot fly for 1-3 hours since the wings are weak. Due to the pumping of hemolymph, wing expansion takes place and the butterfly becomes fully matured. One of the distinguishing features of Papilionidae is their characteristic "swallowtail" hind wings, which extends into elongated projections resembling the forked tail of a swallow bird, hence their name. Wings are black having white dotted rows at the margin of forewings and across hind wings. Each hind wing has red crescents on the margin. Forewings have rows of white spot which gets smaller towards the tip. Amplexiform wing coupling mechanism is found, that is the simplest type since it can be achieved just by overlapping of forewings onto the hind wings. Adults have capitate type of antennae. Mouthparts are siphoning type having a proboscis, which is the modification of galea of maxillae and are kept coiled up as watch spring when at rest. Sexual dimorphismexists in this butterfly species, where females will have paler colouration and more distinct red crescents with a wing span of 40 mm (forewing) and 20mm (hind wing). Adult males are smaller than females. The adult longevity for females is 6-7 days and that of males is3-4 days. The total life cycle lasts for about34-37 days depending on the environmental conditions.

Conclusion

In conclusion, *Papilio polytes*, the common mormon butterfly, embodies a complex relationship with its environment, showcasing both beneficial contributions and potential harmful effects. It shows adverse consequences in the environment as its caterpillar feed on host plants leading to excessive defoliation and stress on plant populations. Thus, for protecting the plants the commonly used method is bagging of fruits. However, as a pollinator, *Papilio polytes* plays a crucial role in ecosystem functioning, facilitating the reproduction of flowering plants through cross pollination and maintaining biodiversity.

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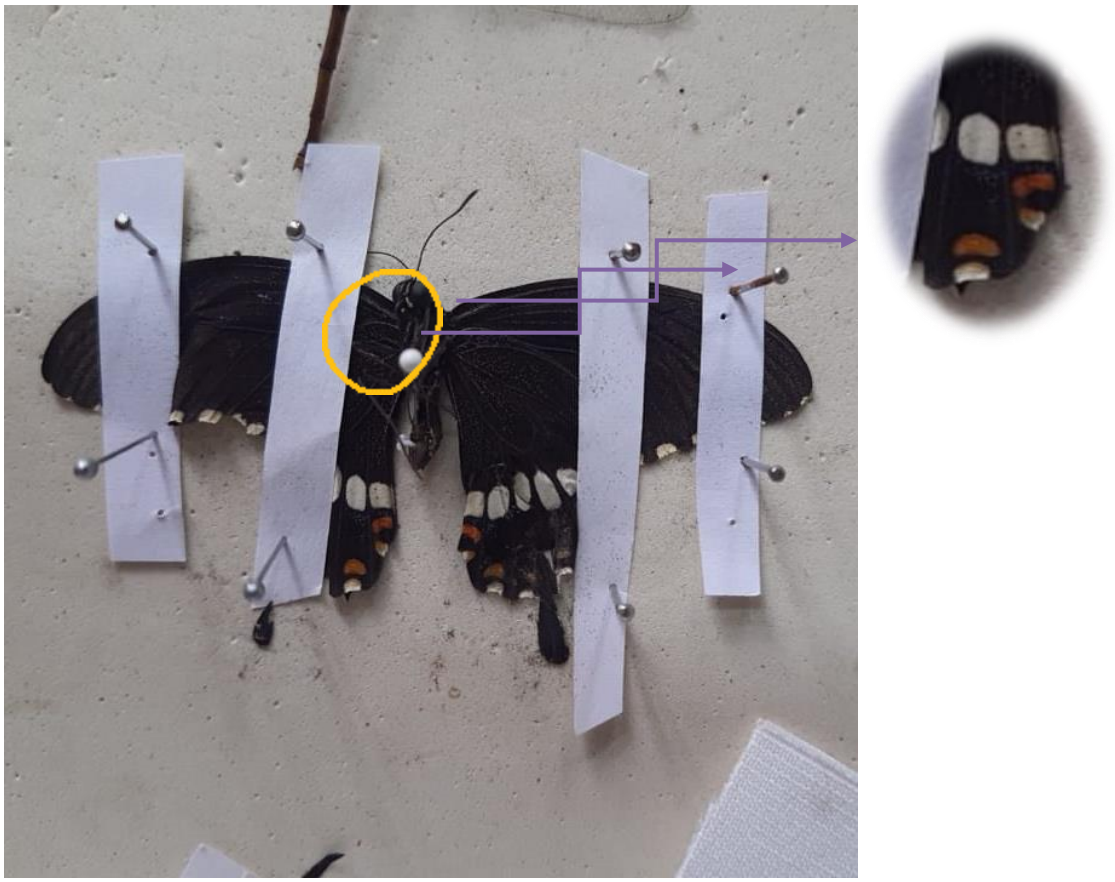

Red crescent

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DIARA CULTIVATION OF CUCURBITS AT THE PLAINS OF THE GANGES

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Abstract
Diara cultivation refers to agricultural practices on fertile riverbank lands, especially in the Gangetic plains. These areas, characterized by rich alluvial soil, are periodically replenished by river floods, providing ideal conditions for growing diverse crops. Commonly cultivated crops include rice, maize, wheat, pulses, and various vegetables. The cultivation process involves careful soil preparation, balanced fertilization, efficient irrigation, and integrated pest management. While diara lands offer high productivity and economic benefits, challenges such as flooding, soil salinity, and infrastructure limitations persist. Farmers employ strategies like crop rotation, raised beds, and organic farming to enhance sustainability and resilience. Despite these challenges, diara cultivation remains vital for local food security and economic stability, leveraging natural advantages to sustain high agricultural yields and environmental sustainability.

Keyword: Cucurbits, Diara Cultivation, Melon

Introduction

Diara lands, often found along the riverbanks of the Gangetic plains, are known for their fertile alluvial soil, making them ideal for agriculture. This rich soil is particularly suitable for cultivating cucurbits, a plant family that includes cucumbers, melons, pumpkins, gourds, and squashes. These crops thrive in the diara's warm climate and well-drained soil, providing an essential source of income and nutrition for local farmers.


Diara Cultivation at Ganga Bairaj Kanpur

Site Selection and Soil Preparation

- **Site Selection**

Choosing the right site is crucial for successful cucurbit cultivation. Diara lands naturally offer fertile, well-drained soil, but it's essential to ensure the selected plot receives ample sunlight. Cucurbits require full sun to grow vigorously and produce abundant fruit.

- **Soil Preparation**

The preparation of soil is a critical step in diara cultivation. Start by plowing the land to a depth of 15-20 cm to break up the soil and improve aeration. This process also helps to control weeds and prepare a fine seedbed. Incorporating organic matter, such as compost or well-rotted manure, can significantly enhance soil fertility and structure, providing the necessary nutrients for the growing plants.

Sowing Timing

The timing of planting is vital for cucurbit crops. In the Gangetic plains, cucurbits should be sown at the beginning of the warm season, typically late spring to early summer. This timing ensures the plants benefit from the entire growing season and avoid frost damage.

Seed Selection

Selecting high-quality seeds is another crucial step. Opt for disease-resistant and high-yielding varieties suited to the local climate and soil conditions. Varieties such as 'Pusa Barkha' for cucumbers, 'Arka Manik' for watermelons, and 'Arka Suryamukhi' for pumpkins are well-suited for diara lands.

Planting

Sow the seeds directly into the prepared soil. The spacing between plants varies depending on the specific type of cucurbit. Generally, space rows about 1 meter apart and plants 60-90 cm apart within each row. This spacing allows enough room for the vines to spread and access sunlight, air, and nutrients.

Irrigation Watering

Cucurbits require consistent moisture, particularly during flowering and fruit set. In diara lands, irrigation management is critical due to the varying water availability. Regular irrigation is essential, especially during dry spells. Techniques like drip irrigation or furrow irrigation can be highly effective, ensuring water reaches the plant roots efficiently while minimizing wastage.

Fertilization Nutrient Management

Providing adequate nutrients is crucial for the growth and yield of cucurbit crops. Start with a balanced fertilizer rich in nitrogen, phosphorus, and potassium (NPK) at the time of planting. Follow up with side-dressings of nitrogen fertilizer as the plants grow, especially during the vining and flowering stages. Organic options, such as compost tea or fish emulsion, can also be beneficial for maintaining soil health and providing nutrients.

Pest and Disease Management

- **Common Pests**

Cucurbits are susceptible to various pests, including aphids, beetles, and caterpillars. Regular monitoring and early intervention are key to managing these pests. Integrated Pest Management (IPM) strategies, combining biological control with judicious use of pesticides, can effectively control pest populations. For instance, introducing beneficial insects like ladybugs can help keep aphid populations in check.

- **Diseases**

Fungal and bacterial diseases, such as powdery mildew, downy mildew, and bacterial wilt, are common in cucurbit crops. Early detection and management are crucial to prevent widespread damage. Implementing crop rotation, ensuring good air circulation around plants, and using resistant varieties can help reduce disease incidence. Fungicides and bactericides may be necessary for severe outbreaks, but should be used as a last resort.

Harvesting Timing

Harvesting cucurbits at the right time is essential for optimal flavor and storage life. The timing varies depending on the type of cucurbit. For example, cucumbers are typically harvested when young and tender, while pumpkins are allowed to mature fully on the vine. Signs of readiness include a deep, uniform color and a hard rind that resists puncture.

Handling

Handle harvested cucurbits with care to avoid bruising and damage. Use sharp knives or pruning shears to cut the fruit from the vine, leaving a small portion of the stem attached to prolong shelf life. Avoid stacking the fruits too high to prevent pressure damage.

Post-Harvest Management

Proper post-harvest management is crucial for extending the shelf life of cucurbits. Cucumbers and melons should be consumed fresh or stored in a cool, humid environment. In contrast, pumpkins and squashes can be stored in a cool, dry, and well-ventilated area for several months. Regularly check stored fruits for signs of decay or pest damage and remove affected fruits to prevent spread.

Conclusion

Diara lands, with their fertile soil and favorable climate, provide an excellent environment for the cultivation of cucurbits. By following best practices in site selection, soil preparation, sowing, irrigation, fertilization, pest and disease management, and post-harvest handling, farmers can achieve high yields and produce high-quality cucurbits. This not only enhances food security but also contributes to the economic well-being of farming communities in the Gangetic plains. Cultivating cucurbits in diara lands is a sustainable agricultural practice that leverages the natural advantages of these unique landscapes.

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ECO-FRIENDLY SOIL HEALTH MANAGEMENT FOR GREEN AGRICULTURE

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ABSTRACT

Rapidly increasing global human population has led to the intensive land use change, and the over exploitation of soil resources resulting in the diminished soil health, ecosystem services, and human well-being. The soil health degradation is one of the important challenges before farmers, researchers and policy makers. This problem has resulted in plateaued or even declining agricultural productivity especially in arid and semi-arid tropics. It also threatened the livelihood of small and marginal farmers in these areas. Therefore, it is the need of the day to restore the health of our soil resources for improving the food and nutrition security of present as well as future generations. In this backdrop, the present paper is aimed to discuss the drivers of eco-friendly soil management and suggest various adaptive practices to maintain the soil health while improving the quality of crop yield for environmental sustainability and human health.

INTRODUCTION

Soil is a living system so the soilhas hunger and thirst like human being. Ignoring the hunger of the soil, not replenishing the existing nutrient deficiencies by application of manure and fertilizer as per the amount of nutrients used by the crop, the fertility of the soil is being depleted and as such is creating the problem of multi-nutrient deficiency, which affects the soil productivity and crop yields. Apart from having adverse effects on productivity and product quality, the environment also does not remain untouched by this menace. Mahatma Gandhi had rightly said, *"Our land has the capacity to satisfy everyone's needs but it is not possible to satisfy their greed."*

In the initial phase of Green Revolution, our soils were fertile and the climate was also favourable. As a result, we succeeded in increasing agricultural productivity through the use of improved seeds of wheat and paddy, irrigation water and nitrogen and phosphorus containing fertilizers and the country became self-sufficient in food grains. But making this success sustainable is now proving difficult. The main reason for this was the farmers generally becoming dependent on urea and DAP based crop nutrition system and not understanding the importance of other essential nutrients. As a result, the process of exploitation of soil nutrients started and deficiency of multi-nutrients started being seen on a large scale. It is important to mention here that only 30-40 percent of nitrogen and only 15-20 percent of phosphorous of nitrogenous and phosphatic fertilizers are utilized by plants, the remaining amount is lost through various pathways (emission in gas form in the atmosphere, leaching of nutrients through irrigation and rain water below the root zone of the crop, denitrification, accumulation of nutrients in the reservoirs along with rain water etc.) proved to be fatal for soil health, crop nutrition and environment. Also, lack of seriousness to use organic manures and bio-fertilizers caused many of these problems. Therefore,

there will be a need for a scientific integration of every method of integrated nutrient management system, whether it is included in modern agricultural methods or is a part of organic or natural farming, which can ensure sustainable green agriculture while reducing the amount of chemical fertilizers.

ECO- FRIENDLY SOIL HEALTH MANAGEMENT

It is important to mention here that before the Green Revolution, there was a general trend of use of farm yard manure, compost, green manure, crop rotation, fallowing, herding sheep in fields, even adding soil from ponds etc. to keep the soil alive and fertile. But during the Green Revolution, farmers' inclination towards chemical fertilizers increased and their interest in the use of these soil fertility nutrient inputs decreased. Today, due to the disturbances in soil health mainly because of farmers' ignorance about these inputs, farmers are facing many problems in the farming and they are unsuccessfully trying to find the solution by increasing the quantity of urea. Here, we are proposing innovative composts and smart fertilizers, which ensure balanced plant nutrition by increasing fertilizer use efficiency.

To control climate change related agricultural problems, it is necessary that in the coming years, the use of chemical fertilizers like Urea and DAP which have adverse effects on the environment should be minimized as much as possible. We need to reduce the use of chemical fertilizers through integrated nutrient management and adopt a climate change resilient agricultural system that is capable of reducing the use of fertilizers and pesticides and their adverse effects, while at the same time maintaining our food, nutrition and environmental security. Along with adopting flexible agricultural technologies, adopting environment friendly crop nutrition system has now become the need of the hour. Use of quality nutrient enriched organic manures (compost, vermicompost, farmyard manure, green manure, crop residues etc.) along with bio-fertilizers and innovative smart nutrient resources (nano urea, nano DAP, water soluble fertilizers, crop growth stimulants like Sagarika etc.) which improve soil health in a eco-friendly way.

Climate resilient technologies i.e. crop cultivars tolerant to climate stresses, crop diversification with other alternative crops like pulses, oilseeds along with cereals, flexible intercropping systems, conservation agriculture, zero till of wheat drill sowing, alternative methods of rice cultivation (rice intensification system, aerobic rice, direct seeded rice), integrated farming systems, integrated nutrient management, integrated pest management, organic farming, site-specific nutrient management, in-situ moisture conservation, micro irrigation methods (drip and sprinkler), etc. should be propagated and farmersbe encouraged to adopt them on each and every holding. It is known that there is a direct relationship between the amount of moisture in the soil and the efficiency of fertilizers being used. This is why well-planned controlled use of water and fully water solublefertilizers through drip irrigation (fertigation) increases the efficiency of both the important inputsie. nutrients and water. Green agricultural technologies are beneficial to society and businesses while also benefiting the environment. Adoption of these technologies helps in reducing greenhouse gas emissions, thereby helping in combating climate change adversities. Also, more efficient use of resources like water and energy helps preserve biodiversity and ecosystems. Additionally, energy efficiency and waste management reduce business operating costs, which often translates into higher profits.

Soil Fertility Based Balanced Crop Nutrition :As a result of intensive agriculture, multi-nutrient deficiencies are being seen in every part of the country, which farmers are ignoring due to lack of

knowledge. Whatever specific nutrients are lacking in the soil, it has become absolutely necessary to improve them by balanced use of new age smart fertilizers and quality indigenous manures as per the requirement of the crop. For this, reliable soil testing and recommendation of nutrients as per the yield target is necessary, otherwise the reckless use of urea and DAP will not only increase the cost of farming but will also affect agricultural productivity, product quality and farmer's profit and ultimately the problem of environmental pollution will also increase. In view of the increasing deficiency of multiple nutrients in the soil on a large scale, the importance of soil-test based nutrient use has increased (Figure 1). Judicious use of nutrients is not only resulting in a significant increase in the yield and quality of the product as compared to the farmer's method, but soil-test based recommendations prove to be important from the economic point of view.

Figure 1. Get soil tested before sowing the crop

Twenty two crores soil health cards have been given to the farmers through this Project so that they can get correct information about the health of the soil to ensure balanced fertilization.

Conservation agriculture (CA):CA is defined as an ecosystem approach to agricultural land management based on three interlinked principles.1. Minimum soil disturbance through no-tillage or reduced tillage: though zero-till is ideal, CA can involve controlled tillage where no more than 20-25 percent of the soil is disturbed 2. Permanent maintenance of soil mulch by retaining crop residues or cover crops on the field: A minimum of 30 percent permanent organic soil cover is maintained as per CA definitions and 3. Diversification of cropping systems through proper crop rotation: crop rotation and intercropping using legumes are recommended. CA is known to enhances biological processes (above and below ground), reduces tillage, and optimises the use of external inputs (agrochemicals) to avoid biological disruption. It involves direct seeding of crops with minimal soil disturbance after the harvest of the previous crop. This requires slashing or rolling the weeds or last crop residues and then directly seeding through the mulch without ploughing. In this way, crop residues are retained, providing soil cover and a source of nutrients for the next crop.

Quality compost

Sustainable soil fertility management through efficient use of compost and compost based quality organic fertilizers has a special important place in crop nutrition. Use of compost leads to

improvement in soil structure, water holding capacity, cation exchange capacity, quality and quantity of soil organic carbon, activity of microbial biomass enzymes, favourable changes in the community of soil organisms and significant increase in mutual competition among them. Compost has the ability that after its use, a hostile environment is created for the pathogens causing plant diseases in the soil, due to which, despite their presence in the soil and the sensitivity of plants towards them, they become inactive, thereby automatically reducing the occurrence of diseases. Continuous use of compost and compost-based bio-improvers increases the disease-control capacity of the soil by adversely affecting the number of soil-borne pathogens and their activity. Regular use of quality compost or cowdung manure increases the amount of organic matter in the soil.

Nutrient enriched compost : To prepare nutrient enriched compost that is called Phospho-Supho-Nitro Compost, use of chemical inputs like urea, rock phosphate and gypsum or phospho-gypsum etc. is recommended.

To prepare compost, mix 500 kg compost material and fresh cow dung in the ratio of 1:1. After this, mix rock phosphate, phosphogypsum-gypsum and urea in the thick slurry of fresh cow dung. By adding urea, the desired improvement in carbon-nitrogen ratio of the compost material is achieved. Carbon : Nitrogen ratio of 30:01 to 40:01 is considered suitable for microbial activities. By adding gypsum/phospho-gypsum, the pH value of the compost material becomes slightly acidic, which reduces the loss of nitrogen in gas form and increases the solubility of phosphorus. Adding rock phosphate improves the carbon : phosphorus ratio, which increases the activity of micro-organisms. Also, the nitrogen, phosphorus and sulphur present in urea, rock phosphate and gypsum/phospho-gypsum respectively helps in increasing the percentage of N, P, S in the finished compost.

Vermi compost : The compost prepared by rotting organic material (crop residues, weeds, garbage, cow dung etc.) with the help of earthworms is called “vermi-compost” or “earthworm compost” (**Picture 2**). The quality of vermi-compost is better as compared to other composts as it contains more nutrients. On an average, it contains 1-1.5% nitrogen (N), 0.75% phosphorus (P_2O_5) and 1.5% potash (K_2O), apart from this, secondary and micronutrients are also present.

Picture2.Vemicompost: A potential compost to improve soil health

Gobar gas plant manure : The manure coming out from the Gobar (dung) gas plant contains 1.5 % nitrogen, whereas the manure prepared by compost method contains only 0.5% nitrogen. Apart

from this, the amount of organic matter in the dung released from the Gobar gas plant is high. Biogas slurry serves as a nutrient-rich source of essential elements, enhances moisture retention and reduces bulk density of soil, alleviate drought and salinity stress in plants, and mitigates environmental pollution by recovering nutrients. However, excessive application of biogas slurry can have negative environmental consequences. A view of gobar gas plant is depicted in **Picture 3**.

Picture3.Gobar gas plant provides clean energy and quality manure

City Compost: Fertiliser industries will now involve themselves to promote use of city compost as the scheme is mandatory and important for improving soil health. IFFCO had initiated this program in the interest of farmers.

Gobar Dhan Yojana : Under the *Gobar Dhan Yojana,* making organic fertilizers from agricultural waste and animal waste is also being encouraged. Scientists are also doing research on the enrichment of organic waste. Due to enrichment, microbial activity in organic waste increases and hence it can be used better as fertilizer.

Green Manuring : With increasing use of fertilizers in intensive cropping the practice of green manuring and also the use of organic manure has become less popular leading to fall in organic matter status of soil and emergence of multi nutrient deficiency. The physical and biological properties of the soils have also been deteriorated. Green manuring brings atmospheric nitrogen to the soil through biological fixation and other nutrients of deeper layer to upper layer and ensures better availability of other nutrients, adds organic matter to the soil, produces green biomass of narrow C:N ratio which is readily decomposable, and improves soil physical and biological properties. Aleguminous green manure crop producing 10-25 MT of green matter/ha will add about 60 to 90 Kg N /ha besides improving availability of other nutrients.

Biochar : Biochar is a promising technology for regenerative farming as it has many benefits for the environment and agro-ecosystems. Since the method used to produce biochar is carbon-negative, it actually reduces atmospheric carbon dioxide levels. Research has shown that biochar is beneficial for composting because it reduces greenhouse gas emissions and reduces nutrients lost from composted materials. Additionally, it encourages microbial activity, which speeds up the biodegradation process. Additionally, it reduces odour, bulk density and ammonia loss in compost.

Bio-capsules as organic fertilizers: Modi government has encouraged the innovation, production and use of bio-capsules. The use of bio-capsules is continuously increasing among farmers as compared to traditional fertilizers. Initial studies conducted on the use of bio-capsules are revealing that young farmers are adopting it on a large scale. In recent years, it is also being seen in the agricultural sector of India that educated youth who were doing very good jobs or business in other sectors are also turning to agriculture. These people are doing modern agriculture in a very scientific manner. Such youth are using these bio-capsules on a large scale as fertilizer. Encouraging data on the use of bio-capsules by farmers is coming from Gujarat, Madhya Pradesh, Uttar Pradesh, Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Telangana, Maharashtra, Himachal Pradesh and other states.

Potash made from the waste of sugar mills (Natural Potash) : Potash made from the waste of sugar mills is also included in this series. The government decided that subsidy will be given on this potash.

Water soluble fertilizers : There are a number of specialty and water soluble fertilizers to minimize emissions of greenhouse gases and enhance nutrient use efficiency. Fertilizers containing completely water soluble NP, NPS and NPK are important for balanced supply of these nutrients (**Picture 4**). Made from high quality raw materials, water soluble fertilizers are aimed at ensuring the supply of required nutrition to crops at any conditions and growth stages. In 20 years period the market size of WSFs grew from mere 10,000 tons in early 2000s to 300,000 tons in 2021. The global WSFs market size is estimated to be valued at USD 18.3 billion in 2023 and it is projected to reach USD 25.1 billion in 2028. The scope of water soluble fertilizers in future would increase with the expansion in area under horticulture and high value crops, increased coverage under micro-irrigation and increasing awareness and availability of these fertilizers.

Figure 4. IFFCO speciality/fully water soluble fertilizers

Bio-stimulants from sea-weed : The work of making alternative fertilizers from sea-weed has also gained momentum in the last few years. The fertilizer made from seaweed is very useful in terms of soil fertility and plant growth. Fertilizer companies are making different fertilizer products from it. IFFCO has made a product named Sagarika from sea-weed (**Picture 5**). The seaweed extract

concentrate in it has been kept at 28 percent. It is made from red and brown algae. It contains many elements which are essential for the growth of plants. Its use among farmers is continuously increasing.

1. **TableCompositionof Sagarika**

NUTRIENTS	RESULTS
Nitrogen (N)	0.25-0.30 g/100g
Phosphorous (P)	0.03-0.04 g/100g
Potassium (K)	14.0-18.0 g/100g
Sodium (Na)	1-1.5 g/100g
Calcium (Ca)	0.15-0.20 g/100g
Silica (Si)	0.2-0.25 g/100g
Magnesium (Mg)	0.35-0.45 g/100g
Iron (Fe)	0.02-0.03 g/100g
Sulphur (S)	0.1-0.15 g/100g
Copper (Cu)	50-70 ppm
Manganese (Mn)	15-20 ppm
Cobalt (Co)	5-10 ppm
Zinc (Zn)	5-12 ppm

Picture5. IFFCO Sagarika for eco-friendly soil health management

Fishery Industry Based Quality Organic Fertilizer : In the process of making its oil or other products in the fishery industry, a sticky substance is released. It contains a good amount of nutrients like nitrogen, potassium, calcium and magnesium. Work is also going on to make fertilizer using it. The fertilizer made from this is very useful for fruits and vegetables. It is absolutely organic fertilizer. One special thing about it is that it is being prepared from raw material which has no other use and if it is not used in making fertilizer then it gets thrown as garbage. Nutrients from the fertilizers made from this are quickly absorbed by the plants.

Combined use of Water soluble fertilizers and biostimulants : Water soluble fertilizers and biostimulants are an essential component of nutrient management of vegetables and fruit trees as they help in ensuring healthy growth of plants, increasing yields and improving fruit quality. The use of biostimulants from the seaweed-based product range is beneficial to support fruit trees during the vegetative stage, flowering and fruit setting. By using bio-stimulants accurately withwater soluble fertilizers, growers reduce waste and environmental impact while promoting plant growth and improving fruit quality.

Biofertilizers : Biofertilizer contains living microorganisms which, besides fixing atmospheric nitrogen, help in increasing the solubility of nutrients like potassium, sulphur, zinc etc. With their use, there is a significant increase in the number of beneficial micro-organisms in the soil, which provides the benefit of improving soil health. Effective liquid biofertilizers are available as NPK consortia, Zn, P, K, S etc. solubilizing microbial cultures (**Picture 6**).

Figure6. IFFCO Biofertilizers

Poly Halite (Poly 4) : Poly-sulphate mined in its natural crystal state (Poly Halite) contains four nutrients (potassium (13.5%), calcium (16.5%), magnesium (5.5%) and sulphur (18.5%) as sulphate. Being a natural crystal, poly-sulphate has a unique dissolution pattern that slowly releases nutrients into the soil after being added to the crop. This availability of nutrients over a long period of time reduces the possibility of their loss. Poly-sulphate is a natural product with a low carbon footprint, licensed for use in organic farming systems.

Fertigation : When in a drip irrigation system, water along with 100% water soluble fertilizers are delivered directly to the roots of the plants, it is called fertigation. Fertigation is the best and most modern method of applying fertilizers and water together. With the use of fertigation, water soluble fertilizers are applied directly to the roots of the plant along with water, which ensures complete utilization of nutrients and water by the plant, thereby significantly increasing the efficiency of both irrigation water and nutrients. Fertigation is known as a good technique to maintain proper level of fertilizer and water according to the needs of the crop and soil.

Fertilizers given through fertigation should be water soluble so that they can easily reach the roots of the plants. Fertilizers containing micronutrients can also be applied to water through fertigation. Therefore, weeds grow in less numbers. Fertigation does not cause groundwater pollution. Fertigation is simple and convenient compared to other methods, which saves time and labour. Through drip fertigation, crops can be successfully grown even in undulated barren (sandy or rocky soils) where it is difficult to control water and nutrients in the environment of the plant's root zone.

Organic farming: Organic farming, also known as ecological farming or biological farming, is an agricultural system that uses fertilizers of organic origin such as compost manure, green manure, and bone meal and places emphasis on techniques such as crop rotation and companion planting. Components of organic farming are shown in **Picture 7**.

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Picture 7.Components of organic farming

Organic farming help protecting the long term fertility of soils by maintaining organic matter levels, encouraging soil biological activity, and careful mechanical intervention, providing crop nutrients indirectly using relatively insoluble nutrient sources which are made available to the plant by the action of soil micro-organisms, ensure nitrogen self-sufficiency through the use of legumes and biological nitrogen fixation, as well as effective recycling of organic materials including crop residues and livestock manures, ensure weed, disease and pest control relying primarily on crop rotations, natural predators, diversity, organic manuring, resistant varieties and limited (preferably minimal) thermal, biological and chemical intervention. Organic farming has gained global attention as a sustainable agricultural practice. However, unresolved issues still need to be addressed before the widespread expansion of such techniques.

Natural Farming: "Natural Farming is a chemical-free traditional farming method. It is considered as an agroecology based diversified farming system which integrates crops, trees and livestock with functional biodiversity"-Niti Ayog Natural farming is a system where the laws of nature are applied to agricultural practices. There are several states practicing Natural Farming. Prominent among them are Andhra Pradesh, Chhattisgarh, Kerala, Gujarat, Himachal Pradesh, Jharkhand, Odisha, Madhya Pradesh, Rajasthan, Uttar Pradesh and Tamil Nadu. Till now 6.5 lakh ha. area is covered under natural farming in India. Different State governments are promoting natural farming through various schemes.

NITI Aayog is among the foremost promoters of natural farming. Multi-location studies are imperative for the scientific validation, its long-term impact and viability of the model promoting it country-wide. The Indian Council of Agricultural Research is also studying the Natural Farming methods practiced by basmati and wheat farmers in Modipuram (Uttar Pradesh), Ludhiana (Punjab), Pantnagar (Uttarakhand) and Kurukshetra (Haryana), evaluating the impact on productivity, economics and soil health including soil organic carbon and soil fertility. Recently Andhra Pradesh Government Launch Indo German Global Academy for Agro ecology Research and learning (IGGAARL) at Pulivendula on 7th July 2022. As per the study, India which holds almost 20 % of the world population has consumption of only 1 % organic produce of the total organic produce. Whereas India itself is the country with the largest farmlands in the world. It suggests that there is a lot of hindrances being faced by organic food products whether obtained organically or naturally in the Indian market. A proper market infrastructure is yet to establish for selling of the produce and awareness among the farmers is required for proper implementation of all the schemes that are promoting the Natural Farming in India.

NanoFertilizers

There is unbalanced use of urea in India. The biggest reason for this is that nitrogen use efficiency in India is only about 35 percent. This means that approximately 65 percent of the nitrogen that plants should get from urea is being wasted. Some gets washed away with water and some gets wasted in the air. Soil is getting spoiled due to excessive use of urea. Besides, water pollution and air pollution are also increasing. Apart from this, its major disadvantage is that the greater the quantity of urea used, the greater will be the burden of subsidy on the government. The nutrient use efficiency of conventional fertilizers is very low. About 60 to 70percent of conventional fertilizers for crop nutrition do not reach their target because they are unstable in the environment and difficult to be taken up by crops. Conventional fertilizers are not only costly for the producer but also prove to be harmful for humans and the environment. Therefore, it is necessary to search for eco-friendly fertilizers with special efficiency.

Picture 8. IFFCO's Nano Urea Plus and Nano DAP

On August 15, 2019, from the red fort, Prime Minister Modi ji had appealed to the farmers of the country to reduce the use of chemical fertilizers. The Prime Minister had said that to maintain the health of our mother earth, it is necessary that we reduce the use of chemical fertilizers. Taking inspiration from this call of the Prime Minister, the Union Ministry of Chemicals and Fertilizers asked the fertilizer companies and other experts to work in this direction. Under the guidance of the Ministry, IFFCO Nano Biotechnology Research Centre (NBRC) of Kalol, Gujarat, the mother unit of IFFCO, had initially developed completely indigenous technology based products like Nano Nitrogen, Nano Zinc and Nano Copper. These products made from nano structure provide effective nutrition to plants. The efficiency of these nano fertilizers was studied by IFFCO and finally Nano Urea (Liquid) and Nano DAP (Liquid) (**Picture 8**) were included in the Fertilizer Control Order.

Very recently, IFFCO invented new version of Nano urea (Nano Urea Plus with 16% N (w/v), Nano DAP (8% N and 10% P_2O_5), Nano Zinc (1% Zinc) and Nano Copper (0.8 % Copper).

Nano Urea Plus : Indian Farmers Fertilizer Cooperative Limited (IFFCO) was the first in the world to develop Nano Urea (Liquid) and India became the first country to commercially produce Nano Urea. The production of this nano-based fertilizer was started from June, 2021 at the Kalol factory in Ahmedabad, Gujarat and IFFCO ensured its availability to the farmers at commercial level, this was completely under the "Make in India" initiative due to which the mission of Prime Minister Shri Narendra Modi is being fulfilled. By mid-January 2024, 7.64 crore bottles of Nano Urea have been produced and 7.23 crore bottles have been sold to farmers.

Nano DAP (Liquid) : Encouraged by the success of Nano Urea, the Narendra Modi government encouraged IFFCO to introduce Nano DAP (Liquid). With the result, in 2023, India became the first country in the world to commercially produce Nano DAP. IFFCO has started production of Nano DAP at its Kalol plant from March 8, 2023. Two more plants will be started in Kandla and Paradip. It is noteworthy that compared to granular DAP, seeds/seedling treatment and foliar spray of Nano DAP helped germination, vigorous root growth, development and growth of plants, higher test weight of grains, higher yield and profits with 50% reduction in the recommended dose of DAP.

Nano Zinc and Nano Copper : Now, the IFFCO has developed Nano Zinc and Nano copper which have also been recently included in the Fertilizer Control Order. Be it Nano Urea Plus, Nano DAP, Nano Zinc or Nano Copper, all these have been found quite effective as revealed from the results of the on-farm and on-station experiments. This is in consonance with Prime Minister Shri Narendra Modi's call to promote the use of Nanofertilizers.

Summary

Eco-friendly soil health management and adoption of climate resilient agricultural technologies as well as environment friendly crop nutrition systems for sustainable green agriculture has now become the need of the hour. Quality nutrient enriched organic fertilizers (compost, vermicompost, farmyard manure, green manure, crop residues etc.) along with bio fertilizers and innovative smart fertilizers (nano urea, nano DAP, water soluble fertilizers, crop growth stimulants, soil physical and biological Joint and effective use of marine products like Sagarika etc. which enhance the qualities and quality should be promoted. IFFCO Nano Urea Plus, Nano DAP, Nano Zinc and Nano Copper are the new age eco-friendly fertilizers which need to be promoted.

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PROTOCOL FOR DEVELOPMENT OF DOUBLE HAPLOID (DH) IN RICE BY ANTHER CULTURE

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Introduction

In world, rice covered the area of about 165.25 million hectares and producing 502.98 metric million tonnes with a productivity of 3.04 tonnes/ha estimated in the year of 2022-23 (annon., 2023). Rice production in India, covered the largest area of about 47 million hectares and producing 132 million metric tonnes with a productivity of 2.80 tonnes/ha estimated in the year of 2022-23 and extensively grown in most of states (Anon., 2023). Although rice production has increased almost three folds over the past three decades, continued increase in yield potential and the number of high yielding varieties are necessary to meet the ever-growing demand of the global population. Hybrid rice, which can offer significant yield advantages over inbreds has revolutionized the rice productivity and production in the world. However, the hybrid rice production technology is bit tedious and costly and therefore the cost of seed material is very high and many a times, the farmers may not offer to buy the seeds (as always, the F_1 hybrid seeds are to be used). Therefore, other suitable techniques/ approaches are required to produce high productive and quality seed material besides completely homozygous lines for further use in crop improvement programmes. Self-fertilization of F_1 hybrids leads to a very rapid increase in homozygosity. Even in F_2, half of the genes are in homozygous state. Thus, self-fertilization quickly separates the progeny from a hybrid into many purelines. Therefore, selection in such a segregating population only picks out the genes combinations present in the population primarily as a result of recombination in F_2.Thus, the two obvious limitations of breeding methods based on self-pollination of the hybrid (e.g., pedigree and bulk methods) are firstly the recombination is limited to two or at the best three generations and secondly there is no possibility for further changing the genotype of the segregants.

To break down yield plateau in highly self-pollinated crops like rice, development of improved variety is the major focus area of research in which simultaneously used population improvement-based breeding approach for creation of variability with anther culture derived doubled haploid (DH) for developing true breeding lines in the immediate generation from any segregating population thereby contributes in shortening the breeding cycle of new varieties. Anther culture technique also offers great opportunities for improving grain quality of rice. Development of rice varieties using anther culture techniques has been reported in several countries. Most of the anther culture derived varieties are of the *japonica* type. The *indica* type rice is generally recalcitrant to culturability compared to *japonica* type and needs improvement through basic research of culturability. *In vitro* response of anthers of both *japonica* and *indica* are genotype specific and affected by too many factors. Thus, each genotype needs standardization. Enormous

advances have been made throughout the world since the invaluable discovery of androgenic haploidy by Guha and Maheshwari and production of rice haploids by Niizeki and Oono. Though anther culture has been recognized as a valuable tool in plant breeding programs but its application is limited due to difficulties in the induction of embryogenic calli from some genotypes. In general, *indica* rice has low anther culturability and the recalcitrance of it relates to early anther necrosis, poor callusing ability, low plant regeneration and frequent regeneration of albino plants. In this regard, several attempts at another culture of *indica* rice have met with limited success. Therefore, an efficient and high throughput technique is required to improve the callusing and regeneration ability of the androgenesis.

Different Factors which affecting Development of DH in Rice by Anther Culture:

The haploid induction and subsequent regeneration of embryos depend on many limiting factors, which include **(1)** plant genotype **(2)** microspore developmental stage **(3)**cold pre-treatment of the panicle **(4)** growth conditions of the donor plants (e.g. photoperiod and light intensity **(5)** orientation of the plated anthers **(6)** nitrogen source of the callus-induction medium **(7)** carbon source **(8)** composition of the culture medium (including culture on "starvation" medium low with carbohydrates and/or macro elements followed by transfer to normal regeneration medium specific to the species) **(9)** physical factors during tissue culture (light, temperature). Therefore, it is highly imperative to come out with a protocol to produce haploids in each of the genotypes in question. Further, it is also equally important to standardize the protocol for doubling the chromosome of haploid plants and confirm their policy through cytological studies or through other known approaches.

Methodology : Development and evaluation of DH using anther culture technology.

Immature panicle collects at booting stage in morning between 8-9 am.

⬇

Standardize Pollen development stage

⬇

Standardize stage of anther mid-uninucleate to early bi-nucleate by staining with acetocarmine solution (2 %)

⬇

Panicles will be wrapped in aluminium foil and cold shock pre treatment

⬇

Check pollen fertility and fertile anthers will be plated on callus induction medium

⬇

Plated anthers will be incubated in dark for at 25 ± 1 ºC for development of callus

⬇

Calli (2-3 mm) were placed on MS regeneration medium for complete plant regeneration, Compact calli will be transferred to MS regeneration medium and incubated under illuminated conditions with 16/8 hrs light and dark regime

⬇

3 to 5 cm Shoots regenerated plant transfer to MS rooting media for induction of rooting

⬇

Well-developed plants with profuse roots will be transferred for plant hardening
Transferred in green house and maintain till maturity

Protocol step for development of DH media for rice anther culture: (* Protocol for DH is specific to each genotype so you must have to standardize your genotype specific protocol by change in basal media and hormone concentration)

1. Sterilization treatment: Explant Rice Anther

T_1 - $HgCl_2$ (0.1%) for 2 min
T_2 - Sodium hypochlorite (5 %) for 4 min

2. Callus initiation:

T_1 = MS (Basal media)
T_2 = MS + 2,4-D (1 mg/l) + Kinetin (0.5 mg/l)
T_3 = N6 (Basal media)
T_4 = N6 + 2,4-D (1 mg/l) + BAP (0.5 mg/l) + Silver Nitrate (10.0 mg/l)

3. Shoot proliferation:

A) Shoot regeneration:

T_1 = MS + BAP (0.5 mg/l) + Kinetin (0.5 mg/l) + NAA (1.5 mg/l)
T_2 = MS + BAP (0.5 mg/l) + Kinetin (1.0 mg/l) + NAA (1.5 mg/l)

B) Rooting:

T_1 = ½ MS + 0.9% agar
T_2 = N & N + 0.5% sucrose + 0.9 % agar

Hardening:

Treatment details: Primary

T_1 = Coco peat
T_2 = Coco peat: Coconut husk (1:1)

Treatment details: Secondary

T_1 = Soil: Sand (1:1)
T_2 = Soil: Sand: FYM (1:1:1)

EXPECTED OUTCOMES

- Another culture will fix the lines in short duration, which saves time of breeder and enlighten fruitful opportunities for farmers so that they can have better choices for cultivation as soon as possible.
- Fixing of this kind of lines will combine the characteristics of all three desirable parents which may break the yield plateau in the highly self-pollinated rice crop. This can be the major achievement in entire agriculture sector at national level.

FUTURE PROSPECTS

1. Standardization of another culture protocol in rice
2. To overcome all the problem associate with hybrids rice variety and break down yield plateau in rice.
3. In near future we can easily develop biotic and abiotic stress *viz.* disease, pathogen, salt, draught resistance homozygous line in rice within short duration.

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EVAPORATIVE COOLING TECHNIQUE FOR FRUITS AND VEGETABLES

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Abstract
Fruits and vegetables are stored at lower temperature as they are highly perishable. The main problem during their storage is the change in the quality parameters which include color, texture, and freshness. In order to prolong the shelf life of fruits and vegetables proper storage is must. Proper storage means controlling both the temperature and relative humidity of the storage area. Preserving fruits and vegetables in their fresh form demands that the chemical, bio-chemical and physiological changes are restricted by proper control of temperature and humidity of the storage. The high cost involved in developing cold storage or controlled atmosphere storage is a pressing problem in several developing countries. Apart from this, the continuous power supply and low income of farmers makes refrigeration expensive. In this context, evaporative cooling can be an efficient and economical means for reducing the temperature and increasing the relative humidity in an enclosure. This effect has been extensively used for increasing the shelf life of horticultural produce. The technology of evaporative cooling is cost effective and could be used to prolong the shelf-life of agricultural produce. This paper gives the general overview of the evaporative cooling technique in fruits and vegetables and the various aspects associated with it.

Key Words : Evaporative Cooling, Relative Humidity, Temperature

1. Introduction

The horticultural produce such as, fruits and vegetables are important food items that are commonly consumed as the important sources of minerals and vitamins especially vitamin A and C. Fruits and vegetables form an important part of a balanced diet. Due to lack of proper storage, there occurs heavy loss to the farmers who produce fruits and vegetables, for example huge losses amounting to 20-30 % have been reported in tomatoes during storage and transportation (Arora, 2021). However, the major problem during their storage is the change in the quality parameters of these products especially the physical characteristics such as; the color, texture, and freshness. In order to extend their shelf life, fruits and vegetables need to be properly stored. Proper storage means controlling both the temperature and relative humidity of the storage area (Susan and Durward, 1995).

Although, refrigeration is very popular but it has been observed that several fruits and vegetables cannot be stored in the domestic refrigerator for a long period as they are prone to chilling injury. The high cost involved in developing cold storage or controlled atmosphere storage is also a pressing problem in several developing countries. Apart from this, the continuous power supply and low income of farmers makes refrigeration expensive. In this context Evaporative cooling is one of the options for tackling this problem (Olusunde *et al.* 2009).

Food and Agriculture Organization (FAO) advocated a low-cost storage system based on the principle of evaporative cooling for storage of fruits and vegetables, which is simple, and relatively efficient. The basic principle relies on cooling by evaporation. Evaporative cooling occurs when air, that is not too humid, passes over a wet surface; the faster the rate of evaporation the greater the cooling. The efficiency of an evaporative cooler depends on the humidity of the surrounding air. Generally, an evaporative cooling structure is made of a porous material that is fed with water. Hot dry air is drawn over the material. The water evaporates into the air raising its humidity and at the same time reducing the temperature of the air. The evaporative cooled storage structure has proved to be useful for short term, on-farm storage of fruits and vegetables in hot and dry regions (Jha and Chopra,2006).

Evaporative cooling is an efficient and economical means for reducing temperature and increasing the relative humidity of an enclosure, and has been extensively tried for enhancing the shelf life of horticultural produce. Such a system provides an inexpensive, energy efficient, environmentally caring and potentially attractive cooling system. Therefore, the main objective of this paper is to give an overview of the evaporative cooling technique for fruits and vegetables and the various aspects associated with it.

2. Factors Affecting the Shelf Life of Fruits and Vegetables

There are various factors that do affect the shelf life of fruits and vegetables which would lead to their spoilage. The various factors include:

2.1 Ambient Condition: The environmental condition has a great effect on the shelf life of fruits and vegetables and the factors can be sub-divided into temperature and relative humidity.

2.2 Temperature: Temperature is defined as the degree of hotness or coldness of a material. Temperature has a great impact on the shelf life of agricultural products. FAO, (1998) found that all produce is subject to damage when exposed to extreme temperatures leading to increase in the level of respiration.

2.3 Relative Humidity: This is the measurement of the amount of water vapour in the air as a percentage of the maximum quantity that the air is capable of holding at a specific temperature. It has a great effect on the deterioration of fruits and vegetables because it has a direct relationship with the moisture content in the atmosphere which determines whether the shelf life will not be exceeded. The relative humidity of storage unit directly influences water loss in produce (Wilson *et al*., 1995).

2.4 Variety and Stage of ripening: Post-harvest operation does not stop the fruits and vegetables from respiring which if not controlled will lead to the over-ripening of the fruits which will lead to early deterioration. Depending on the stage fruits are harvested, which in practice varies from mature green to fully ripened, the commodities have different storage conditions (Olusunde, 2006).

3. Theory and basic principle of evaporative cooling system

Evaporative cooling is a physical phenomenon in which evaporation of a liquid cools an object in contact with it. When considering water evaporating into air, the wet-bulb temperature, as compared to the air's dry-bulb temperature, is a measure of the potential for evaporative cooling. The greater the difference between the two temperatures, the greater the evaporative cooling effect. Evaporation of water produces a considerable cooling effect and the faster the evaporation the greater is the cooling. When the temperatures are the same, no net evaporation of water in air occurs, thus there is no cooling effect. The principle of working of this system is 'when a particular space is conditioned and maintained at a temperature lower than the ambient temperature surrounding the space, there should be release of some moisture from outside the body'. This maintains low temperature and elevated humidity in the space compared to the surrounding. This evaporative cooling chamber achieves all these requirements and is helpful to small farmers in rural areas (Dadhich *et al.*2008).

Evaporative coolers provide cool air by forcing hot dry air over a wetted pad. The water in the pad evaporates, removing heat from the air while adding moisture. When water evaporates it draws energy from its surroundings which produces a significant cooling effect. Evaporative cooling occurs when air, that is not too humid, passes over a wet surface; the faster the rate of evaporation the greater the cooling. The efficiency of an evaporative cooler depends on the humidity of the surrounding air. Very dry air can absorb a lot of moisture so greater cooling occurs. In the extreme case of air that is totally saturated with water, no evaporation can take place and no cooling occurs. The evaporative cooled storage structures work on the principle of adiabatic cooling caused by evaporation of water, made to drip over the bricks or cooler pads. Generally, an evaporative cooler is made of a porous material that is fed with water. Hot dry air is drawn over the material. Water evaporates into the air raising its humidity and at the same time reducing the temperature of the air. Cooling is provided by the evaporative heat exchange which takes advantage of the principles of latent heat of evaporation where tremendous heat is exchanged when water evaporates. It makes use of the free latent energy in the atmosphere (Basediya *et al.* 2011).

4. Methods of Evaporative Cooling

There are two main methods of evaporative cooling.

4.1 Direct Evaporative Cooling: This is a method by which air is passed through a media that is submerged with water. The latent heat associated with the vaporizing of the water cools and humidifies the air streams which now allow the moist and cool air to move to its intended direction. Sellers (2004)disclosed that direct evaporative cooling has the following major limitations:

- The increase in humidity of air may be undesirable.
- The lowest temperature obtainable is the wet-bulb temperature of the outside air.
- The high concentration and precipitation of salts in water deposit on the pads and the other parts, which causes blockage, and corrosion, and requires frequent cleaning, replacement, and checking.

4.2 Indirect Evaporative cooling: A heat exchanger is combined with an evaporative cooler and the common approach used is that it passes return or exhaust air through an evaporative cooling process and then to an air-to air heat exchanger which in turn cools the air, another approach is

the use of a cooling tower to evaporatively cool a water circuit through a coil to a cool air stream Sellers (2004) also said indirect cooling differs from direct cooling in the sense that in indirect cooling the process air cools by the evaporation of water but there is no direct contact of water with process air. Instead a secondary airstream is used for evaporation of water. So the moisture content of process air remains the same.

5. Forms of Direct Evaporative Cooling

Dzivama, (2000) studied the forms of evaporative cooling process and discovered that there are two forms in which the evaporative cooling principle can be applied. The difference is based on the means of providing the air movement through the moist materials. These is the passive and non-passive forms. The passive form of evaporative cooling relies on the natural wind velocity, to provide the means of air movement through the moist surface to effect evaporation. This form can be constructed on the farm, for short term on farm storage while the non- passive form uses a fan to provide air movement.

5.1 Passive-direct evaporative cooling system: Construction and design varies but the general principles are the same. The main components include:

- The cabinets where the produce is stored.
- The absorbent material used to expose the water to the moving air
- An overhead tank through which water seeps down on to and wet the absorbent material.

The absorbent material covering the cabinet absorbs water from the tank on top of the cabinets, the entire cloth that was used as cabinet is soaked in water and the air moves past the wet cloth and evaporation occurs. As long as evaporation takes place, the contents of the cabinet will be kept at a temperature lower than that of the environment and the temperature reduction obtained in this type of cooler ranged from 5-10°C. Zero energy cooling chambers (ZECC) are direct type of evaporative cooling system. It is developed by Indian Agricultural Research Institute (IARI), New Delhi, and is suggested for short duration storage of fruits and vegetables on the farm**.** It is a double walled structure with a gap of about 75 mm (3”) between the two walls which is filled with sand. It is covered by a cover made of cane or sack. The sand is saturated with water to keep it moist. As the water evaporates, it removes the heat from within the chamber through the process of evaporative cooling. The chamber can keep the temperature 10-15°C cooler than the outside temperature and maintain about 90 % relative humidity. It is suitable for almost all fruits and vegetables except onion, garlic, ginger, potato etc., as these crops require lower relative humidity (65-80 %) (iasri.res.in).

5.2 Non- passive direct evaporative cooling system: This uses a small fan, a water pump which is powered by electricity. The products are kept in storage cabins inside the coolers, Absorbent material which receives the water and expose it to evaporation with the help of the fan which draws air through the pad and an overhead tank which is constantly supplying water to the absorbent material. Materials used as the absorbent materials are hessian materials, cotton waste and the body frame is made of wood. The pad and the fan are directly opposite to each other.

6. Design consideration while choosing Evaporative Cooling Technique

It is important to review carefully the cooling needs, weighing them against a range of other factors before making decision (Odesola and Onyebuchi, 2009). The following checklist may be useful in choosing the right design:

1. Cooling needs: Cooling of different foods requires different temperatures.

2. Average relative humidity of the area where cooling is needed. If the relative humidity is consistently high, evaporative cooling will not be a viable option. If the relative humidity is low, then evaporative cooling maybe effective.
3. Windy area, where the cooling is needed. If there is little wind evaporative cooling may not be the way to go.
4. A good supply of water where the cooling system will be used. If this is readily available, evaporative cooling may be feasible.
5. The materials and skills needed to build the cooler available.
6. If commercial systems are not too costly available, then it may be a better technology.
7. Heat load factors in a cold storage design. Heat load factors normally considered in a cold storage design are:
    - wall, floor and ceiling heat gains due to conduction
    - wall and ceiling heat gains from solar radiation
    - load due to ingression of air by frequent door openings and during fresh air charge
    - product load from incoming goods
    - heat of respiration from stored product
    - heat from workers working in the room
    - cooler fan load and aging of equipment

7. Advantage of Evaporative Cooled Storage

1. It requires no special skill to operate and therefore is most suitable for rural application.
2. It can be made from locally available materials.
3. Its size can be fitted to the house hold need.
4. Better marketability of fresh horticultural produce than ambient.
5. Retain nutritive value.
6. Environment friendly storage system with no pollution.
7. Highly efficient evaporative cooling systems that can reduce energy use by 70%.
8. Evaporation not only lowers the air temperature surrounding the produce, it also increases the moisture content of the air. This helps to prevent the drying out of the produce, and therefore extends its shelf life.
9. Less expensive to install and operate. It can be easily made and maintained.
10. The evaporative cool chamber does not require mechanical or electrical energy input and can be constructed with locally available material with unskilled labour.

8. Disadvantage of Evaporative Cooled Storage

1. Evaporative cooling system requires a constant water supply to wet the pads. Therefore, need to be watered daily.
2. Space is required at outside the home.
3. Water high in mineral content leave mineral deposits on the pads and interior of the cooler gets damaged.
4. High dew point (humidity) condition decreases the cooling capability of the evaporative cooler.
5. No dehumidification. Traditional air conditioners remove moisture from the air, except in very dry location. Evaporative cooling adds moisture and in dry climates, dryness may improve thermal comfort at higher temperatures.

Conclusion

The shelf life of most of the fruits and vegetables products can be extended by prompt storage in an environment that maintains product quality. It has been estimated that around 23–35% of the horticulture produce goes waste due to improper post-harvest operations and due to lack of enough storage facilities. Evaporative cooling system can be an effective storage technique for on-farm storage of fruits and vegetables. This system not only lowers the air temperature surrounding the produce, it also increases the moisture content of the air. This may help in preventing the drying amount of the produce, therefore extending the shelf life of horticultural produce. Evaporative cooling system is well suited where; temperatures are high, humidity is low, water can be spared for this use, and air movement is available. The design depends on the materials available and the user's requirements. It is most suitable for the short-term storage of vegetables and fruits soon after harvest. Further research needs to be done in order to resolve the existing issues associated with the evaporative cooling techniques in fruits and vegetables.

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FROM FOREST TO PLATE: THE NUTRITIONAL AND MEDICINAL VALUE OF FIDDLEHEAD FERN

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Abstract

The subtropical Himalayas are home to the well-liked edible wild fern, *Matteuccia struthiopteris* (L.) Todaro. The fiddlehead fern is well-known for its antiviral, antibacterial, anti-inflammatory, antioxidant, and antidiabetic properties. It is also frequently utilized in traditional medicine to treat a variety of illnesses. Owing to its complex nutritional, pharmacological, and medicinal properties, fiddlehead fern is widely acknowledged in the Ayurvedic Pharmacopoeia.With an emphasis on possibilities for further research, the current review attempts to give up-to-date knowledge on the pharmacological effects, phytochemistry, botany, and toxicity approaches of *Matteuccia struthiopteris*. The antioxidant potential of this substance in promoting health is also highlighted. Several online databases (research and reviews), books, websites, theses, and other sources were examined in order to conduct an in-depth investigation of the literature. Micropropagation and tissue culture are two other plant biotechnology techniques that are covered. In addition to being beneficial as an antioxidant and free radical scavenger, *Matteuccia struthiopteris* is proven to be helpful in the treatment of a variety of disorders, including diabetes, viral infections, and microbial infections. It even helps with weight loss. In order to provide the mechanistic role of crude extracts and their bio-actives and even to identify the structure–function relationship of active ingredients, further research is necessary.

Introduction

The fiddlehead fern (*Matteuccia struthiopteris*) is an edible wild fern popularly found in the subtropical Himalayas. It is also called as the ostrich fern because of its large and arching sterile fronds, which resemble ostrich feathers. Fiddlehead ferns have terrestrial or wetland habitats and are mostly distributed in forests, along the shores of rivers or lakes.

This edible wild fern has demonstrated efficacy in treating various ailments including microbial and viral infections, diabetes management, weight loss, as well as exhibiting antioxidant properties. It can also be consumed as a dish and pickle.

Fiddlehead fern is suitable for consumption and culinary preparation. As a result, fiddlehead fern is incorporated into various Indian cuisines.

Found in the Himalayan states of North and Northeast India on the Indian subcontinent, the fiddlehead fern is consumed and prepared across the area which varies from region to region with their characteristic and unique way. In the Kokborok language, the fiddlehead fern is referred to as ‘muikhonchok’ in the state of Tripura. It is prepared by stir-frying it, which is then served as a side dish called ‘bhaja’ in Tripuri cuisine. This edible wild fern is referred to as "Chekoh" in the native Thadou language of Manipur. It is typically consumed alone as stir-fried or with other vegetables like potato and with meats such as prawns, poultry, or eggs.

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In Mandi, Himachal Pradesh is referred to as lingad and is used for pickling vegetables. It is referred to as lingri locally in the Kullu Valley of Himachal Pradesh, where it is used to make lingri ka achaar, a pickle. isThe fiddlehead fern consumed as a vegetable in the Kangra Valley and is referred to as lungdu in the local dialect. It is referred to as "kasrod" in Chamba. It is known as limbra in the Uttarakhand division of Kumaon. It is known as languda in Uttarakhand's Garhwal region and is used as a vegetable. It is known as niyuro in the districts of Darjeeling and Sikkim. It is typically served as a vegetable side dish, sometimes pickled and frequently combined with local cheese. It is referred to as dheki shaak or dheki shaag in West Bengal's southern parts.It is a popular side dish in Assam and is called dhekia xak. In Jammu & Kashmir, it is referred to as kasrod . Played with ferns, kasrod ka achaar is the most well-known dish from the Dogra cuisine. The local term for it in Poonch is 'Kandor'. It is referred to as ted in Kishtwari, the native language. It can also be prepared as a dry vegetable side dish to go with parathas or rotis. It is known in the Khah language as "DheeD" in the Ramban area of Jammu and Kashmir.


Chemical Constituents

The herb plant *Matteuccia struthiopteris* is known to contain a variety of phytoconstituents, including derivatives like flavonoids, isocoumarins, phthalides, lignans, and stilbenes. It has been identified as a member of the genus *Matteuccia*, which is primarily composed of flavanones with C-methylation at C-6 and/or C-8 (Huh et al. 2017; Shao et al. 2010). Various techniques, including GC-MS and HPLC, are available for screening phytochemical components (Li et al. 2013; Dvorakova et al. 2021). According to Chen et al. (2003), it also includes a number of phenolic chemicals. There are several components that have been separated from various fern parts that work well for various purposes.

Antidiabetic Activity

Matteuccia struthiopteris and the harvested rhizomes and fronds of nine different fern species were cleaned, freeze-dried, and ground. After 30 minutes of ultrasonification extraction in an ultrasonic water tank using a 100% methanol solvent, the α-glucosidase inhibitory activity was evaluated and vacuum filtration was performed. The positive control was acetacarbose. Following a 10-minute reaction at 37°C with 100 µL of extract and 0.7 unit α-glucosidase enzyme solution, 50 µL of 1.5 mM ρ-NPG solution was added, and the mixture was then left to react at 37°C for 20 minutes. After the reaction was stopped with one milliliter of 1 M Na2CO3, the absorbance at 405 nm was measured. The amount of solubility solids that can block 50% of 0.7 units of α-glucosidase solution (the corresponding value of the IC50) activity was investigated. Compared to acarbose

(IC50 = 1413.70 µg/mL), the frond (IC50 = 14.00–913.33 µg/mL) and rhizome extracts (IC50 = 12.93–205.84 µg/mL) of nine pteridophyte species exhibited greater α-glucosidase inhibitory activity (Kim et al. 2013). The hypoglycemic impact of flavanols with C-methylation in the A-ring was also demonstrated by Matteuccia struthiopteris (Basnet et al. 1993; Li et al. 2019).

Antibacterial Activity

According to Shan et al. (2007), 46 extracts, such as ostrich fern, dietary spices, and medicinal herbs, have antibacterial qualities against Salmonella anatum, *B. cereus, L. monocytogenes, S. aureus, and E. coli,* among other foodborne pathogens. Twelve extracts demonstrated high efficacy against every tested bacterium, including *Matteuccia struthiopteris* (MIC 100 µg/mL, DIZ 13.7 mm). It was discovered that the medicinal herbs' antibacterial qualities were noticeably stronger than those of the other dietary spices (Shan et al. 2007; Efenberger-Szmechtyk et al. 2021).

Conclusion

Matteuccia struthiopteris has been employed for its nutritious and energizing properties since ancient Ayurvedic and Unani research. The current review clarified the information that *M. struthiopteris* contains a variety of phytochemicals that are responsible for the plant's therapeutic evaluation and have been linked to several pharmacological properties in the treatment of various diseases, such as diabetes, viral infection, and microbial infection, as well as in weight loss and as an efficient antioxidant and free radical scavenge. Conversely, given its abundance of phenolic chemicals, more research is required to determine this plant's potential for immunomodulatory, cardioprotective, nephroprotective, and neuroprotective associations. To fully understand the metabolites and pharmacological action mechanism of the edible fern, further research is necessary. The overuse of forests, negligence of practical assets, lack of improvement, and unlucky reintroduction of species in typical natural environments have all contributed to the reverse state of this useful and restorative plant species' flora. As a result, many opportunities to take the crucial step to increase its population measure, efficiency, shield, and even usage have already passed.

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MANAGEMENT OF FRUIT FLIES IN MANGO AND GUAVA

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In India, fruit flies are responsible for substantial financial losses, costing farmers billions of rupees annually without control measures. The Oriental fruit fly (*Bactrocera dorsalis*), the guava fruit fly (*Bactroceracorrecta*), and the peach fruit fly (*Bactrocerazonata*) which belongs to Tephritidae family are especially problematic. Among these, the Oriental fruit fly is the most aggressive and damaging, causing major losses in mango and guava orchards which are key horticultural crops in Telangana.

For farmers in Telangana, these pests are particularly concerning as they can lead to 40-60% of crop loss at harvest. It's crucial for farmers to implement effective management strategies to mitigate the impact of fruit flies and protect their yields. This includes regular monitoring of crops, using traps, and possibly integrating control methods to reduce the fruit fly population and minimize damage.

Damage Symptoms

1. **Punctures on Fruits:** Female fruit flies damage the fruits by creating tiny holes in the skin to lay eggs. This usually happens on fruits that are nearing maturity.
2. **Maggot Infestation:** After the eggs hatch, the resulting maggots (small, legless, and creamy yellow or white, about 10mm long) burrow into the fruit pulp. As they feed, they cause the fruit to become discolored and foul-smelling.
3. **Fruit Drop:** The affected fruits often rot and fall from the tree prematurely along with the maggots. This not only leads to a loss of yield but can also contribute to further infestation if not managed properly.
4. **Maggots in the Soil:** After exiting the fruit, maggots drop to the ground and burrow into the soil to pupate. If fallen fruits are not removed, maggots can emerge and continue the cycle by maturing into adult flies that will infest new fruits.

Management of fruit flies

Farmers often rely on chemical insecticides to control fruit flies, but this method has led to increased resistance in the flies and adverse effects on both the environment and human health. As an alternative, Integrated Pest Management (IPM) is recommended. IPM aims to enhance farmers' profits through improved crop yields and market competitiveness by using a variety of management tools designed to control pests with minimal ecological disruption. This approach keeps pest damage at economically tolerable levels.

It's important to note that with IPM, only adult fruit flies are typically vulnerable to direct control measures, while eggs and maggots remain protected within the fruit and are often unaffected by insecticides. Therefore, managing fruit flies effectively requires a combination of tactics, each with its own advantages and limitations. The suitability and effectiveness of each tactic can vary, making it crucial to integrate multiple strategies for comprehensive pest management.

A. Cultural Practices for Managing Fruit Flies:

- **Soil Management:** During the summer, plough the topsoil (5-10 cm) deeply to expose fruit fly pupae to predators, sunlight, and heat, which can kill them.
- **Field Sanitation:** Keep the fields clean by removing weeds and debris, which can harbor pests.
- **Fruit Collection:** Regularly collect all fallen fruits from beneath the trees to prevent maggots from continuing their lifecycle.
- **Waste Management:** Dispose of rotten fruits from the farm regularly, ideally twice a week from fruit setting to harvest. Bury these fruits deep in the ground (about 2-3 feet) to destroy any larvae and eliminate breeding grounds.
- **Harvest Timing:** Harvest fruits slightly earlier than usual to avoid peak susceptibility to fruit fly attacks.
- **Remove Overripe Fruits:** These serve as prime breeding sites for fruit flies and should be picked to prevent infestation.
- **Soil Treatment:** Stir up the soil under the trees and spray targeted insecticides like chlorpyriphos 20 EC at a concentration of 2.5ml/l to kill any pupae.
- **Crop Selection:** Avoid planting crops like watermelon, muskmelon, gourds, lemons, papaya, custard apple, Sapota, and jamun near mango and guava orchards, as fruit flies may shift to these as alternate hosts after the main season.

B. Mechanical Practices:

- **Fruit Protection:** Wrap or bag fruits from the early growth stages until maturity using materials like newspaper or paper bags. This physically prevents the female flies from laying eggs on the fruits, thus ensuring they remain free from infestation. Although labor-intensive, this method effectively reduces the risk of fruit fly damage to zero.

C. Physical Control:

To eliminate larvae inside harvested fruits, dip them in water heated to 48°C for 5-10 minutes. This effectively kills the larvae without damaging the fruit.

D. Biological Control: Utilize natural enemies to manage fruit fly populations:

Red ants **(***Oecophyllalonginoda***)** are effective in managing fruit fly larvae.Parasitic wasps (*Fopiusarisanus*) can disruptfruit fly life cycle.

Bio-pesticides:

Apply *Metarhizium anisopliae* granules by hand around tree bases to target pupae. Incorporating neem cake into the soil also helps control pests by disrupting their lifecycle. Fungus *Metarhiziumanisopliae* @ 20 g/Land *Beauveria bassiana* WP @ 20 g/L can be sprayed around the base of trees to kill emerging pupae.

E. Chemical Control: Since the early 20th century fruit flies have been managed using traps combined with specific insecticides.

Lambda cyhalothrin 5 EC @ 1 ml/l or Spinosad @ 0.4 ml/l can be sprayed in a targeted manner to maximize effectiveness and minimize environmental impact.

a. Pheromone Traps: To monitor and manage fruit fly populations effectively:

- **Low-Cost Trap making:** Convert 1-liter plastic bottles into traps by cutting window-like openings on the sides and a small hole in the cap. Use a wire or thread to hang the bottle.

- **Lure Preparation:** Mix 60 ml ethyl alcohol, 40 ml methyl eugenol, and 20 ml Deltamethrin/Lambda cyhalothrin. Soak cotton ropes or wooden pieces in this solution for 24 hours, and then wrap them in aluminum foil until ready for use.
- **Trap Installation:** Hang traps about five meters off the ground in semi-shaded areas within the orchard. Replace lures every fifteen days. Start placing traps before adult fruit flies become active or around five to six weeks before fruits ripen.
- **Trap density:** Two to three traps per hectareare sufficient for monitoring purposes but for control, use eight to twelve traps per hectare

b. Baiting Strategy: Preparepoison bait using 100 grams of jaggery and 2 ml of decamethrin 2.8 EC mixed in one liter of water. Spray this mixture near tree trunks weekly to attract and kill adult flies.

Fruit fly infestation in guava fruits

Pheromone traps installation in guava

Fruit fly infestation in mango

Installation of methyl eugenol traps in guava

Fruit bagging in mango tree

Fruit fly adult on matured mango fruit

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GREEN MANURES ARE AN ORGANIC WAY

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Green manure refers to green, undecomposed material used as manure. It is obtained in two ways: by cultivating green manure crops or by gathering green leaves (together with twigs) from plants grown in wastelands, field bunds and forests. Green manuring is the process of growing plants in the field, mainly from the leguminous family, and incorporating them into the soil once they have grown sufficiently. Green manure crops are plants grown to produce green manure. The most important green manure crops include sunnhemp, dhaincha, pillipesara, clusterbeans, and Sesbania rostrata. In order to improve the physical and biological conditions of the soil as well as its fertility status, green manuring is the process of turning or ploughing newly green, undercomposed plant tissue into the soil.

Green manures are an organic technique

- To boost soil fertility,
- Supply nitrogen, and improve soil structure for better drainage and water retention.
- Suppress weeds and attract beneficial insects and predators.
- These plants grow quickly, making the process straightforward. You sow, they grow, and you dig them in. Green manures can help soil in as little as a few weeks.

A characteristic of crops used for green manuring is:

- Fast establishment and growth.
- Tolerant to pests and diseases.
- Adaptable to harsh weather circumstances, including drought, water logging, hot and low temperatures, etc.
- It is necessary to have sufficient Rhizobium nodulation potential and to be a proficient nitrogen fixer.
- It should be easy to absorb and decompose quickly.
- It should be able to develop very quickly and accumulate enough fixed N in 4-6 weeks.

GREEN MANURING IN SITU:

Either as an intercrop with the primary crop or as a pure crop, green manuring crops are planted and buried in the crop field. The common green manuring crops are Sunhemp (Crotolariajuncea), Green Gramme (Vigna radiata), Dhaincha (Sesbania aculeata), Cluster bean (Cymopsis tetragonoloba), Cowpea (Vigna sinensis), Khesari (Lathyrus sativus), Berseem (Trifolium alexandrium), etc.

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Fig 1 Sesbania


Fig 2 Green manure turn in to the soil

GREEN LEAF MANURING:

This involves gathering leaves and fragile twigs from trees and bushes that are cultivated on waste land, in the vicinity of forests, and bunds, then incorporating them into fields that can be farmed. Ipomea, Jatropha gossipifolia, various fodder crops, green manuring crops, and other shrubs and trees are frequently utilised for green leaf manuring.

The following fractions make up the incorporated green matter from the perspectives of breakdown and nutrient release:

Water-soluble fraction: Amino acids, soluble proteins, carbohydrates, and organic acids, among others.

Insoluble: cellulose and hemicellulose, for example.
Resistant fraction. Lignin.

Benefits of Green Manuring

- Give N in the range of 50–175 kg/ha.
- A significant amount of organic matter is incorporated into the soil.
- Expands the soil's ability to retain water and nutrients.
- Expands the soil's microbial population.
- Enhances the physical state of the soil and makes more macro- and micronutrients available.
- Has no negative effects on the environment or soil, making it environmentally benign and assisting in the long-term preservation of soil fertility.

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HYDROPONICS AND THEIR TECHNIQUES FOR CULTIVATION OF CROPS

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Abstract
Hydroponic technique has became one of the most cultivation method for production of crop. Now a days the population has become more and there are no sufficient amount of land for cultivation. So hydroponics has become popularly and every are depending on these hydroponic technique commercially. There are different system under these hydroponics and each system has different process and method for growing of crops. Commercially NFT one of the technique has been used throughout the for successful production of leafy as well as other vegetables with 70 to 90% savings of water.

Keywords : NFT (Nutrient film technique) ;Ec (Electrical conductivity)

The hydroponics technique was coined by professor William Gerickle in the year 1930's he described the growing of plants in water containing nutrients and the roots are suspended in the water. Hydroponics technique was developed due to insufficient amount of lands present now a days. At present soil less cultivation has become successful in growing of horticultural crops .Now a days it has became commercial that vegetable crops are cultivated in hydroponics technique are like tomato, Amaranth's, palak, cucumber , lettuce, strawberries.

INTRODUCTION

Hydroponics is defined as the technique of growing plants in water containing a mineral nutrients solutions under required environment without soil. The word hydroponics is derived from the Latin word Hydro means "water" and pons means "labour" literally working through water. The plants which are grown in hydroponics technique the roots are exposed to the nutrient media and the plant placed on a with cocopeat and clay balls which gives support to the plant. The hydroponics technique are constructed in a greenhouse under controlled climate conditions which help for the growth of the plants. The suitable environment and proper management will give better yield.

DIFFERENT TYPES OF HTYDROPONIC TECHNIQUES

There are many different types of hydroponics technique based on the requirement for growing of different crops. The mostly commonly used techniques are wick system, Drip system , Ebb-flow, Deep water culture and Nutrient film technique (NFT).

WICK SYSTEM

These is simple hydroponics technique system where there is electricity is not required pump and aerators .The plants are placed on grow trays which contains growing media like cocopeat, pellite, vermiculite and nylon thread are placed. The water(which contain nutrients) from the

storage tank are absorbed by the roots of the plant through the capillary action .These systems works with less amount of water and it is used for small plants.

Ebb and Flow SYSTEM

These hydroponic system technique works on the principle of flood and drain and these is one of the most commercially used technique. The water which contain the nutrients is pumped and reach certain level and absorbed by the plants and the remaining water are pump back to the reserviour. In these system different types are grown and some disadvantage in these method is it cause algal infection which affect the plants.

DRIP SYSTEM

These system is similar to the Ebb and flow system where the water will not come back to the reserviour .In these system the water and nutrients are absorbed individually to plant to plant with the help of the pump. In these method the plants are placed with a media and water and nutrients is supplied with the drip slowly. These is one of the commercially method used in the home gardens and different crops are grown in these system. (Rouphael and Colla, 2005).

DEEP WATER CULTURE SYSTEM

These deep water culture is the example of bucket system where the plant is placed in a net pots and the roots are suspended in water and nutrient solution and roots absorb the air directly through air stone. The plants grow quickly with large quantity. It is important to monitor the PH, oxygen levels and the algae and moulds can spread easily and affect the plant. These system I used for growing of large plants like fruits, cucumber, tomato grown in these system. (Domingues *et al.,* 2012).

NFT (Nutrient Film Technique)

These system was developed by the Dr. Alen copper in the 1960's in England. In these system water and nutrients circulates entire unit through the pump and water enters to the growing trays and there is no time limit control. The system is slightly slanted so the nutrient and water absorb by the plant are get back into reserviour. The plants can be affected with algal or mould infection as the roots are constantly immersed in water. These system is mostly used for the leafy vegetables and mostly for growing of lettuce. (Domingues *et al.,* 2012).

BENEFITS OF HYDROPONICS

Recently the hydroponic system has become one of the most commercial method for cultivation of crops. The plants grown in hydroponic technique are free from soil borne disease and pest. The plants which are grown in hydroponics need not require any insecticides and pesticides and they are free from weeds to reduce labour and several traditional agricultural practices can be eliminated, such as weeding, spraying, watering and tilling (Jovicich *et al.,* 2003).. For cultivation of plants in hydroponics require low amount and these technique doesn't require any land. Crops in hydroponic system are not influenced by climate change therefore, can be year-round and considered as off season (Manzocco *et al.,* 2011).Although hydroponics is soil less cultivation but it require specific skills and techniques for operating the system. Maintenance of pH, EC and proper concentration of the nutrient solution is of prime importance. Finally, light and energy supply is required to run the system under protected structure.

PH AND EC (ELECTRIAL CONDUCTIVITY)

The optimum amount of PH requires for plants are 5.5 -6.5 if it exceeds more than these if leads to nutrient imbalance and toxicity. EC of nutrient solution increased from 0 to 3 dSm and

decreased as the EC increased from 3 to 5 dS m-1 due to increase of water stress (Zhang *et al.*, 2016)

Table 1. Optimum range of EC and pH ponic crops

Crops	EC (dSm^{-1})
Asparagus	1.4 to 1.8
African Violet	1.2 to 1.5
Basil	1.0 to 1.6
Bean	2.0 to 4.0
Banana	1.8 to 2.2
Broccoli	2.8 to 3.5
Cabbage	2.5 to 3.0
Celery	1.8 to 2.4
Carnation	2.0 to 3.5
Courgettes	1.8 to 2.4
Cucumber	1.7 to 2.0
Egg plant	2.5 to 3.5
Ficus	1.6 to 2.4
Leek	1.4 to 1.8
Lettuce	1.2 to 1.8
Pak Choi	1.5 to 2.0
Peppers	0.8 to 1.8
Parsley	1.8 to 2.2

PLANTS GROWN UNDER HYDROPONIC TECHNIQUES

Different types of vegetables are grown in hydroponic technique in different ststems and the plants grown in hydroponic will have different taste and give higher yield the plants grow very fatster.

Table 2. Various species of plants grown under soil less hydroponic system

Type of crops	Name of the crops
Cereals	Rice, Maize
Fruits	Strawberry
Vegetables	Tomato, Chilli, Brinjal, Green bean, Beet, Winged bean, Bell pepper, Cucumbers, Melons, green Onion
Leafy vegetables	Lettuce, Spinach, Celery, Swiss chard, Atriplex
Condiments	Coriander leaves, Methi, Parsley, Mint, Sweet basil, Oregano
Flower / Ornamental crops	Marigold, Roses, Carnations, Chrysanthemum
Medicinal crops	Indian Aloe, Coleus
Fodder crops	Sorghum, Alfa alfa, Bermuda grass, Carpet grass

CONCLUSION:

Now a days hydroponics is seen as a promising strategy for growing different crops. As it is possible to grow crops in short duration. The crop can be grown throughout the year in very

limited spaces with low labour, so hydroponics can play a great contribution in areas with limitation of soil and water and for the poorer and landless people. It is expected that India should develop the hydroponic industry in future to encourage farmers and it help in reduce the labour cost.

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TERRACE GARDENING

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Abstract

Population growth that results in increased food production in a smaller area. According to this perspective, terrace gardening has emerged as one of the most significant methods for ensuring that people have access to enough food. Terrace gardening is the practice of growing a garden on a building's roof or terrace as opposed to the ground. In addition to saving us money on toxic-free fruits and vegetables, terrace gardening also offers us clean, fresh air. Additionally, it enhances aesthetic perception and lessens the growers' stress and strain. It inspires others to take part in gardening. This page discusses terrace gardening and how it is grown.

Introduction

Humans have cultivated plants on top of structures since the ziggurats of ancient Mesopotamia (4th millennium BC–600 BC), when bushes and trees were planted on aboveground terraces. One example from the Roman era is the Villa of the Mysteries at Pompeii, which had an upper terrace with plants growing on it. Large rooftop gardens were constructed in New York City between 1880 and Prohibition, including those above Stanford White's 1890 Madison Square Garden, the American Theater on Eighth Avenue, the Hotel Astor (New York City), and the Paradise Roof Garden, which Oscar Hammerstein inaugurated. 1900 At least since 1969, when Terrestris rooftop nursery debuted on 60th street in New York City, there have been commercial green houses atop rooftops. Large-scale commercial hydroponic rooftop farms were popular in the 2010s.

Terrace gardening

Growing plants in containers or raised beds on a terrace, balcony, rooftop, or other outdoor area with little or no access to ground soil is known as terrace gardening. Terrace gardening entails using potting media in the prescribed ratios needed for the plants we plant in the garden, such as red sand, cocopeat, vermiculite, perlite, and other organic manures.

Large cities and towns do longer have enough land for gardening because to urbanization, industrialization, ceilings, extensive road building, offices, and markets. There is a lot of pollution because of the growing population, especially in cities where there are too many buildings and no space for plants to flourish. For those who enjoy gardening, terrace gardening presents a chance. Terraces are paved using local stones, bricks, gravel, concrete, wood, and mosaic tiles. This gardening can also be done in tubs and bowls, and it can be particularly elegantly placed in a finished paved terrace. You might also add a lily pool to the landscape.

Containers

The ideal for gardening are the containers. Typically, vessels composed of clay, wood, metal, and other materials are utilized. Avoid using plastic containers since the heat can cause them to shatter. Recyclable materials such as cement bags, grower bags, rice bags, and wheat bags are available for utilization. The kind, size, and development of the plant are taken into consideration

when choosing a container. To drain extra water when we are watering the plants, the containers should have two to three drain holes .

FIG -1 : Terrace garden

Plants Selection For Terrace Gardening

The choice of plants is determined by the local climate and weather in the area where they will be grown. A variety of fruits and vegetables, such as orange, lemon, guava, sapodilla, tomato, and all green leafy vegetables as well as egg plants and curcurbits, pomegranates can be planted as well. Round pots that are two to three feet in diameter can be utilized for terrace gardening, and regular tree pruning is advised. Lawn grasses such as Bermuda grass and Zoysia grass can also be grown. Other plants that can be planted include roses, tulip bulbs, pansies, hydrangeas, marigolds, petunias, snake plants, money plants, and so on.

Water Requirement for the Plants

The terrace gardening should be close to a water source. For watering, we can use the cups and buckets or a rose can and a water hose. The water needs to be pure. Avoiding chlorinated water is advised. You can utilize natural oils such as ginger oil and neem oil cake, as well as organic fertilizers.

Advantages of Terrace gardening

1. Because terrace gardening produces no pollution, the plants are extremely nutrient-dense.
2. It facilitates our continued connection to nature.
3. It contributes to air purification.
4. It keeps the building cool, particularly in the summer.
5. People's mental health is enhanced by it.
6. It raises the garden's oxygen content and lowers carbon emissions.

Disadvantages of terrace gardening

1. The terrace garden setup is highly costly when it comes to soil tools and containers.
2. It requires extensive upkeep, which takes a lot of time and labor.
3. It is challenging to manage illnesses and pests as successfully as in a typical garden..

Conclusion

In conclusion, the roof requires the majority of the labor when building a terrace garden. The roof and structure need to be tested for water tightness, changed for water protection, and evaluated

for durability before installation. The most crucial aspect of terrace gardening is choosing the right plant species. We must choose the species based on the availability and conditions of your local home. Vegetable crops can be panted to maximize output by maintaining ideal conditions, such as offering green shade nets that provide the right amount of light intensity...Watering plants on a terrace is essential; during the heat, do so twice a day. Thus, we can cultivate a wide variety of plants, including various cucurbits and vegetables like tomato, chilli, and brinjal, through terrace gardening. Beautiful and fragrant plants such as Mogra, weeping fig, Jade plant, Syngonium, Chinese evergreen, and PotMum (Chrysanthemum morifolium), among others. Annual flowers: salvia, petunias, marigolds, roses, etc. green veggies, such as spinach, fenugreek, and mint. Terrace gardens are enjoyable for city people and offer a chance to improve creativity in addition to psychological advantages. Furthermore, they alter the building's exterior to screen it from neighbors and to hide unsightly scenery and an obtrusive pipeline. The primary driving force behind these initiatives is suspicion regarding the quality of the vegetables sold in urban marketplaces and the recycling of domestic garbage.

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IMPACT OF AQUATIC POLLUTION ON FISH FAUNA

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Abstract

Environmental and industrial pollutants can have both direct and indirect impacts on aquatic ecosystems and the behavior of aquatic organisms. Pollution can affect fish biota by altering their biochemical, respiratory, population structure, developmental, and structural functions. There is strong evidence confirming the harmful effects on fish fauna due to increased pollution from expanding industrial development. Pollutants like heavy metals, hydrocarbons, and industrial wastes have measurable environmental impacts. A key activity in the restoration of polluted environments and in anticipating man-made effects on environmental changes is the monitoring of environmental parameters. It is a major challenge to monitor aquatic pollution for its effects on fish development and reproductive cycles. A better understanding of the responses of fish to aquatic pollution is strongly needed.

Introduction

Assessment of water quality over the years revealed that in 2015, 70% of rivers monitored (275 out of 390) were identified as polluted, whereas in 2022, only 46% of rivers monitored (279 out of 603) were identified as polluted. It is estimated that approximately 70% of India's surface water is unfit for human consumption.

Twenty to thirty years ago, environmental awareness and regulations were not as stringent as they are today, leading to higher levels of pollution in many water bodies. This pollution could have affected fish populations through habitat degradation, water contamination, and disruption of aquatic ecosystems. If these wastes are released into aquatic ecosystems without adequate treatment, they will cause water pollution (Chowdhary *et al*., 2020). Arsenic, cadmium, and chromium are significant pollutants discharged in wastewater, and the industrial sector is a major contributor to these harmful pollutants (Chen *et al*., 2019).

Starting with an estimate that 150 million tonnes of plastic are already polluting the world's oceans, and that "leakage" adds at least 9.1 million tonnes more each year — a figure that is said to be growing by five percent annually - the MacArthur report calculates there will be 850-950 million tonnes of ocean plastic by 2050, versus total fish stocks of 812-899 million tonnes. The volume of global fish production amounted to 186.6 million metric tons in 2023, up from 184.6 million metric tons in 2022. There are 5.25 trillion pieces of plastic waste estimated to be in our oceans. 269,000 tons float, and 4 billion microfibers per km² dwell below the surface. In terms of plastic, 8.3 million tons are discarded in the sea yearly. In 2022, around 311 river stretches in India were identified as being polluted.

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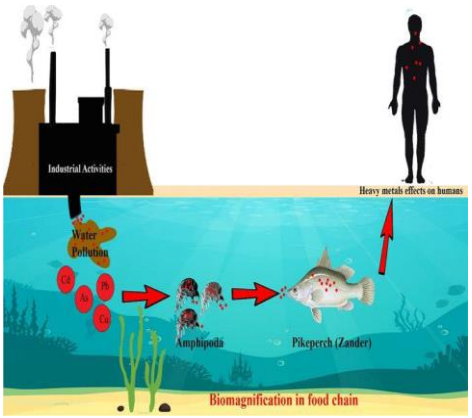
Type of aquatic pollution

Sr.no	Type	Clarification
1.	**Chemical pollution**	Chemical runoff from agricultural areas and industrial discharges.
2	**Plastic pollution**	Widespread contamination of water bodies with plastic waste.
3.	**Eutrophication Excessive**	Nutrients leading to algal blooms and oxygen depletion.
4	**Thermal pollution**	Discharge of heated water from industrial processes into water bodies.

Impacts of pollutants

1. **Chemical Runoff :** Chemical runoff from agriculture and industry can contaminate freshwater habitats, impacting fish species and their ecosystems.
2. **Plastic Pollution :** Discarded plastics in oceans and rivers pose a serious threat to fish fauna, causing entanglement and ingestion issues.
3. **Oil Spills :** Oil spills have devastating effects on fish fauna, leading to suffocation, and poisoning. And habitat destruction.

Impacts on human health Aquatic pollution poses a serious threat to human health through the consumption of contaminated fish, leading to exposure to toxic substances such as heavy metals and hazardous chemicals. Furthermore, the bioaccumulation of pollutants in fish can lead to the transfer of these harmful substances up the food chain, impacting human health at multiple levels.



Change in fish behavior and physiology

Fish exposed to aquatic pollution may exhibit altered behavior patterns and physiological changes. This can include abnormal swimming, feeding, and reproductive activities. Additionally, pollutants can affect their respiratory and circulatory systems, leading to health issues and reduced survival rates.

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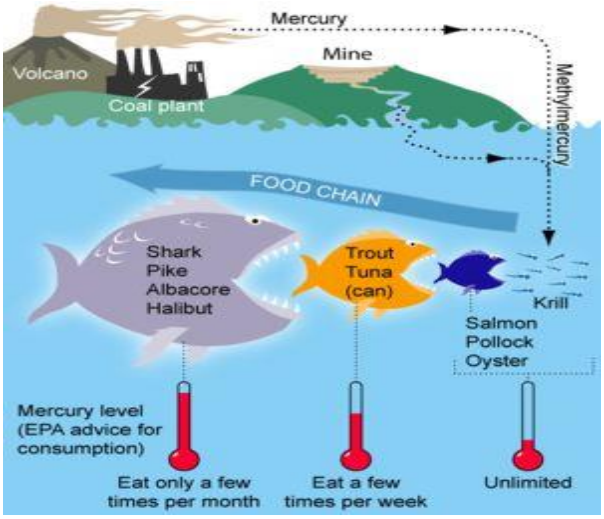
Bioaccumulation of pollutants in fish

As fish consume polluted water, the toxic substances can accumulate in their bodies over time. These substances include heavy metals, pesticides, and industrial chemicals



Effects of aquatic pollution on fish fauna

No.	Effects	Causes
1.	Altered Behavior	Chemical pollutants can alter the behavior of fish, making them more vulnerable to predators.
2.	Reduced reproduction	Aquatic pollution can lead to hormonal changes in fish, affecting their ability to reproduction.
3.	Habitats distraction	The pollution of aquatic environments leads to the destruction of fish habitats, affecting their ability to reproduce and thrive
4.	Disruption of food chain	Pollutants in water sources can lead to a decrease in food availability for fish, impacting their survival and population.
5.	Health Impacts	Pollutants can cause diseases and deformities in fish, impacting the overall health of fish fauna

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INTEGRATED PEST MANAGEMENT IN COTTON: A COMPREHENSIVE APPROACH TO SUSTAINABLE PEST CONTROL

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ABSTRACT

Integrated Pest Management (IPM) stands as a cornerstone for sustainable cotton production, offering a multifaceted approach to pest control while mitigating environmental and health risks associated with chemical pesticides. This abstract provides an overview of IPM principles, components, and benefits specifically tailored for cotton cultivation. Emphasizing preventive measures, monitoring, and threshold-based decision-making, IPM in cotton integrates cultural, biological, and chemical control tactics. Key components include crop rotation, resistant varieties, biological control agents, cultural practices, and advanced monitoring systems. By reducing pesticide use, enhancing ecosystem services, and improving crop health and quality, IPM contributes to sustainable pest control, cost savings, and profitability in cotton farming. This abstract underscores the importance of adopting IPM strategies for ensuring the long-term sustainability and resilience of cotton production systems

INTRODUCTION

Cotton, often referred to as "white gold," holds significant economic and cultural importance worldwide, serving as a primary source of fiber for textile production (Ali *et* al. 2011, 2013, 2014). However, the sustainability of cotton cultivation faces numerous challenges, including pest infestations that can devastate yields and compromise crop quality. In response, Integrated Pest Management (IPM) has emerged as a pivotal strategy for promoting sustainable cotton production while minimizing the environmental footprint of pest control practices. This article delves into the intricacies of IPM in cotton cultivation, highlighting its holistic approach to pest management and its potential to foster resilience and profitability in cotton farming systems. By exploring the principles, components, and benefits of IPM tailored for cotton, this article aims to underscore the critical role of integrated pest management in ensuring the long-term sustainability and success of the cotton industry. Integrated Pest Management (IPM) is a holistic approach to pest control that emphasizes the use of multiple strategies to manage pests effectively while minimizing risks to human health and the environment. In the context of cotton production, IPM plays a crucial role in controlling insect pests, diseases, and weeds, thereby ensuring sustainable crop yields and reducing reliance on chemical pesticides (Dhawan & Peshin, 2009). This article provides an overview of integrated pest management practices tailored for cotton cultivation, highlighting its principles, components, and benefits.

Principles of Integrated Pest Management:

Integrated Pest Management in cotton are guided by several key principles aimed at preventing pest problems, monitoring pest populations, and implementing appropriate control measures. These principles include:

1. **Preventive Measures:**
   - Emphasize cultural practices such as crop rotation, sanitation, and planting resistant varieties to minimize pest pressure and prevent pest outbreaks.
2. **Monitoring and Identification:**
   - Regularly scout cotton fields to monitor pest populations and identify pest species and their life stages accurately.
   - Utilize traps, pheromone lures, and sampling techniques to assess pest densities and distribution.
3. **Threshold-Based Decision Making:**
   - Establish economic thresholds for pest populations, where intervention is warranted based on the level of pest infestation and potential crop damage.
   - Decision-making is informed by scientific monitoring data and economic considerations to minimize unnecessary pesticide applications.
4. **Biological Control:**

   Biological control strategies are essential components of Integrated Pest Management (IPM), harnessing the natural allies found in the agroecosystem to combat pests. Natural enemies like predators and parasitoids, play a very importance role for pest outbreaks and reducing crop loseess. (Lewis et al., 1997).
   - Encourage natural enemies such as predators, parasitoids, and pathogens to regulate pest populations through biological control.
   - Enhance habitat diversity and conservation to support beneficial insects and reduce reliance on chemical pesticides.
   - Ex. Predator -Release of *chrysoperla* and lady bird beetle, 5000 to 10000 per ha for control of sucking pests.
   - Ex. Parasitiod - Release of egg parasitoid of *Trichogramma* 1.5 lakh /ha. at weekly interval for 6 -7 times for control of bollworms in cotton.
   - Ex. Micro-organisms - HNPV @ 250 -450 larval unit /ha. mix with ranipal 100 g + jaggery 1000 g for biological control of heliothis in cotton.
5. **Cultural Control Practices:**
   - Implement cultural practices such as planting trap crops, using cover crops, and managing irrigation to disrupt pest life cycles and reduce pest pressure.
   - There are various cultural practices like sowing time, seed rate, spacing, deep ploughing; interculturing, trap cropping, crop rotation, fertilizer management, irrigation management, field sanitation and harvesting techniques are adopted.
6. **Chemical Control as a Last Resort:**
   - Reserve chemical pesticides as a last resort and use them judiciously in combination with other IPM tactics.
   - Select pesticides with minimal impact on non-target organisms and the environment, adhering to integrated pest management principles.

Components of Integrated Pest Management in Cotton:

Integrated Pest Management in cotton comprises several components designed to address pest challenges comprehensively:

1. **Crop Rotation and Diversity:**
   - Rotate cotton with non-host crops to break pest cycles and reduce pest buildup in the soil.

- Integrate diverse cropping systems to disrupt pest habitat and enhance natural pest control.

2. **Resistant Varieties:**
   - Plant cotton varieties with inherent resistance or tolerance to specific pests, reducing the need for chemical pesticides.
   - Utilize genetic resources to develop cotton cultivars with enhanced pest resistance traits.
3. **Biological Control Agents:**
   - Introduce or conserve natural enemies of cotton pests, including predators, parasitoids, and microbial pathogens.
   - Implement habitat management practices to enhance biological control services and promote biodiversity.
4. **Cultural Practices:**
   - Implement agronomic practices such as planting date adjustment, row spacing, and tillage management to mitigate pest damage and optimize crop health.
5. **Monitoring and Decision Support Systems:**
   - Deploy monitoring tools and decision support systems to assess pest populations, predict pest outbreaks, and guide timely intervention strategies.
   - Utilize predictive models, remote sensing technologies, and mobile applications to facilitate real-time pest management decisions.
6. **Mechanical and Physical Control Methods:**
   - Use physical barriers, traps, and mechanical methods such as mowing and cultivation to manage weeds and disrupt pest habitats.
   - Employ technologies such as precision agriculture and automated machinery to enhance efficiency and precision in pest control operations.

Modern methods:

1. **Sterile Insect Technique (SIT):**
   This method involves the mass rearing and release of sterilized male insects into the environment. These sterile males compete with wild males to mate with females, resulting in infertile eggs and a decline in the pest population over time. SIT has been used successfully to control certain pests like the pink bollworm in cotton.
2. **Pheromone Traps:**
   Pheromones are chemical substances emitted by insects to communicate with others of the same species. Pheromone traps utilize synthetic versions of these chemicals to attract and trap specific pests. By monitoring pest populations using pheromone traps, farmers can implement targeted control measures when pest populations reach a certain threshold.
3. **Antifeedants:**
   Antifeedants are substances that deter insects from feeding on plants by making them unpalatable or interfering with their feeding behavior. Natural compounds or synthetic chemicals can act as antifeedants. By applying antifeedants to cotton plants, farmers can discourage insect feeding damage and reduce pest populations.
4. **Repellents**:
   Repellents are substances that deter insects from settling or feeding on plants. They work by emitting odors or tastes that insects find unpleasant or by physically obstructing insect access to plants. Natural repellents like plant extracts or essential oils can be applied to cotton crops

to repel insect pests. Additionally, synthetic repellents can also be developed and formulated for specific pests. Repellents offer a non-toxic alternative to chemical pesticides and can be integrated into IPM programs to manage insect populations in cotton fields.

5. **Biotechnology:**
   Biotechnology plays a significant role in modern insect control strategies in cotton. This includes the development of genetically modified (GM) cotton varieties with built-in resistance to insect pests. One of the most notable examples is Bt cotton, which produces insecticidal proteins derived from the bacterium Bacillus thuringiensis (Bt). These proteins are toxic to certain insect pests but harmless to humans and non-target organisms. Bt cotton has been widely adopted globally and has contributed to significant reductions in pesticide use and increased yields.

Benefits of Integrated Pest Management in Cotton:

Integrated Pest Management offers numerous benefits for cotton producers, the environment, and society as a whole:

1. **Reduced Pesticide Use:**
   By integrating multiple pest management tactics, IPM reduces reliance on chemical pesticides, minimizing pesticide residues in cotton products and mitigating risks to human health and the environment.
2. **Enhanced Ecosystem Services:**
   Promotes biodiversity and ecosystem resilience by conserving natural enemies and beneficial organisms, fostering ecosystem services such as biological control and pollination.
3. **Improved Crop Health and Quality:**
   Maintains cotton crop health and vigor by preventing pest damage and reducing yield losses, resulting in higher-quality cotton fiber and improved market competitiveness.
4. **Sustainable Pest Control:**
   Provides long-term, sustainable pest control solutions that are economically viable, environmentally sound, and socially acceptable, supporting the sustainability of cotton production systems.
5. **Cost Savings and Profitability:**
   Reduces input costs associated with pesticide applications, pest management, and crop losses, enhancing the profitability and resilience of cotton farming enterprises.

Conclusion

Integrated Pest Management in cotton represents a proactive and sustainable approach to pest control that integrates biological, cultural, mechanical, and chemical tactics to manage pests effectively while minimizing adverse impacts on the environment and human health. By embracing IPM principles and practices, cotton producers can achieve sustainable pest management outcomes. The integration of repellents, biotechnology, and other innovative approaches into insect control strategies enhances the sustainability and effectiveness of cotton production by reducing reliance on conventional chemical pesticides and mitigating the risks associated with pest resistance and environmental contamination.

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THE VERSATILE WONDER : *Ocimum basilicum* (TULSI)

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Ocimum basilicum, commonly known as basil, is one of the most cherished and widely used herbs in the world. From its rich historical significance to its multitude of culinary and medicinal applications, basil stands out as a true botanical marvel. This article delves into the diverse facets of *Ocimum basilicum*, exploring its origins, varieties, cultivation, uses, and benefits, and offering a comprehensive look at why this humble herb is held in such high regard.

Origins and Historical Significance:

Basil has a storied history that stretches back thousands of years. Native to tropical regions spanning from central Africa to Southeast Asia, basil was first cultivated in India. The herb is deeply rooted in various cultures and religions. In Hindu tradition, basil (known as Tulsi or Holy Basil) is revered as a sacred plant, often associated with the goddess Lakshmi and believed to possess protective and healing properties. The ancient Greeks and Romans also held basil in high esteem. The Greeks called it "basilikon phuton," meaning "royal plant," indicating its prestigious status. They believed it possessed medicinal properties and used it in various healing concoctions. In medieval Europe, basil was used for its aromatic and purported therapeutic qualities, becoming a staple in both gardens and kitchens.

Varieties of Basil

Ocimum basilicum boasts numerous varieties, each with its unique flavor profile, aroma, and appearance. Some of the most popular varieties include:

Sweet Basil : Sweet basil, or Genovese basil, is perhaps the most well-known variety. It features large, vibrant green leaves and a sweet, slightly peppery flavor. This variety is commonly used in Italian cuisine, forming the backbone of dishes like pesto and Caprese salad.

Thai Basil : Thai basil has smaller, darker leaves and a distinctive anise-like flavor. It is a staple in Southeast Asian cuisines, particularly Thai and Vietnamese dishes. Its robust flavor holds up well in stir-fries and soups.

Holy Basil : Holy basil, or Tulsi, is revered in India for its medicinal properties. It has a more pungent, peppery flavor compared to sweet basil. Tulsi is often used in teas, traditional medicines, and religious rituals.

Purple Basil : Purple basil, with its striking dark purple leaves, adds a visual and flavor twist to dishes. It has a slightly spicier and more astringent taste compared to sweet basil, making it a favorite for salads and garnishes.

Lemon Basil : Lemon basil, as the name suggests, has a lemony aroma and flavor. It is perfect for adding a citrusy note to dishes and is often used in fish recipes, salads, and teas.

Cinnamon Basil : Cinnamon basil has a warm, spicy flavor reminiscent of cinnamon. It pairs well with fruit dishes, desserts, and beverages, adding an unexpected twist to traditional recipes.

Cultivation of Basil : Basil is relatively easy to grow, making it a popular choice for home gardeners and commercial growers alike. Here are some key points on cultivating this versatile herb:

Climate and Soil : Basil thrives in warm, sunny climates. It requires well-drained soil rich in organic matter. While basil can be grown indoors or outdoors, it is sensitive to frost, so it is best planted after the last frost date in your area.

Planting: Basil can be grown from seeds or cuttings. If starting from seeds, plant them in small pots or seed trays indoors about 6-8 weeks before the last expected frost. Transplant seedlings outdoors once the soil has warmed up. If using cuttings, place them in water until roots develop, then transplant them into soil.

Care and Maintenance : Basil plants need consistent moisture but should not be waterlogged. Regular watering, along with occasional feeding with a balanced fertilizer, will keep the plants healthy. Pinch off the flower buds to encourage leaf growth, as flowering can cause the leaves to become bitter.

Harvesting : Harvest basil leaves regularly to encourage new growth. The best time to harvest is in the morning when the leaves are at their peak flavor. Use sharp scissors or pruning shears to cut the stems just above a pair of leaves.

Pests and Diseases : Basil is generally resilient but can be susceptible to pests like aphids, spider mites, and whiteflies. Organic insecticidal soap or neem oil can help manage these pests. Basil downy mildew, a fungal disease, can also affect plants, so ensure good air circulation and avoid overhead watering to minimize risk.

Culinary Uses : Basil's culinary applications are vast and varied. Its distinctive flavor enhances a wide range of dishes, from simple salads to complex sauces. Here are some popular culinary uses of basil.

Pesto : Pesto is a classic Italian sauce made with fresh basil, garlic, pine nuts, Parmesan cheese, and olive oil. It is traditionally used as a pasta sauce but also serves as a flavorful addition to sandwiches, pizzas, and grilled vegetables.

Caprese Salad : A simple yet elegant dish, Caprese salad features fresh basil leaves, ripe tomatoes, and mozzarella cheese, drizzled with olive oil and balsamic vinegar. The combination of flavors and textures makes it a perennial favorite.

Soups and Stews : Basil adds depth and freshness to soups and stews. It is commonly used in tomato-based soups like minestrone and tomato bisque, as well as in Thai and Vietnamese soups for its aromatic qualities.

Sauces : Basil is a key ingredient in many tomato-based sauces, such as marinara and Bolognese. Its sweet and peppery flavor complements the acidity of tomatoes, creating a balanced and delicious sauce.

Beverages : Basil can be used to infuse beverages with a unique flavor. Basil lemonade, for example, is a refreshing summer drink. Basil can also be used in cocktails, such as a basil gin smash, where it adds a fresh, herbal note.

Desserts : Basil's versatility extends to desserts as well. Basil pairs surprisingly well with fruits like strawberries and peaches, and can be used to create basil-infused syrups, ice creams, and sorbets.

Medicinal Uses and Health Benefits

Beyond its culinary appeal, basil is renowned for its medicinal properties. It has been used in traditional medicine for centuries to treat various ailments. Here are some of the health benefits associated with basil.

Anti-Inflammatory Properties : Basil contains essential oils like eugenol, citronellol, and linalool, which have anti-inflammatory properties. These compounds can help reduce inflammation and alleviate symptoms of inflammatory conditions such as arthritis.

Antioxidant Effects : Basil is rich in antioxidants, which help protect the body from damage caused by free radicals. The antioxidants in basil, including flavonoids and polyphenols, can help reduce oxidative stress and lower the risk of chronic diseases.

Antibacterial and Antimicrobial : Basil has natural antibacterial and antimicrobial properties. Its essential oils can inhibit the growth of harmful bacteria and fungi, making it useful in preventing infections and supporting overall immune health.

Cardiovascular Health : Basil can benefit cardiovascular health in several ways. Its anti-inflammatory and antioxidant properties help protect the heart and blood vessels. Additionally, basil's ability to lower cholesterol levels and reduce blood pressure contributes to overall heart health.

Digestive Health : Basil aids digestion by stimulating the production of digestive enzymes. It can help alleviate symptoms of indigestion, bloating, and gas. Basil tea is often used as a remedy for stomach discomfort.

Stress Reduction : Basil is known for its adaptogenic properties, meaning it helps the body adapt to stress. Holy basil, in particular, is used in Ayurvedic medicine to reduce stress and promote mental clarity. Consuming basil can help regulate cortisol levels and improve mood.

Respiratory Health : Basil can be beneficial for respiratory health. It has expectorant properties that help clear mucus from the respiratory tract, making it useful in treating coughs and colds. Basil tea is a popular remedy for soothing sore throats and alleviating respiratory symptoms.

Cultural and Religious Significance

Basil holds a special place in various cultural and religious traditions around the world. Its significance goes beyond culinary and medicinal uses, symbolizing various spiritual and cultural values.

Hinduism: In Hinduism, holy basil, or Tulsi, is considered a sacred plant. It is often grown in courtyards and used in religious rituals. Tulsi is believed to bring spiritual purity, protection, and

blessings to the household. The plant is also associated with the goddess Lakshmi and is used in worship and prayer ceremonies.

Christianity : In Christianity, basil is sometimes referred to as "St. Joseph's Wort." According to legend, basil was found growing near the tomb of Jesus Christ after his resurrection. This association has led to the use of basil in some Christian religious ceremonies and as a symbol of resurrection and eternal life.

Greek and Roman Traditions : The Greeks and Romans considered basil a symbol of royalty and nobility. The Greeks believed that basil should be sown while cursing to ensure its proper growth. In Roman times, basil was associated with love and fertility, and it was often used in wedding ceremonies and love potions.

African Traditions : In some African cultures, basil is used in traditional healing practices and rituals. It is believed to have protective properties and is used in spiritual ceremonies to ward off evil spirits and negative energies.

Environmental Benefits

Basil is not only beneficial for human health but also for the environment. Growing basil can have several positive environmental impacts:

Pollinator Attraction : Basil flowers attract pollinators such as bees and butterflies. By planting basil in your garden, you can support local pollinator populations and contribute to biodiversity.

Companion Planting : Basil is an excellent companion plant for vegetables like tomatoes, peppers, and asparagus. It can help repel pests such as aphids, mosquitoes, and whiteflies, reducing the need for chemical pesticides. Companion planting with basil can also improve the flavor and growth of neighboring plants.

Soil Health : Basil contributes to soil health by improving soil structure and increasing organic matter. Its roots help prevent soil erosion and promote nutrient cycling, making it a valuable addition to sustainable gardening practices.

Modern Research and Innovations

Recent scientific research has further highlighted the potential of basil in various fields, from medicine to agriculture. Here are some notable areas of research and innovation involving basil:

Phytochemicals and Drug Development

Scientists are exploring the phytochemicals in basil for potential drug development. Compounds like eugenol, rosmarinic acid, and ursolic acid have shown promise in preclinical studies for their anti-inflammatory, anticancer, and antimicrobial properties.

Genetic Engineering : Genetic engineering techniques are being used to enhance the desirable traits of basil. Researchers are working on developing basil varieties with improved disease resistance, higher yields, and enhanced nutritional profiles. These innovations aim to make basil cultivation more sustainable and productive.

Functional Foods : Basil is being incorporated into functional foods and nutraceutical products. Basil extracts and essential oils are added to dietary supplements, herbal teas, and fortified foods to provide health benefits and enhance flavor. The trend towards natural and plant-based ingredients has increased the demand for basil-derived products.

Sustainable Agriculture : Basil is being studied as a potential crop for sustainable agriculture practices. Its ability to grow in diverse climates and its positive impact on soil health make it a valuable candidate for sustainable farming systems. Research is focused on optimizing cultivation techniques to maximize yields while minimizing environmental impact.

Conclusion

Ocimum basilicum, with its rich history, diverse varieties, and multifaceted uses, stands as a testament to the wonders of nature. From its origins in ancient cultures to its modern-day applications in cuisine, medicine, and sustainable agriculture, basil continues to captivate and benefit humanity in myriad ways.

Whether you're a gardener nurturing basil plants, a chef crafting culinary masterpieces, or a health enthusiast exploring its medicinal properties, basil offers something for everyone. Its versatility, combined with its cultural and historical significance, makes basil more than just a herb—it's a symbol of tradition, innovation, and the enduring connection between humans and the natural world.

So, the next time you enjoy a dish flavoured with fresh basil or sip on a soothing cup of basil tea, take a moment to appreciate the rich legacy and remarkable versatility of *Ocimum basilicum*, the true wonder herb.

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MARINE PROTECTED AREAS (MPA): OPPORTUNITIES AND CHALLENGES

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Abstract
Marine Protected Areas (MPAs) implement diverse protective measures to manage vulnerable marine ecosystems, notably coral reefs susceptible to climate change-induced bleaching events. Beyond cultural, educational, and recreational objectives, MPAs are established to conserve, restore, and preserve biota, ecosystems, and ecological processes. They effectively safeguard biodiversity, enhance fishery yields, and mitigate human impacts on marine environments, thereby delivering crucial ecosystem services and promoting sustainable resource management. However, realizing the full potential of MPAs requires overcoming obstacles such as insufficient funding for establishment and sustainable management, limited in-situ training, inadequate local capacity building, and a scarcity of essential biological and ecological data. Active stakeholder involvement is essential to address these challenges and unlock the substantial benefits that MPAs offer for marine conservation and the preservation of marine resources.

Keywords : Marine protected areas, National Park, conservation, Biosphere reserve, Ecotourism, Biodiversity

Introduction

In order to safeguard, preserve and restore the natural and cultural resources in coastal and marine seas, it has been understood that marine protected areas (MPA) are an essential management tool. They are frequently employed for maritime management with the sole objective of conserving biodiversity and marine life resources (Fabinyi, 2008; NRC, 2001; Pita *et al*., 2011). MPAs offer vast opportunities to fisheries, national economies, and the marine ecosystem, through the preservation of biological variability and ecosystems, mitigating the decline in fish populations worldwide by safeguarding crucial breeding, nursery, and feeding habitats. It also enhances marine tourism opportunities and diversify national economic prospects. Moreover, they serve as platforms for scientific research, education, cultural heritage preservation, and community involvement.

India has implemented several legislative measures to conserve its coastal regions and maritime ecosystems, including the Environment Protection Act (1986), Coastal Regulation Zone (1991), and National Biodiversity Act (2002). In addition, the Wildlife Protection Act of 1972 empowers state governments to establish protected areas (PAs) (Sivakumar *et al*., 2012). In India, Marine Protected Areas (MPAs) are defined as protected areas that fully or partially fall within a 500-meter radius of the highest tide line and encompass maritime ecosystems. The country has designated 12 such MPAs in accordance with arrangements under the IUCN Transboundary Protected Area Programme. A database that is unparalleled in geographic scale is required to evaluate how the cumulative effects of five essential planning and management elements on MPAs' conservation value are reflected in the responses on the ecological health of their fish communities;

A. Permitted fishing within MPAs
B. Frequency of enforcement
C. MPA period
D. MPA graph
E. Longitudinal habitat enables limited movement of fish over MPA boundaries.

What is MPA?

The term "marine protected area" refers to a broad category of safeguarded zones for marine conservation and management across the globe. It includes marine national parks, botanical gardens, and independently governed marine habitats that conserve coral reefs, beds of seagrass, shipwrecks, sites of historical significance, intertidal lagoons and muddy beaches, marshlands, the mangrove forest, rocky channels, submerged spaces along the shorelines, and the seafloor in deep seas. The effects of implementing Marine Protected Areas (MPAs) on ecological dynamics exhibit considerable regional variation, reflecting the complex processes within marine ecosystems. Predicting these outcomes with precision remains challenging due to the intricacies involved. The principal conservation approach for the preservation of marine environments and their resources is the implementation of marine protected zones (Agardy *et al*., 2011). To conserve biological diversity within fragmented systems, Marine Protected Areas (MPAs) consist of networks of core habitats interconnected by ecological corridors, which are established, restored, and/or sustained. These networks represent valuable mechanisms supporting the implementation of long-term ecosystem-based management strategies.
An essential aspect of effective design and management involves identifying, conserving, and enhancing connectivity among different sites within the network. Within a short span of time (Halper and Warner, 2003), the initiation of the Marine Protected Area (MPA) has induced a considerable increase in both biomass and species densities (Halpern, 2003; Selig & Bruno, 2010). MPAs are present across a spectrum of diverse biophysical environments, ranging from tropical ecoregions dominated by reefs to temperate and arctic ecoregions where kelp prevails. High biodiversity is frequently seen in MPAs, resulting in complex interactions and functions. Sustaining these relationships is imperative for safeguarding ecological functioning and integrity. MPAs are often perceived as a "simple yet beautiful solution" in this regard (Anonymous, 2006). This approach has been extensively applied in fisheries and coastal regions for ecosystem management, serving as an effective remedy for prior governance failure (Pomeroy, 2003). MPAs are established by a wide range of national and international entities employing unique legal mechanisms (Humphreys and Clark, 2020) with each MPA designed to fulfill a range of specific objectives.

Objectives

- **To protect the natural environment :** MPAs protect and restores biodiversity within an area's ecosystems. National marine sanctuaries and animal refuges are a few examples.
- **To protect the cultural heritage :** This encompasses the provision of protection for historical artifacts, such as shipwrecks. Certain national marine sanctuaries, national and state parks, as well as historical sites, may fall within this classification.
- **Sustainable production :** The management of the region would prioritize facilitating the extraction of living resources (e.g., fish, shellfish, plants) that depend on the environment of the protected areas for activities like feeding, mating, and spawning. Examples include designated fishing grounds and specialized animal refuges.

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Figure 1: Kaziranga National Park in Assam famous for its one horned rhinoceros (Photo courtesy: Siddhartha)

Figure 2: Great Himalayan National Park (Source: UNESCO site)

Figure 3: Simlipal National Park in Odisha (Photo courtesy: Bhakta Barik)

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Figure 4: Royal bengal tiger in Sundarban biosphere reserve (Photo courtesy: Soumyajit Nandy)

Figure 5: The Black Chinned Laughingthrush in the Nilgiri biosphere reserve (Photo courtesy: Antony Grossy)

Figure 6: Panna Biosphere reserve (Source: Tourism of India)

India has implemented the MPA network to govern the nation's natural maritime resources, aiming to safeguard their biodiversity and ensure the welfare of communities reliant upon them. In India, four distinct categories of legally safeguarded locations are established: -

- ✓ National Park
- ✓ Wildlife reserve

- ✓ Biosphere reserve
- ✓ Community reserve

National parks

ICUN defined national parks as “a geographic area that has been acknowledged, devoted, and administered through law or other effective methods in order to achieve the long-term conservation of nature and the related ecosystem services and cultural values”. An area under protection is a national park. Their aim is to preserve biological diversity, comprising the diversity of indigenous species and the ecosystems they foster. Healthy and resilient ecosystems play a crucial role in providing essential ecological functions, such as pollination, water and atmospheric regulation, climate moderation, and nutrient cycling. National parks are vast expanses of public land designated to conserve indigenous flora, fauna, and habitats. They serve as guardians of the natural beauty and heritage, harboring diverse native plant and animal species. Additionally, national parks safeguard sites of cultural significance to aboriginal peoples, providing insights into their ancestral ways of life. In India, there are currently 106 national parks, occupying an area of 44,372.42 sq. km, or 1.35% of the area in the country (National Wildlife Database, May 2022).

Wildlife sanctuary

The word "wildlife sanctuary" refers to a large geographic area, typically forested, where animals are kept in their native habitats. For the purpose of providing animals with conducive habitats for residence and natural development, territories are initially demarcated as wildlife sanctuaries. A wildlife sanctuary protects animals from other dangerous species as well as poachers. These sanctuaries have played a significant role in preventing the extinction of numerous endangered animal species over the years. The wildlife sanctuaries in India are categorized under IUCN Category IV, which designates protected areas primarily for the conservation of habitats and native fauna. As of December 2020, India's wildlife sanctuaries spanned a collective area of 119,776 square kilometers, comprising a total of 553 designated sites.

Importance

- ✓ To protect wildlife
- ✓ Preserve landscapes
- ✓ Ecotourism
- ✓ Preserving History and Culture
- ✓ Conserving the biodiversity
- ✓ Prevents overexploitation of animals

Biosphere reserve

A biosphere reserve constitutes a designated region encompassing both terrestrial and coastal ecosystems, serving as a framework for sustainable development practices. Biosphere reserves undergo systematic management by state governments and has notable international recognition. They represent protected areas with the primary objective of conserving both flora and fauna. Moreover, biosphere reserves aim to revive traditional lifestyles for local tribal communities. The conservation of the biosphere is indispensable for the economy and the survival of the human race on Earth. Biosphere reserves promote economic, social, and cultural advancement while safeguarding landscapes and biodiversity without jeopardizing local communities. Furthermore, for certain tribes, trees symbolize moral and traditional values. Biosphere reserves offer a safeguarded environment for flora and fauna, apart from human civilization. Moreover, they

contribute to combating deforestation, thereby aiding in preserving the natural equilibrium of the planet. Biosphere reserves play a role in mitigating global warming as they facilitate carbon sequestration through increased vegetation, leading to reduced pollution levels.

Community reserve

In 2002, the Wildlife Protection Act (1972) was amended to establish a new protected area category known as Community Reserves. If community members or relevant stakeholders agree to allocate specific areas for conserving plants, animals, and traditional activities, as well as cultural practices, the State Government has the authority to designate any community or private land as a Community Reserve. It aims to protect the wildlife while also enhancing the socioeconomic standing of the local populations.

Benefits of MPAs

1. Preserving biodiversity and conserving threatened species and habitats
2. MPAs can assist in reducing climate change.
3. Support healthy coastal communities
4. Enhance local fishing catches, both commercial and recreational
5. Provide a chance to co-government and safeguard culturally significant sites.

Selecting the sites of MPA

- Selecting the site and geographical scope of conservation areas requires a different strategy compared to terrestrial areas of protection.
- When evaluating conservation sites, it's vital to consider the needs of neighbouring communities that depend on the sea for sustenance.
- A well protected core region with a buffer zone is the optimal configuration. This can be accomplished either as a significant zone MPA or as a collection of minor MPAs with complementary limitations governing the usage of the surrounding region.

Table 1: Benchmark of protection related to MPA

Benchmark of protection	Well protective	Strongly protective	Barely protective	Lightly protective	Incompatible with preservation of the environment
Is mineral extraction, petroleum, oil and/or gas prospecting or development permitted?	No	No	No	No	Yes
Is excavating and dumping permitted?	No	No	Rarely (selective purpose)	Infrequent (selective purpose)	Yes
Is there any anchorage?	Allowed; only for short duration; low impact	Allowed; short duration; low impact	Moderate impact; medium scale; moderate duration	Large impact	Yes; incompatible with conservation

Benchmark of protection	Well protective	Strongly protective	Barely protective	Lightly protective	Incompatible with preservation of the environment
Is infrastructure allowed?	At small scale; specific purpose; minimal impact	Minor impact, small size	Medium impact; medium scale	Large impact	Yes; incompatible with conservation
Is aquaculture permitted?	If yes; restoration; not extraction	Low impact; low density; small scale	Semi-intensive to intensive unfed, low population density, small-scale fed	Medium to high densities	Yes; incompatible with conservation
Is fishing permitted?	No	Yes; highly selective gears; low impact	Moderate number of gears (10 or fewer); low impact	High number of gears are allowed but not industrial	Any gear is incompatible with conservation of biodiversity
Are non-extractive operations permitted?	If yes, minimal impact, low population density, small size, and restricted applications	If yes, examine low impact, lack of density, small size, and limited use	All non-extractive; recreational; conventional spiritual; socioeconomic issues are permitted.	All non-extractive; recreational; traditional spiritual; socioeconomic issues allowed.	All non-extractive; recreational; traditional spiritual; cultural issues allowed.

- Prioritize actions outside the intended MPA during the selection process, even if they may impact the MPA.
- Select a biogeographic system which fulfils the requirements of country.
- Establish specific goals before beginning the selecting procedure.
- Since political assessments are an inherent component of selection, numerical systems involving balanced criteria can only serve as a supporting role and take the risk of being profoundly misleading.
- System plans are essential, but they shouldn't be used to limit the creation of MPAs.

Declaring MPA

The forthcoming agreement necessitates a structured framework for identifying, designating, and effectively managing a globally inclusive network of large-scale marine protected areas (MPAs) outside national jurisdictions. Particular emphasis must be placed on establishing no-take marine reserves, informed by scientific delineations of essential parameters required to mitigate oceanic biodiversity loss, ensure food security, facilitate marine ecosystem rehabilitation, and fortify resilience against ocean acidification and climate change impacts. Notably, empirical assessments advocate for the prioritization of fully protected marine reserves due to their superior cost-

effectiveness in terms of administrative efficiency, surveillance efficacy, and enforcement feasibility, compared to alternative MPA configurations.

Under the new UN Ocean Agreement, there is a step-by-step procedure to identify, create, manage, and enforce MPAs, including no-take marine reserves, in areas beyond the national jurisdiction.

Step 1 Identification
Step 2 Proposal
Step 3 Consultation
Step 4 Designation
Step 5 Conservation and management
Step 6 Monitoring
Step 7 Report and review
Step 8 Compliance
Step 9 Enforcement
Step 10 Dispute settlement

Contribution of IUCN in MPAs

Since the 1970s, the International Union for Conservation of Nature (IUCN) has been pivotal in advancing Marine Protected Areas (MPAs). Initially spearheaded by a dedicated cadre, the IUCN formulated programs to foster MPA development globally, establishing the foundational concept of MPAs. Presently, the majority of the IUCN's provincial and regional branches actively engage in diverse marine conservation initiatives through its enduring Marine Conservation Programme. Since the inception of the Vice-Chair (Maritime) role in 1986, the World Commission on Protected Areas (WCPA), formerly known as CNPPA, has overseen a dedicated marine wing. This wing supervises 18 volunteer specialist groups, each dedicated to specific maritime coastal zones, along with a group focused on addressing challenges pertaining to ocean floors. The coordination of these groups falls under the purview of the Vice-Chair. The IUCN recognizes six categories of MPAs, each aligned with distinct conservation objectives. These range from multiple-use areas, permitting various resource extraction activities, to entirely protected areas, known as no-take zones, where all forms of extraction are prohibited, aligning with stringent conservation goals.

Category	Descriptions
I	Extreme Nature Reserve/Wilderness Area
II	National Park
III	Natural Monument or creatures
IV	Habitat and Species Management Area
V	Protection of landscape/ seascape
VI	Managed resource protection area

Challenges of MPAs

- Enhancing the habitats of MPA networks will be quite challenging, given the socio-economic perspective present in India.
- Since the status and geographic distribution of the majority of marine species in India are mostly unknown, the state of their conservation has not yet been systematically evaluated. Threats include sea horses, shells, sea turtles, corals, and extinct shark and ray species, all of which are protected by the 1972 Wildlife Act.

- The degradation of the environment spurred on by industrialization and urbanisation has also had an effect on marine biodiversity. These human-made activities harm ecosystems by merely adding pollution to them.
- Both economically and in terms of tourism attractions, mangroves are quite advantageous. However, they have seen significant exploitation over the years and have decreased significantly.
- Climate changes continuously exert pressure on the ocean ecology. Human activities in and around the ocean, such as fishing, shipping, oil production, and tourism, will continue to have an impact on the ocean biodiversity as a result of the effects on salinity and acidity and the rising sea levels.

Conclusion

The establishment of protective measures like MPAs has been necessitated by the ongoing degradation of marine ecosystems attributed to both human activities and natural phenomena. This degradation has led to declines in fish stocks and loss of biodiversity. Observable improvements in fish abundance, species diversity, coral cover, and other ecological parameters serve as tangible indicators of effective coastal protection efforts. Active engagement of local communities is imperative for the successful management of MPAs. The management process typically encompasses several stages: planning, design, implementation, monitoring, evaluation, communication, and adaptation. Involving local stakeholders throughout these stages enhances community ownership and fosters effective conservation outcomes. Key indicators of MPA success include improvements in biological metrics such as fish biomass, coral cover, and species composition. The expansion of fish populations beyond MPA boundaries can lead to enhanced Catch per Unit Effort (CPUE), signaling broader ecological benefits resulting from effective MPA management strategies.

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MECHANIZATION AND CHALLENGES IN SOWING OF KHARIF CROPS

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Kharif crops are crops grown with the coming of monsoon in different parts of the country. The Kharif season varies according to the crop and region, starting in May at the earliest and ending in January at the latest. Kharif crops are usually sown at the beginning of the first rains during the arrival of the south-west monsoon season, and they are threshed towards the end of the monsoon (October–November). These crops depend on the amount of rain water as well as its timing. Kharif crops require hot weather with abundant amounts of water. Most of it comes under rain-fed irrigation system. Pests and diseases are also more prevalent in Kharif crops than in Rabi crops. It requires short day length for flowering. The main Kharif crops grown in India includes paddy, maize, sorghum, millet, cotton, sugarcane, groundnut, pulses etc.

Sowing method

Broadcasting method

Broadcasting method is the scattering or spreading of seeds on soil which may or may not be incorporated into the soil. Seed spreading can be done by hand, mechanical spreader or aero plane. This method is suitable for closely sown crops, which do not require specific spacing for optimal expression of their growth and development. For mixed cropping, the common practice of sowing seeds is broadcasting. Although it is an easy, quick and cheap method of sowing, there are difficulties in uniform distribution, keeping the soil at optimum and uniform depth and providing cover and compaction of the soil. Germination through this method is uneven, and its control is difficult either ways i.e., manually or mechanically. This method requires more quantity of seeds. Spreading of seeds is done in dry, semi-dry and wet fields. In this method, 100 kg seeds are required in one hectare.

Disadvantages of Broadcasting method

- Some seeds are not covered with soil.
- The density and depth of seeds is uneven.
- Seed germination is uneven.
- Crop stand is affected by uneven distribution.
- Birds attack on seeds is very high.

Broadcasting of rice seeds

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Dibbling Method

It is a method of inserting a seed into a hole or pit made at a predetermined distance and depth with a dibbler or planter. This method is suitable for crops planted in wide space that require a proper spacing for their canopy growth or cultural practices such as weeding, tilling, etc. Seeds can be sown in flat fields or on ridges. For this method there is no need to prepare the entire field for seed bed. This method is suitable for sowing of maize, cotton, castor, groundnut, pigeon pea, onion, ginger, etc. Dibbling is more laborious, time consuming and expensive than the earlier method, but it requires less seed and gives faster and healthier germination. In dibbling, seeds are placed 2/3 from the top or 1/3 at the bottom of the ridge.

Transplanting method

Transplanting is a common planting technique used to move seedlings from one location to another, typically from a seed tray to a larger pot or directly into the ground. The growth of seedlings is very slow in the initial stage, due to the delicacy of the plants and extra care is required to establish them in the field. Small seeded crops like tobacco, chili, tomato should be sown at shallow depth and irrigated frequently for proper germination. Taking care of germinated seeds/plants spread over a large area is a problem related to watering, weed control, pest control etc. Therefore, the seeds are sown in a small area called nursery. When they grow to a certain stage, they are taken out of the nursery and transplanted to the main farm.

Here's a general method for transplanting: Prepare the Seedlings- Ensure that the seedlings are healthy and sturdy before transplanting. Water them thoroughly a few hours before transplanting to make the soil easier to work with. Prepare the Destination- If transplanting into the ground, prepare the soil by loosening it with a garden fork or shovel. If transplanting into a pot, make sure the pot has drainage holes and fill it with potting soil. Dig Holes- Dig holes in the destination soil or potting soil that are large enough to accommodate the root ball of each seedling. Space the holes according to the recommended spacing for the particular plant species. Remove Seedlings- Gently remove the seedlings from their original container, being careful not to damage the roots. A small trowel or spoon can be used to lift the seedlings out of the tray, if they get stuck. Plant Seedlings- Place each seedling into its prepared hole, making sure that the top of the root ball is level with the surrounding soil. Fill in any gaps with soil and gently firm the soil around the base of the seedling to provide support. Water thoroughly- After transplanting, water the seedlings thoroughly to help them settle into their new environment and to prevent transplant shock. Keep the soil consistently moist in the days following transplantation. Monitor and Care- Keep an eye on the transplanted seedlings over the next few weeks, ensuring they receive adequate water and

sunlight. Protect them from extreme weather conditions if necessary, and provide any additional care specific to the plant species.

Remember to handle seedlings gently during transplanting to minimize stress and damage. Additionally, timing is crucial – transplant seedlings when they are still young and actively growing to improve their chances of successful establishment.

Drilling/Line

Drilling is the practice of sowing, dropping seeds into furrows. Furrows are made at predetermined distances, seeds are dropped at a certain depth and distance followed by covering them with soil. Sowing equipment like 'seed drill' or 'seed cum fertilizer drill' are used. The use of seeding funnels and sowing behind the plow is also practiced. Other works like application of manure and fertilizers, pesticides and soil amendments are also done during sowing. Drilling requires more time, energy and cost, but it maintains a uniform plant population per unit area. Row to row distance is also maintained in this method. Drilling enables sowing of crops like wheat barley, upland rice, jowar, pulses, safflower, sesame, etc.

Disadvantages of drilling method

1. Drilling requires equipment like seed-drill which increases the cost of farming.
2. Drilling requires more time, energy and cost.
3. Skilled labor is required.
4. Drilling takes more time than the broadcasting method.
5. Drilling is difficult in clay and rocky soil.

Limitations of traditional sowing methods

In manual seeding it is not possible to achieve uniformity in distribution of seeds. A farmer may sow at the desired seed rate but the intra and inter-row distribution of seeds is likely to be uneven resulting in clumps and gaps in the field. Poor control over seeding depth which requires high seed rate and thinning to bring plant populations to desired levels. Labor requirement is high as at least two persons are required to drop seeds and fertilizer. During Kharif sowing, planting of seeds at uneven depth may damage their emergence leads to poor plant health.

Sowing method used for different crops

1. Peanuts : Groundnut is mostly sown with seed drill under rainfed conditions. For seed drill, the number of tines is 3 to 6 and the distance between them vary from 150 to 200mm.

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2. Soybean : The most common time for sowing of soybean in Kharif season is with the onset of monsoon or from the last week of June to the first week of July. Line sowing is followed by seed drill as it requires less seeds/hectare. Row-row spacing of 250 mm is considered. Soybean requires a temperature of about 15 to 32 degrees for germination but the crop requires higher temperatures for rapid growth. Pruning of crop at about 600-650 cm height at flowering or just before flowering.

3. Pulses : Pulses crop are mainly green gram, red gram, bengal gram, peas. Digging and drilling method is mainly used for sowing. The seeds are sown at a depth of 50 to 70 mm. Green gram is sown at a distance of 100-300 mm, red gram at a distance of 300-450mm, and bengal gram at a distance of 100-300 mm.

4. Jowar : Jowar is sown from mid-June to mid-July. For early green fodder, jowar is sown from mid-March. Sorghum is sown either by broadcasting method or in seeding behind the plough. Seeds should not be sown more than 20-30 mm deep.

Benefits of sensor based technology used in sowing method

Seed is an important input in agriculture so it is essential to minimize seed sowing and maintain proper germination conditions of the seed. Proper placement of seeds, seed rate and good growth and uniformity of seeds are desired for high productivity of the crop. In India, the main sowing machinery are seed drill, seed cum fertilizer drill and planter. The main sowing machinery components are seed box, metering mechanism, seed tube, furrow opener and ground wheel. The problem associated with sowing machinery is that there is no fixed sowing depth, changes in seed rate while working and blockage in the seed and fertilizer tubes. All the above problems are major issues resulting in low productivity of any crop. Hence there is a need to solve these problems efficiently and economically. Sensor-based technology solves these problems, as it can easily provide data of sowing depth, seed rate and seed and detect feedback blockage. Now-a-days it is a most widely used technique for planting.

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MUSHROOMS: EARTH'S SILENT ARCHITECTS

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Abstract

For centuries, mushrooms have played a crucial role in human diets and traditional medicine, valued for their culinary uses and health benefits. As macro-fungi, they are rich sources of natural antibiotics and essential nutrients. This article explores the diverse types of mushrooms, including edible, poisonous, and medicinal varieties. Mushrooms are valuable for their bioactive compounds, which contribute to immune enhancement, inflammation reduction, and antioxidant protection. Incorporating mushrooms into the diet can promote overall well-being and support various health functions.

Keywords : edible mushroom, medicinal mushroom, poisonous mushroom, bioactive compounds.

Introduction

Mushrooms have been an integral part of human diets and have as a traditional medicine for centuries. These fungi are not only delicious but also hold great medicinal value, and are characterized as macro-fungi with rich sources of natural antibiotics. Unlike plants, they do not produce their food since there is a lack of chlorophyll in it. Instead, they rely on the breaking down organic matter to obtain nutrients. These are considered saprophytic and are in high demand due to their medicinal and nutritional properties. In this article, we will delve into the fascinating world of mushrooms and explore their numerous benefits to humanity.

Types of Mushrooms:

1. **Edible mushrooms :** Edible mushrooms, as their name implies, are not only safe for consumption but also offer a delightful addition to a wide variety of dishes. With low calorie and fat content, they are an ideal choice for individuals aiming to manage their weight effectively. Whether sourced from the wild or cultivated commercially, edible mushrooms are abundant in essential vitamins, minerals, fiber, and protein, making them a valuable addition to a healthy diet. Some examples of these mushrooms are;
    - Button mushroom (*Agaricus bisporus*)- Commonly found in food stores, these mushrooms have a delicate flavor and are flexible in cooking.
    - Portobello mushrooms- These large, mature button mushrooms have a meaty texture and are often used as a substitute for meat in dishes.
    - Oyster mushrooms (*Pleurotus* species)- Delicate and mellow in flavor, they are used in soups, stir-fries, and as a meat substitute because of their texture.
    - Shiitake mushrooms (*Lentinula edodes*)- have a distinct smoky flavor, these are popular in Asian cuisine and are believed to have immune-boosting properties.
2. **Poisonous mushrooms :** Caution should be exercised when consuming mushrooms, as some varieties are highly poisonous and can result in severe illness or even death. It is crucial to be able to identify toxic mushrooms to prevent any potential accidents. Some fatal mushrooms include;

- Death cap mushrooms (*Amanita phalloides)- These are the most dangerous mushrooms, highly toxic, and the cause of the majority of fatal poisoning.*
- *Destroying angel (Amantia species)*- These highly toxic fungi closely resemble edible button and meadow mushrooms, leading to a frequently mistaken collection.
- *Web caps and fool's web caps (Cortinariusrubellusand C. orellanus)*-They are very similar in appearance to each other and to several edible varieties. In instances of misdiagnosis, the toxin has the potential to result in kidney failure and, in severe cases, fatality.

3. **Medicinal mushrooms :** Medicinal mushrooms have a rich history of use in traditional medicine practices, dating back centuries, particularly in Asian cultures. These compounds are believed to contribute to a range of potential health benefits, which include immune system support, anti-inflammatory properties, and overall disease protection. Medicinal mushrooms are commonly consumed in various forms, such as extracts, powders, and teas, and continue to play a significant role in traditional medicine systems worldwide.
    - Lion mane's mushroom (*Hericium erinaceus)* : It has a unique appearance making it a popular choice in gourmet cooking. These are highly prized for its medicinal properties.
    - Reishi mushrooms (*Ganoderma lingzhi) : These are often referred to as "mushrooms of immortality". It is known for its nutritional properties and* symbolizes longevity and wellness.
    - Turkey tail mushroom (*Trametes Versicolor) : They got their name for their distinctive appearance, resembling the tail feathers of a turkey. Mainly known for enhancing the immune system.*

Health Benefits

Mushrooms provide a huge range of health-promoting properties, with unique bioactive compounds. Since they are low in calories, have higher levels of vitamins, minerals, and antioxidants. Vitamin B (niacin, riboflavin, pantothenic acid) as well as minerals like selenium, potassium, and copper are a good source. Certain mushrooms, like shiitake, reishi, contain active compounds like beta-glucans and polysaccharides that have immune-boosting activity. This also enhances the activity of white blood cells and strengthens the body's defense against infections and diseases. Some include oyster and button mushrooms has anti-inflammatory compounds that reduce inflammation in the body. Several mushrooms are rich in antioxidants, selenium, and phenolic compounds, which help to neutralize the free radicals present in the body by protecting the cell from oxidative stress and also help to reduce the risk of chronic diseases like cancer and cardiovascular diseases by lowering the cholesterol levels and improve blood vessel functions. Since mushrooms give low calories but are high in fiber, can help to promote a feeling of fullness and satiety, aiding in weight management and appetite control. The fiber and prebiotics present in the mushroom help promote the growth of beneficial gut bacteria thereby supporting good digestive health.

Incorporating a variety of mushrooms into our diet can offer numerous health benefits and contribute to overall well-being. According to the World Health Organization (WHO), the recommended daily allowance (RDA) consumption for vitamins and minerals is 100mg of mushroom for male and female.

Conclusion

Mushrooms are fascinating organisms that serve a crucial role in various ecosystems. They have been an integral part of human cultures for thousands of years, contributing to cooking traditions, traditional medicine, and even spiritual practices. These organisms are enriched with a wide range of bioactive compounds, many of which have been utilized for their medicinal properties. Despite current knowledge, there are still numerous untapped resources of valuable natural compounds waiting to be discovered within the diverse world of mushrooms.

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IFFCO'S NANOFERTILIZER MOVE TOWARDS GREEN AGRICULTURE

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Abstract

Utilizing green technologies in agriculture is important because they reduce environmental damage, produce less fossil fuel as by-products, and aid in sustainable agricultural development. Sustainable agriculture requires a minimal use of agrochemicals that can protect the ecosystem and spare biodiversity from extinction. Mineral nutrients if applied to crops in the form of Nano fertilizers (NFS) hold potential to offer numerous benefits for making the crop production eco-friendly and more sustainable. This paper aims at highlighting how IFFCO's Nano Fertilizer Move can be potential tool for sustainable green agriculture.

Introduction

Balanced and efficient use of fertilizers plays a pivotal role towards improving soil fertility, crop productivity, produce quality and farmers' profit. However, precise nutrient management is a big challenge and crucial for sustainable green agriculture because the efficiency of conventional chemical fertilizers to supply nutrients hardly exceeded 30%–40% for nitrogen, 15-20% for phosphorus, 40-50% for potassium and sulphur and less than 5% for micronutrients due to associated problem like environmental losses. Nanofertilizers provide efficient nutrient management through increased nutrient use efficiency. Additionally, nanofertilizers also enhance abiotic stress tolerance and ensure many more benefits. This paper aims at highlighting how IFFCO's Nano Fertilizer move can be a game changer for sustainable green agriculture.

Nanotechnology Based Fertilizers

Nanotechnology is a promising field of research which has the potential to offer sustainable remedies to pressing challenges confronted to modern intensive agriculture. Nanotechnology employs nanomaterials which typically have the size of 1–100 nm and this small size imparts unique characteristics and benefits to nanomaterials. Nanotechnology has the potential to reinforce the mission toward ever-green revolution by enhancing agricultural productivity with limited inputs. It is emerging as a paradigm shift and evolving as a promising tool to begin a new era of precise farming techniques and therefore may provide a possible solution for crop improvement, even in challenging environments. Nanofertilizers hold potential to fulfil plant nutrition requirements along with imparting sustainability to crop production systems and that too without compromising the crops yield.

Nanofertilizers Advantages over Conventional Mineral Fertilizers

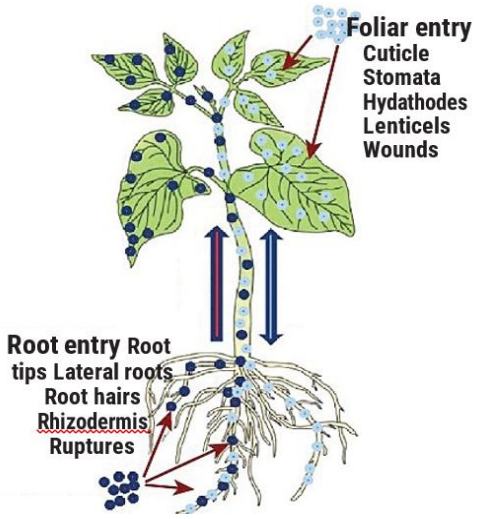
Fertilizers based on nanotechnology have the potential to surpass conventional fertilizers. Mineral nutrients if applied to crops in the form of NFs hold potential to offer numerous benefits for making the crop production eco-friendly and more sustainable. The benefits of NFs are

summarized below:

1. Impart superiority over conventional fertilizers due to comparatively higher solubility and diffusion.
2. Increase the bioavailability of nutrients due to miniature size, high specific surface area and high reactivity.
3. Influence metabolic activities of the plant to different degrees and havethe potential to mobilize native nutrients in the rhizosphere due to their unique properties.
4. Provide plant nutrients gradually in a controlled manner in contradiction to rapid and spontaneous release of nutrients from chemical fertilizers.
5. Ensure higher efficiency of nutrient uptake matching the uptake pattern of the crop in a controlled manner by slow, and targeted efficient release. For example, nutrients can be released over 30 days in a slow-release fashion. Research has shown that NFs release nutrients as much as 12 times slower than fertilizers, and they can significantly increase the yields and quality traits of crops.
6. Prevent undesirable nutrient losses to soil, water and air via direct internalization by crops, and avoiding the interaction of nutrients with soil, microorganisms, water, and air that enhance the NUE and reduce the costs for environmental protection.
7. Avoid premature contact with soil and water due to thin coating encapsulation of nanoparticles such as leading to negligible loss of nutrients. These become available as soon as plants are in position to internalize the released nutrients.
8. More efficient in terms of nutrients absorption and utilization due to considerably lesser losses through leaching and volatilization and offer lower risk of environmental pollution.
9. Ensure significantly higher uptake owing to free passage from nano sized pores and by molecular transporters as well as root exudates. Nanoparticles also utilize various ion channels which lead to higher nutrient uptake by crop plants. Within the plant, nanoparticles may pass through plasmodesmata that results in effective delivery on nutrient to sink sites.
10. Applied in smaller amounts due to considerably small losses of nano fertilizers in contrast to synthetic fertilizers which are being applied in greater quantities keeping in view their major chunk that gets lost owing to volatilization, leaching, eutrophication, emission etc. resulting poor use efficiency.
11. Prevent undesirable nutrient losses to soil, water and air via direct internalization by crops, and avoiding the interaction of nutrients with soil, microorganisms, water, and air that enhance the NUE and reduce the costs for environmental protection.
12. Facilitate the crop plants to fight various biotic and abiotic stresses by providing balanced nutrition.
13. Minimizeoveraccumulationofsaltinsoilastheyarerequiredinsmallamount.
14. Useful for mitigating the chronic problem of moisture retention in arid soils and enhance crop production by increasing the availability of nutrients in the rhizosphere.
15. Required in small amount thus reduce the cost of transportation and field application.

The world's largest cooperative (Indian Farmers Fertilizer Cooperative Limited- IFFCO) took lead to invent Nanofertilizers viz. Nano nitrogen, Nano Zinc and Nano Copper in liquid form and initiated large scale on-station and on-farm testing since 2019. The benefits of IFFCO nano fertilizers have been well documented(Kumaretal.,2021;Singh,2022;Kashyap,2023;Upadhyayetal., 2023; Tiwari

and Kumar, 2023) which established that these fertilizers can arrest the increasing use of conventional fertilizers in a ecofriendly way.



Picture1. Potential entry points of nanoparticles into plants (Wang et al. 2016)

IFFCO Ventures into R&D and Production of Nano- Fertilizers

IFFCO launched nanotechnology-based indigenous nano products – Nano Nitrogen, Nano Zinc and Nano Copper on 3rdNovember, 2019 and simultaneously, undertook 11,000 farmers' field trials (FFTs) and "On Station" trials in collaboration with 22 State Agricultural Universities (SAUs)/Research institutes. Experimental trials undertaken during *rabi/zaid* 2019- 20 in different crops like paddy, wheat, mustard, maize, tomato, cabbage, cucumber, capsicum, onion and states have recorded encouraging results. Summary of State Agricultural Universities/ICAR-KVK trials indicate that nano nutrient can enhance farmer's crop yields, besides effecting substantial savings on subsidized bulk fertilizer applications.

Field trials conducted with SAUs/Research Institutes indicate that 25-50% urea reduction may be possible with foliar application of nano nitrogen. All the growth and yield contributing characters improvement with 2 sprays of nano nitrogen or alternate combination sprays of nano nitrogen, nano zinc and nano copper with 50% reduction in nitrogen and zinc, wherever recommended. ICAR-Indian Agricultural Research Institute, New Delhi states that nano fertilizers (alone or in combination) when applied with graded doses of fertilizers can lead toup to 25% reduction in the fertilizer nitrogen. Curtailing of 25% nitrogen fertilizer in wheat and 50% nitrogen fertilizer in mustard could be possible with two sprays of nano nitrogen. Similar or better results have been conveyed by other research institutes and SAUs. More number of effective tillers, higher growth and biomass yields and grain and straw yield were recorded in treatments receiving nano-fertilizers. Mahatma Phule Krishi Vidyapeeth, Rahuri evaluated IFFCO's nano products on onion crop and found that nano nitrogen and nano zinc increased yield even when their conventional counterpart application dose was reduced by 50% and Nano copper improved the fruit quality. Economic benefits *i.e.* B:C ratio of Nanofertilizer applications have to be seen in terms of extra yield achieved at reduced dose of fertilizers and direct/indirect benefits of reduction of soil-air-water pollution. A view of the field the on-farm trials and promotional activities are being displayed in **Picture 2** and **3**.

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To strengthen nationwide campaign, IFFCO has also ordered tractor-mounted boom sprayers, tractor- mounted hose reel sprayers, HTP power sprayers with gun, static/portable sprayer, Niyo sprayers for foliar application of agro-chemicals which are being provided to the farmers at subsidized prices. The drones and sprayers can be used for any kind of spray application. It's, indeed, is a welcome development. A view of moving gradually from topdressing of urea to foliar spray of Nano fertilizers and other agrochemicals and now through drone for better precision and efficiency is depicted in **Picture 4**.

Picture 4. Moving gradually from topdressing of urea to foliar spray of Nano fertilizers and other agrochemicals and now through drone for better precision and efficiency

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IFFCO's Nano Fertilizers Related New Initiatives

IFFCO has now embarked on providing redesigned Nano Urea as Nano Urea Plus, Nano DAP, Nano Zn and Nano Cu to the farmers and facilitate their use through smart high-tech solutions. These nano fertilizers (NFs) will be a game changer. The specifications of Nano urea Plus, Nano DAP, Nano Zn and Nano Cu recently included in the Fertilizer Control Order are given in **Table 1** and **2**.

Table 1. FCO Specifications for IFFCO Nano Fertilizers

S. No	Parameters	Specifications	
	NANO DAP AND NANO UREA PLUS		
		NANO DAP	**Nano Urea Plus**
1	Total Nitrogen (N),per cent by weight	7-9	16
2	Total Phosphorus (as P2O5) per cent by weight	15-17	
3	pH	3-6	4-8.5
4	Viscosity	5-30 cps	5-30 cps
5	Particle size in nano metre (nm) in one dimension		
	(a) Physical particle size as per TEM ANALYSIS (minim um 50 per cent of the material	20-70 nm	20-50 nm
	shall be in range of 20-70 nm)		
	(b) Hydrodynamic Particle size (as per DLS Analysis)	<100 nm	20-80 nm
6	Surface charge /Zeta potential mV (+/- scale)	>5	>15
7	Date on which it comes in FCO	02-03-2023	15-04-2024

IFFCO's Nano Urea Plus and Nano DAP recently included in Fertilizer Control Order are being displayed in **Picture 5.**

Picture 5**.** IFFCO's Nano Urea Plus and Nano DAP

Table 2 FCO Specifications for IFFCO Nano Zinc and Nano Copper

S.no	Parameters	Specifications
	NANO ZINC	
1	Total Zinc (Zn),per cent by weight	1
2	pH	3.5-6
3	Viscosity	5-30 cps
4	Particle size in nano metre (nm) in one dimension	
	(a) Physical particle size as per TEM ANALYSIS (minim um 50 per cent of the material	10-80 nm
	shall be in range of 20-70 nm)	
	(b) Hydrodynamic Particle size (as per DLS Analysis)	10-90 nm
5	Surface charge /Zeta potential mV (+/- scale)	>15
6	Date on which it comes in FCO	22-04-2024
	NANO COPPER	
1	Total copper (Cu), per cent by weight	0.8
2	pH	3-6.5
3	Viscosity	5-30 cps
4	Particle size in nano metre (nm) in one dimension	
	(a) Physical particle size as per TEM ANALYSIS (minim um 50 per cent of the material	10-80 nm
	shall be in range of 20-70 nm)	
	(b) Hydrodynamic Particle size (as per DLS Analysis)	10-90 nm
5	Surface charge /Zeta potential mV (+/- scale)	>15
6	Date on which it comes in FCO	22-04-2024

Agricultural Drones

In recent years, unmanned aerial vehicles (UAVs) or drones have emerged as an innovative tool for precision agriculture. By using drones, farmers can monitor their crops and livestock from a bird's eye view and make data- driven decisions to improve their yields and efficiency. By using innovative techniques like drones, we can spray fertilizers, insecticide, fungicide etc. on the crops and fruit trees in much less time (5-10minutestocover0.4ha) with about one-tenth of water. Drones can help farmers optimize irrigation, manage water resources, and reduce the use of fertilizers and pesticides with precision resulting in a more sustainable and eco-friendly agriculture. With the advances in drone technology, it may not be a surprise that the use of drones in agriculture is growing rapidly, and we can expect to see more and more farmers adopting this innovative technology in the coming years.

IFFCO's Initiative for Agricultural Drones

IFFCO has already initiated procurement of 2,500drones under IFFCO Kisan Drones to develop "**IFFCO DRONE DIDI"** as spray solutions for its products(nano urea, nano DAP, Sagarika, 100% water soluble fertilizers(WSFs),bio-stimulants, pesticides, etc.), enabling to improve efficiency of the applied products. IFFCO will also be procuring 2500 electric three-wheelers (loader type) to carry the drones to the farmers' fields along with the nano fertilizers and associated utilities (**Picture 4**).

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Picture 4. IFFCO's Drone Didi Initiative

To access the technical capabilities, manufacturing capacity and quality processes, training curriculum, and infrastructure, IFFCO has hired a New Delhi-based consultant, Drone Federation of India. It is expected that one drone would be able to cover 8 ha per day for spraying IFFCO's smart inputs to address climate change issues. This will lead to the development of 5,000 rural entrepreneurs who are identified by IFFCO to be trained to accomplish the job of spraying of nano fertilizers, other specialty fertilizers and pesticides through drones.

IFFCO's alternative fertilizers (Nanofertilizers), fully water-soluble fertilizers, bio-stimulants, biofertilizers, secondary and micronutrients, fortified fertilizers, organic fertilizers, biopesticides etc.) being made available to the farmers through its robust marketing network aim to achieve the goal of sustainable green agriculture.

Nano Fertilizers Not Just Promise to Cut Down Subsidy Burden But also Improve Farmers Income

Fertilizer Subsidy *:* Currently, urea is the only controlled fertilizer and is sold at a statutory notified uniform sale price. It is the most commonly used fertiliser because it is highly subsidised. Neem-coated urea is currently sold at Rs 266.5 per 45 kg bag after Rs. 2183.50/- per bag subsidy on purchase of Urea (Imported), Rs. 2501/- of DAP, Rs. 1918/- of NPK (Nitrogen, Phosphorus, and Potassium), Rs. 759/- per bag subsidy on purchase of MOP (Muriate of Potash). During kharif 2023-24 season ended September the government had allocated a subsidy of ₹1.08 lakh crore including a ₹70,000 crore subsidy for urea and ₹38,000 crore for DAP and other fertilisers.

Efficiency of Nano Urea : The efficiency of conventional urea is around 40% and of nano urea, in contrast, it is more than 80%. Nano bottles are easily portable, apart from, many other benefits. Farmers generally apply DAP and NPK complexes at the time of sowing/transplanting of the crops avoiding urea as basal application and as such roughly 20% of the recommended dose of nitrogen is applied and remaining nitrogen is applied in 2-3 splits as topdressing. This means that the benefit of 80% efficiency (albeit of nano urea) will be available to 80% of the total quantity of urea applied through topdressing.

As estimated by Gupta (2022), a policy analyst, the government can save a whopping about Rs 55,000 crore in subsidy annually on 9 million ton of urea import that will be replaced by 198 million bottles of nano urea requiring no subsidy. The low cost and much higher efficiency of Nano fertilizers makes to earn more profit with the use of Nanofertilizers.

IFFCO's Other Initiatives for Green Agriculture

Apart from nanotechnology-based fertilizers, IFFCO has introduced and invested in various path-breaking agro-technologies including promotion of agri-drones, rural e-commerce, digitally enabling farmers and farms and the Internet of Things (IoT) to achieve the goal of green agriculture. The society aims to be the flag-bearer of modern Indian agriculture, by being the brand resonating with innovators and progressive rural entrepreneurs aiming at climate resilient sustainable agriculture through green-tech agriculture.

Epilogue

Nano fertilizers are essential resources in agriculture in order to increase crop productivity and produce quality through increased nutrient use efficiency and nutrient uptake. Nano-fertilizersare efficient for specific use of nutrients ensuring their targeted delivery at appropriate site and time of plant growth. Growing crops with heavier fertilizer concentrations through conventional fertilizers has proven nonperforming and further increases in the crop productivity may be limiting and deterrent to environment. Nano-fertilizers provide more area for photosynthesis, leading to more sunlight absorption and greater crop yields. It will help plants survive challenging environmental factors such as abiotic and biotic stresses.

Limitations in agricultural land and water supplies can also be improved through the use of Nanofertilizers. In conclusion, nano-technology based fertilizers have the potential of transforming Indian as well as global agriculture. The principle of fertilizer use is known to use less resource and to be free from chemical side effects. Nanostructured formulations deliver active ingredients in response to environmental cues and biological demands more properly.

Nanofertilizers have enormous potential to contribute significantly to sustainable green agricultural production.

To achieve abovementioned objectives, IFFCO established Nano Biotechnology Research Centre (NBRC} at Kalol, Gandhinagar, Gujarat on 3rd November, 2019. To achieve the goal, NBRC developed Nano Urea and Nano DAP which were already included in the Fertilizer Control Order.Very recently, IFFCO NBRC invented and developed Nano Urea Plus (upgraded version), Nano Zinc and Nano Copper which have been included in the Fertilizer Control Order. These have nanoscale nutrients of desired particle shape, particle size, particle purity, composition, concentration, stability, polydispersity index (PDI value), pH and crystal phase. They are bioavailable and within the scientific limits of application (10 to 80 ppm) as per their desired content in plants, thus fulfilling plant nutritional requirement as a fertilizer. They help to increase NUE for increasing crop yields, reduce bulk fertilizer's consumption and increase farmer's profitability at reduced cost and reduced environmental foot print. IFFCO's Nanofertilizers are cost-effective and can be applied in irrigated, rainfed and dry land agriculture as well as in protected cultivation in all the crops. These are also compatible with most of the agrochemicals, bio-stimulants and specialty fertilizers.

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PADDY FIELDS : FAUNAL BIODIVERSITY RICH AGRO-ECOSYSTEMS

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Abstract
The rice field agro-ecology is distinguished by a number of unique features, including a wide variety of habitat that is ephemeral and subjected to rapid fluctuations, as well as a brief period of natural wetlands mimicking that provide a number of ecosystem services necessary for the flourishing and survival of faunal diversity. However, various intensive agricultural practices are having negative consequences, such as killing non-target species, which can directly contribute to loss of biodiversity by uprooting or even causing the extinction of native species that depend on these habitats, as well as beneficial insects, birds, and amphibians. With appropriate conservation action plans aiming at protection of wetland ecosystems, including paddy fields that can help maintain faunal populations, conservation of paddy fields and associated biodiversity is therefore of utmost importance.

Keywords : Paddy agroecosystem, Faunal biodiversity, Conservation

Introduction

Since the beginning of organized agriculture, paddy fields have existed as artificial ecosystems that carry out some of the activities of natural wetlands and offer a variety of ecosystem services. There are five major groups into which the rice agro-ecosystems found worldwide can be divided: Irrigated rice fields, rain-fed rice fields, deep water rice fields, upland rice fields, and tidal water rice fields are the five primary types of rice fields. Water regimes, drainage patterns, temperature fluctuations, soil composition, topographical features, and geographic location are some of the factors that determine the category. Because of their lengthy history, extensive coverage in humid tropics, variety of ecological niches, and multiple stages during the production cycle, rice fields have come to be recognized as unique ecosystems. In addition to producing rice for human consumption, paddies serve a variety of other purposes (Matsuno *et al*., 2006; Yoon, 2009). These purposes include food security, preserving and ensuring the viability of rural communities, and environmental protection through land conservation, sustainable management of renewable natural resources, biodiversity preservation, and the creation of aesthetically pleasing landscapes. Because paddy fields have given rise to a wide variety of biological species, the relationship between them and surrounding environment is crucial to biodiversity. Rice fields are suitable habitat for a wide range of floral and faunal species due to the variety of agronomic practices and sequential growth phases of rice crop experiences within a restricted period. Approximately, one-third of world's rice production originates from the irrigation-practicing rice fields in tropical Asia. The agronomic techniques required to cultivate rice have a significant impact on the ecological characteristics of rice fields. Rice cultivation requires a number of essential practices, including pre-planting ploughing of the field, controlled flooding and draining, application of basal fertilizer

prior to planting and during critical growth stages, use of pesticides and weedicides, manual weeding and post-harvest field abandonment for fallowing. The emergence of unwanted plant species, commonly known as 'weeds', within designated rice field area, mostly broad-leaved plants as well as presence of bordering bunds add another layer of complexity to this situation by acting as a heaven for both rice pests and their natural predators. The rice plant and related weeds are home to a broad and complex network of both specialized and generalist predators and parasitoids.

Aquatic organisms : Different species colonize rice fields in multiple stages. The first organisms to arrive are microscopic primary producers and saprophytes. These first settlers are essential in setting the stage for later waves of occupants. In order to ensure a good crop, farmers have contributed to this ecological system that are ingrained in this cycle of recurrent events. To ensure that the rice fields are flooded, an aquatic phase must be added to the plant during the seed germination and seedling stages, which can be accomplished with the use of an irrigation or rain-fed system. Many populations of aquatic invertebrates, such as benthos, nekton, periphyton, zooplankton, and neuston, thrive in rice fields. Freshwater fish and amphibians are among the aquatic animals that colonize fields during the aquatic phase in order to procreate. Predatory birds like kingfishers, herons, and egrets, as well as reptiles like water snakes and monitor lizards, are drawn to the area as a result of this colonization. The flooded rice fields' submerged debris serves as a home for a wide variety of animals. Protozoans, annelid and nematode worms, and arthropods are among the organisms taken into consideration. Numerous mosquito species, including disease-carrying ones, have made their home in the rice field waters. Certain pathogenic diseases can also find intermediate hosts in aquatic snails.

Arthropods : The wealthy spider community, which is made up of three distinct guilds that each occupy a certain microhabitat, is primarily in charge of the predatory arthropods in the rice fields. Ordinary orb-weavers weave an intricate orb web in the canopy, the topmost stratum of the forest. The instant web spinners begin to weave their webs at the bottom, with a mismatched gap between each web. There are no webs spun by the cursorial hunting spiders. Spiders use their web to trap unwary prey, and they hide their presence by carefully placing themselves among the surrounding vegetation. Rice fields are attractive to a variety of animals that eat grains includes arthropods like paddy bug, whose role in feeding grains causes grains to become partially or entirely empty causing damage and regular drops in crop yields.

Amphibians : Globally, rice agroecosystems may be crucial to preserving local amphibian populations that offer ecosystem services to the surrounding area and to the farmers who oversee their fields. Farmers in tropical farming systems rely on the number of frogs for cultural, provisional, and regulatory resources. Higher frog abundances in rice fields have been shown by Fang *et al.* (2021) to increase both rice root porosity and oxygen secretion, which in turn reduce methane emissions emitted from rice fields indirectly. In rice fields, insectivorous frogs that practice aestivation display their normal behavior.

Reptiles and Mammals : Including predatory reptiles and mammals including cobras, rat snakes, Russell's vipers, fishing cats, and bats, as well as rodents like rats and mice.

Birds : A variety of bird species, such as ibises, herons, and egrets, hunt insects and other small invertebrates in paddy fields. They wade through shallow water, catching prey in mud and water with their long bills. In paddy fields, certain birds graze on the seeds of rice plants, including

munias, parakeets and sparrows. Many species of shorebirds and ducks can make their nests on paddy fields. Nests are constructed by birds such as ducks, coots, and jacanas amid the dense undergrowth and thick grasses that envelop the flooded fields. Suitable breeding habitats are provided by these wetland locations. Paddy fields are frequently used by birds as roosting places, particularly when breeding is not occurring. In rice fields, large flocks of birds, including cormorants and black-headed ibises, congregate for communal nighttime roosting that provides protection from predators. Bird species that are accustomed to wetland environments, in particular, benefit from paddy fields' contribution to conservation efforts. By offering vital habitats for both local and migratory birds, protecting these agricultural landscapes contributes to preservation of biodiversity. Wading birds like egrets and herons, which eat insects and small rodents that can be harmful to rice harvests, can help reduce pest populations in paddy fields. Certain bird species, such flower peckers and sunbirds, may visit rice fields in order to feast on nectar that rice plants' blooms provide. A variety of species, including terns, bitterns, rails, shorebirds, and ducks, frequently build their nests in rice fields. Herons frequently make extensive use of rice fields when mating in nearby habitat. In these agrarian environments, birds serve a number of vital functions that are advantageous to both farmers and environment.

Conclusion : Rice fields serve as habitats for a diverse array of natural enemies to mitigate substantial insect pests; nonetheless, it is crucial to avoid becoming overlay dependent on any one technique or tactic. Encouraging biodiversity would facilitate the development of effective strategies to create tactics that work for biodiversity conservation. Trophic interactions that may lessen damage caused by pests and problems with soil fertility. Natural arthropod pest populations can be effectively reduced while improving communities by selectively lowering weed coverage on bunds. A natural reservoir is also provided by the non-rice habitats that surround and border rice fields. The paddy farming practice has resulted in a multitude of repercussions on the biodiversity of a country. The use of biocides and other modern agronomic techniques in rice farming has a significant effect on the biota in rice fields and its effects on environmental systems. The application of agrochemicals in rice fields has a detrimental effect on terrestrial arthropods. Benthic oligochaetes are the natural enemies of aquatic insects. The paddy farming practice has resulted in a multitude of repercussions on biodiversity of a country. The use of biocides and other modern agronomic techniques in rice farming has a significant effect on biota of rice fields and its effects on environmental systems.

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GENE STACKING AND PYRAMIDING AGAINST BIOTIC STRESSES IN SOLANACEOUS CROPS

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Introduction

Solanaceae family occupies an important place among cultivated species and also in some other groups. Vegetables such as potato, pepper, tomato and brinjal play a determining role in the human diet and also in economy of the countries. Other species are widely grown as ornamental crops or for industrial and pharmaceutical purposes. But unfortunately, insect-pests and diseases have a serious and even destructive impact that can challenge these crops now days.

Sustainable agricultural production is endangered by several factors such as parasitic ailments and insect-pest infestation. These challenging factors may have adverse effects on agricultural production in many countries. In modern agriculture, conventional plant breeding techniques alone are inadequate for achieving food demand of the increasing population on a sustainable basis. An advancement of molecular genetics and related technologies are promising tools for the selection of new crop species.

Gene stacking is a type of gene cloning that refers to the process of combining two or more genes of interest into a single plant. The emerging combined traits from this process are called stacked traits. Stacks offer broader agronomic enhancements that allow farmers to meet their needs under complex farming conditions. Biotech stacks are engineered to have better chances of overcoming the numerous problems in the field such as insect pests, diseases, weeds and environmental stresses so that farmers can increase their productivity without any risk.

Further, gene pyramiding through Marker Assisted Selection (MAS), ddRAD and other techniques have accelerated the development of durable resistant and tolerant lines with high accuracy in the shortest possible period of time for agricultural sustainability.

Losses due to biotic stresses:

NITI Aayog - GoI (2015) has submitted the report to agri. sector with shocking results that crop yield losses in India due to biotic stresses such as weeds, insect-pests, diseases, nematodes and rodents, range from 15 to 25 per cent.

0.9 to 1.4 lakh crore annual loss**(Source: NITI Aayog (2019)**

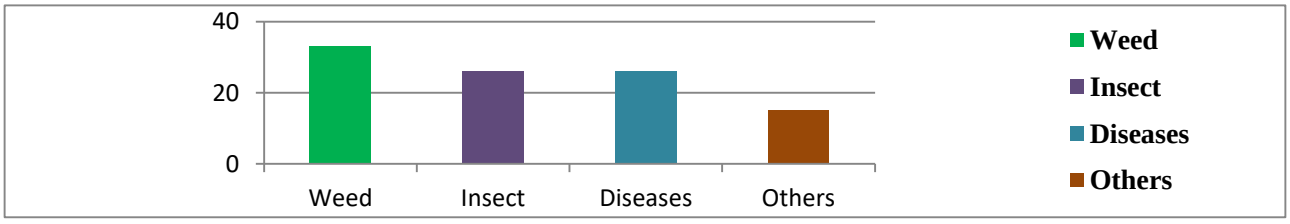

Figure-1 : % Losses due to biotic stresses

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Why we need resistant genotype?

43,400 crore annual cost, Pesticide used in India in India Kumar(2018)

- ✓ Cases of **adverse health impact** on society include acute poisoning, cancer, neurological effects and reproductive and developmental harms also increasing day by day.

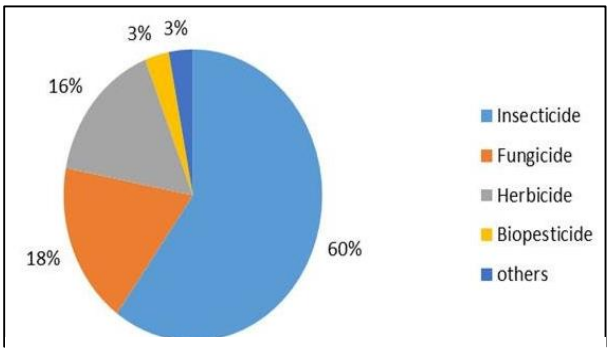

Figure 2: % Pesticides used in 2018

Genetic resistance is the cheapest source of stress management.

- ✓ **Vertical Resistance (VR):** is single-gene resistance (Monogenic). In vertical resistance there is single gene for resistance in the host plant, and there are also single genes for parasitic ability in the parasite.
- ✓ **Horizontal Resistance (HR):** is many-gene resistance (Polygenic), which is sometimes also called **generalized resistance**.

Why we go for horizontal resistance…?-**Easy breaking of Vertical Resistance**


NEWS

Bt cotton ineffective against pest in parts of Gujarat, admits Monsanto

Firm asks farmers to switch to its second-generation product to delay resistance further

Studies conducted by ICAR-CICR over the past 2 years, clearly showed that the pink bollworm developed resistance to 2 *Cry* toxins deployed in Bollgard-II.

- **HR can be achieved by gene pyramiding/stacking** approach that has reduced the potential of resistance breakdown as it is more **difficult for the pest to overcome multiple insecticidal proteins.**

What is Gene Pyramiding?

- Watson & Singh (1953) first introduced the concept of gene pyramiding.
- Gene pyramiding is defined as a method aimed at assembling multiple desirable genes/QTLs from multiple parents into a single genotype for specific/multiple trait through conventional breeding (Kumar and Nayak (2010).)
- A pyramid could be constructed with major genes, minor genes, defeated genes, race-specific genes, non-race-specific genes or any other type of host gene that confers resistance.

Objectives

- **Enhancing trait performance** by combining two or more complementary genes.
- **Remedying deficits** by introgression of genes from other sources.
- **Increasing the durability** of disease and/or disease resistance.
- **Broadening the genetic basis** of released cultivars.

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Basic assumptions

1. **Locations** of a series of genes of interest (target genes) **and the linkage relationship** between them is known.
2. **Target genotype for these genes is defined prior to selection** as the genotype with favorable alleles at all loci of interest.
3. The genotype of an individual can be **identified by these genes or markers** linked to them.
4. A collection of lines containing all the target genes should be available.

Strategy for gene pyramidin

Identification of resistant genes / gene sources

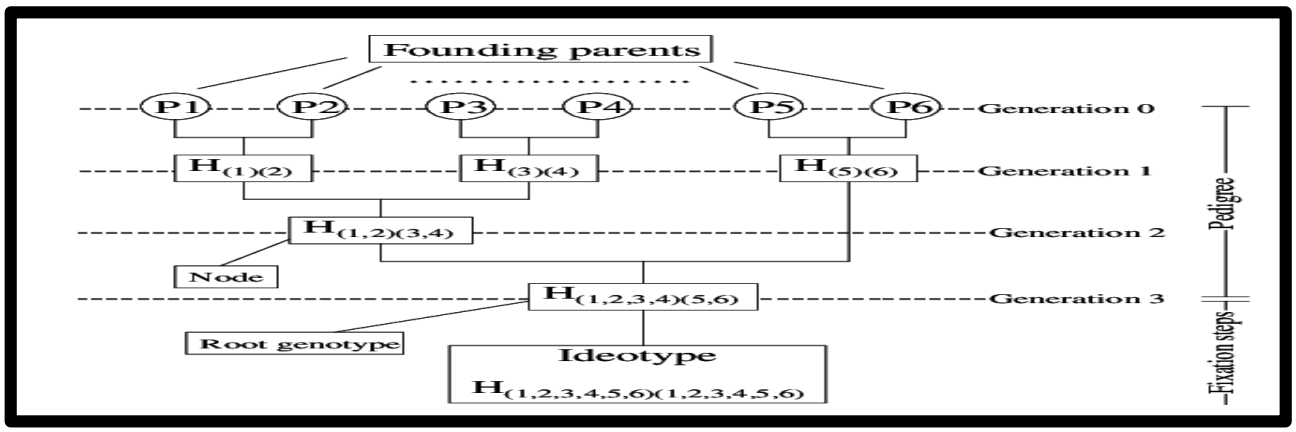
⇩

Transfer in to elite genotype deficient for that resistant gene through Back Cross, Double Cross, Two-way Cross, Multiple Cross

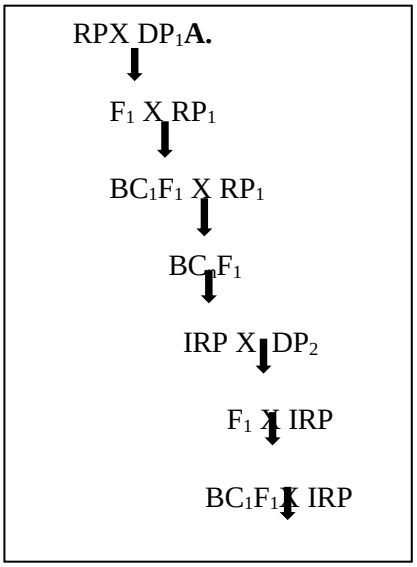
⇩

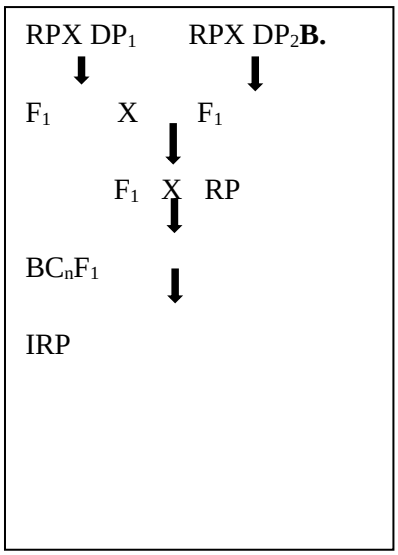
Fixation of that genotype → **Ideal genotype**

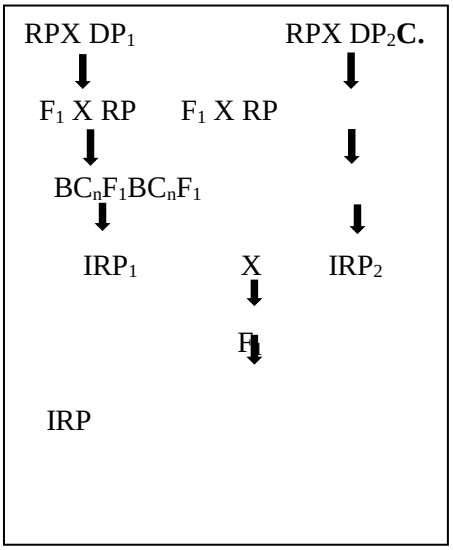
Gene Pyramiding scheme



For BC-based gene pyramiding, there may be **Three** strategies or breeding schemes: **A.stepwise, B. Simultaneous / synchronized and C. Convergent backcrossing or transfer.**







Main factors affecting gene pyramiding

1. **Population size:** Muller (1923) and Sedcole (1977) promoted to use the following equation
   $N = \log_e (1-P)/\log_e (1-f)$
   where, **N** = Minimum population size ,**P** = Desired probability of success (e.g. 99%, 95%, 90%) , **f** = Frequency of the event (i.e., an individual plant having all desired alleles).
2. Number of genes and combination of genes
3. Reliability of phenotyping at individual level
4. Inheritance model of the genes for the target traits, linkage and/or pleiotropism between the target trait and other traits.
5. Efficiency of hybridization
6. Reproductive characteristics, a breeder's capability to identify the desired genotypes, operating capital and interaction with foreign genes and its own genotype.

Fixation of pyramided genotype

Major advantage of work with asexually propagated crops is, easy maintenance of improved progeny where as for sexually propagated crops we have to go for following practices.

- Production of doubled haploids from root genotype
- Selfing the root genotype
- Crossing the root genotype with a **blank parent** and selfing the offspring
- Crossing the root genotype with one of the **founding parent**

Gene stacking

Gene stacking is the process of including more than one transgenic event in one plant to produce stacked traits, stacked transformation events, or a stacked genetically modified organism (GMO).According to the **OECD**, stacked transformation events are defined as “new products with more than one transformation event” (OECD, 2004)

Advantages

- Transfer of gene from distant gene pools
- Zero linkage drag
- Horizontal gene transfer
- Early variety release

Table 1: Global area of Biotech Crops, 2015-2016 by trait (Million hectares)

Traits	**2015**	**%**	**2016**	**%**	**+/–**	**%**
Herbicide Tolerance	95.9	53	86.5	47	-9.3	-10
Stacked Traits	58.5	33	75.4	41	**+16.9**	**+29**
Insect Resistance	25.2	14	23.1	12	-2.1	-8
Virus Resistance/ Other	<1	<1	<1	<1	<1	<1
Total	**179.7**	**100**	**185.1**	**100**	**+5.4**	**+3.0**

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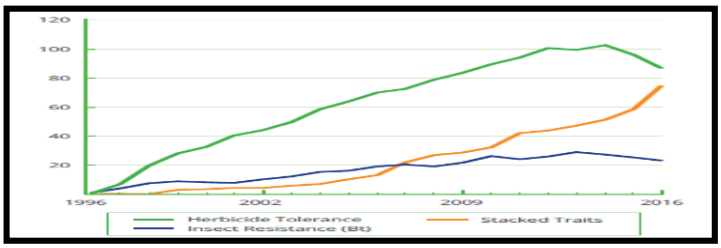


HR/IR has consistently been the dominant trait grown by farmers, but has declined through the years with the increasing prominence of stacked traits.

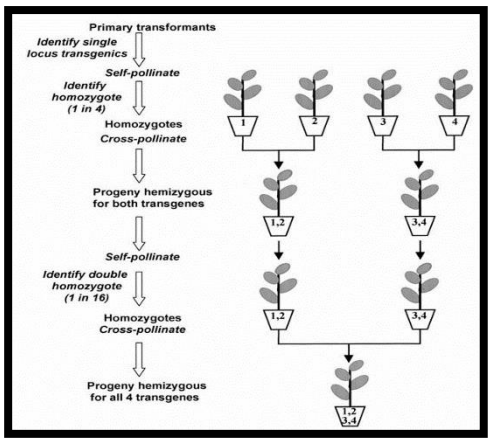
Figure 3: Global area of Biotech Crops, 1996 to 2016: by trait (Million hectares)

Strategies for gene stacking

1. **Iterative procedure / Sexual hybridization**

Limitations:

- Increased breeding costs, Labour intensive and time consuming.
- Transgenes not linked & can segregate.
- Obtaining homozygous plants for all transgenes difficult.
- Variety of selectable markers needed in the strategy.
- Marker removal slow, multistep process.
- Each unlinked transgene introduced would double the size of breeding population.



2. **Re-transformation / Sequential transformation**

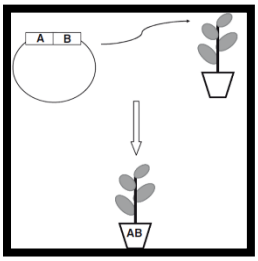
Limitations:

- Re-transformation can induce transgene silencing.
- Need for a range of selectable marker gene.

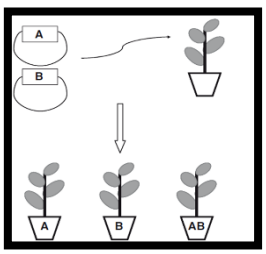
3. **Co-transformation**

Advantages

1. Integration of multiple transgenes, less transformation events & less time consuming.
2. Assembly of diff. expression cassettes is easier as it is done on independently on different plasmids.
3. Single-plasmid co-transformation offers an advantage over multiple-plasmid co-transformation in that integration of both genes together into the same genomic location is ensured as they are linked as a single piece of DNA.



Single plasmid Co-transformation of linked transgenes



Multiple plasmid Co-transformation of unlinked transgenes

Limitations

1. Difficulty to assemble complex plasmids with multiple gene cassettes.
2. Problem of Gene silencing
3. High copy number integrating
4. Undesirable incorporation of a complex T-DNA molecules from multiple sources.
5. Transgenes derived from different sources typically integrate at different locations in plant genome, which may lead to **various expression patterns and possible segregation** of the transgenes in the offspring.

Recent technique

1.	Polycistronic and polyprotein expression system	• Polycistronic Transgenes • Protease susceptible linker sequence • Nia protease sequence • 2A Polyprotein System • Internal Ribosome Entry Site
2.	jStack technique	
3.	Gene targeting and transgene stacking	

Conclusion

Gene pyramiding &gene stacking is one among the way to produce resistant &tolerant varieties against biotic stresses which are major factors for yield and quality losses in solanaceous crops.

- **Horizontal resistance** confirms the more durable resistance than vertical resistance because having more resistant genes.
- **Molecular marker** offers great scope for improving the efficiency of conventional plant breeding.
- A few conventional as well as novel techniques are in existence for the pyramiding/stacking of genes as no single method is ideal yet**.**
- **Co-transformation is an effective method** for gene stacking as compared to crossing and re-transformation.
- Chimeric transgenes with fused sequences of several 'effect genes' **under the control of single promoter** offer very significant advantages.
- **New techniques for gene stacking** are provides tools to the scientists to **redesign, assemble and shuffle** whole stretches of gene clusters into any transformable plant species.

Future Thrust

- **Identification and mapping** of new disease resistance gene/sources in germplasm/wild relatives of **major/minor crops** for gene pyramiding/stacking.
- Development of **software or easy calculation methods** for minimal population requirement calculation.
- Development of tissue culture and transgene protocols in Solanaceae crops for gene stacking.
- **Refinement of the existing technique** to be require for coordinated multi-gene manipulation in plant **to provide more durable and cleaner transgene technologies** that can **simplify** the route to **regulatory approval** and can reassure the **consumers about safety and stability** of GM product.
- **More suitable vector** system for both nuclear and **plastid transformation** should be design which can be transfer more than one gene with single transfer.
- Increase the knowledge and use of linker peptides for multiple gene transformations.

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PITUITARY GLAND BANKS FOR SUSTAINABLE FISH SEED PRODUCTION IN INDIA

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Fish raised in aquaculture systems exhibit different forms of reproductive dysfunction due to failure in experiencing natural conditions. The major problem observed is in the final stages of oocyte maturation in females and spermiation in males. Also, the neuroendocrine systems responsible for gonadal growth and maturation do not function maximally which results in lower production of hormones in central and peripheral bloods. Additionally, information on neuronendocrine factors responsible for reproduction in cultured fishes in India are lackling. Hence, there is necessity to use different types of hormones to overcome this problem in aquaculture.

The first generation use of hormone include use of natural crude pituitary extract (CPE) from different mammalian and non-mammalian sources. This extract consists of natural gonadotropins (GTHs), which act on gonads to induce final stages of gonad maturation and spawning. The major drawback with use of CPE is non-specificity and higher dose requirement for induced fish breeding. The method of using pituitary extract for induced fish breeding is known as hypophysation. Second generation includes use of semi-purified fish gonadotropins mainly salmon, carp and tilapia gonadotropins and synthetic gonadotropins including human chorionic gonadotropin (HCG). An advantage with this form of gonadotopins is species specificity and easy availability particularly HCG hormone in pharmaceutical shops. Third generation hormones include use of gonadotropin-releasing hormone (GnRH), primarily produced in fish brain for induced breeding. Initially, mammalian GnRH peptides were tested and used for induced breeding. However, based on GnRH research in different fish species, it came to know that salmon GnRH peptide was more effective in cultured fishes. Also, information on dopaminergic inhibition on GnRH and GtH release into the pituitary gland was demonstrated by Peter and his team. This findings led to use of GnRH peptides along with dopamine antagonists like pimozide and domperidone for induced finfish breeding, the method known as LINPE technique. To induce multiple spawning, slow release medium like cholesterol and cocoa butter was used to deliver GnRH peptides in peripheral fish blood, which resulted in sustained GtH surge. In the market, GnRH based analogues along with dopmaine antagonists are sold in the name of Ovaprim, Ovatide, WOVA-FH, Ovapel etc. This sustained surge of pituitary hormones result in mutiple spawning during the natural spawning season of cultured fishes. Unlike CPE and HCG, GnRH analogue products act on the pituitary gland to release gonadotropins, which in turn results in sex steroid surge driving final stages of gametogenesis in females and males. Presently, the fourth generation of hormones include use of central neuropeptides namely kisspeptins, neurokinin B and dynorphin for induced breeding. This central peptides when administered alone or along with dopamine receptor antagonists act on the pituitary gland to potentiate the action of GnRH stored in the pituitary gland and also the release of GtH into the peripheral blood to regulate gametogenesis.

In recent years, with the advancements in the field of biotechnology, recombinant hormones of the above generation of inducing hormones have been tested and shown to be successful in the laboratory level. However, commercial scale application of recombinant reproductive hormones are not available. Studies on recombiant fish gonadotropins have been evaluated in number of fish species like carps, catfishes, tilapia and goldfish. Also, recombinant GnRH protein has been evaluated in goldfish. In the Indian context, cost effective inducing agent need to be tested for commercialization as aquafarmers are presently using third generation GnRH based analogues for induced fish breeding except the state of West Bengal where fish farmers are preferring to use first generation pituitary extract for induced breeding.

Among the above inducing agents for finfish breeding, there is great scope for promoting use of pituitary gland extract for Indian aquafarmers as successful results have been observed in the state of West Bengal through pond and bundh breeding. A major constraint in the current scenario is lack of pituitary gland bank in the country unlike a separate pituitary gland market exisitng in the state of West Bengal. In the consumer point of view, synthetic hormones are unsafe for fish breeding and human consumption. In light of the above, there is an urgent need for establishment of fish pituitary gland bank in the country particularly in the state of Tamil Nadu where there are more than 40 fish seed production centres.

*The contents included in the article is authors personal opinion.

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POLYCHAETE WORMS

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INTRODUCTION

The Polychaeta or polychaetes are a class ofannelid worms, generally marine. Morethan 10,000 species are described in this class. Common representatives include the lugworm (*Arenicola marina*) and the sandworm or clamworm *Nereis*. Polychaetes as a class are robust and widespread, with species that live in the coldest ocean temperatures of the abyssal plain, which tolerate the extreme high temperatures near hydrothermal vents.

Keywords : Aquaculture, Habitat, Life cycle, Polychaete, Sustainability.

BIOLOGY

Each body segment has a pair of fleshy protrusions called parapodia that bear many bristles, called chaetae, which are made of chitin. They are segmented worms, generally <10cm (3.9 inches) in length, although ranging at the extremes from 1mm (0.039 inches) to 3 m(9.8 ft). They are often brightly colored and may be iridescent or even luminescent. Each segment bears a pair of paddle-like and highly vascularized parapodia, which are used for movement, in many species, act as the worm's primary respiratory surfaces. Polychaetes are those that crawl along the bottom, but others have adapted too many different ecological niches, including burrowing, swimming, pelagic life, tube-dwelling or boring, commensalism, and parasitism, requiring various modifications to their body structure. The head or prostomium, is relatively well developed, compared with other annelids.It projects forward over the mouth, which therefore lies on the animal's underside. The head normally includes two to four pairs of eyes, although there are some blind species. The outer surface of the body wall consists of a simple columnar epithelium covered by a thin cuticle.

Polychaetes have 3 types of life style

- ✓ Errant or free living. Ex: *Nereisvirens.*
- ✓ Burrowing. Ex: *Arenicolalumbricoides*
- ✓ Tube dwelling. Ex: *Eudistyliagigantea*

FEEDING

The mouth of polychaetes varies in form depending on their diet, since the group includes predators, herbivores, filter feeders, scavengers, and parasites. In general, however, it possesses a pair of jaws and a pharynx that can be rapidly everted, allowing the worm to grab food and pull it into the mouth.

IMPORTANCE OF POLYCHAETES

The importance of polychaetes in aquaculture industry is as live feed for varieties of cultivable species. Polychaetes as alive feed can stimulate gonad maturation during spawning in hatchery-reared species, e.g., *Soleavulgaris, Soleasenegalensis*, *Penaeus kerathurus*, and *Penaeusvannamei*.

The other main point of the culture is to reduce the substrate-harvesting disturbance and the great bio geo-chemical and benthic community impact as they are used as commercial bait.

CULTURE

Collections of Brood Stocks, Breeding, and Development Adult worms are collected from the habitat. Adults are gravid from April or May to October. The worms can be kept in room temperatureaerated aquaria in 32ppt artificial seawater and adults sexed according to the colour of their game to genicparapodia. Adult male and female worms are best kept in separate tanks to prevent premature spawning. Separation of adult male and female are easier in tube dwelling polychaetes. Oocytes are obtained by cutting off a single parapodium from a gravid female and emptying the contents (several thousand eggs) into 150µm screen immersed in 0.2-µm filtered artificial seawater (FASW) at 32ppt salinity in 35mm petri dish. Oocytes are washed through this screen; retained mucous and parapodial fragments are discarded. The sieved oocytes are washed three more times by transferring them into 100mm petri dishes of fresh FASW and then incubated in FASW for about 40 min before fertilization to allow for germinal vesicle break-down. Sperm is prepared by cutting off the parapodium of a ripe male without allowing the contents to mix with seawater. The “dry sperm” is extracted with a Pasteur pipette and diluted 1:1000 with FASW. This sperm suspension is examined through a stereo microscope, and when the sperm are seen to be motile, 1–3 drops are added to the eggs in a 100mm petri dish. Swimming ciliated blastulae develop by12h at room temperature (21–23℃). These blastulae may then be transferred to the culture apparatus. In many interstitial polychaetes, fertilization is internal and its embryos are brooded inside the mother’s tube. This makes obtaining early embryonic stages difficult, because gametes are not easily harvested for in vitro fertilization. Most of the tube-dwelling polychaetes have early swimming larvae in the development stages.

FOOD FOR POLYCHAETES

After 20–25 days, they have to feed daily, because of cannibalism activity. Attempts to use commercially available aquarium food, such as the liquid invertebrate food or dried rotifers, resulted in excessive bacterial growth in the colonies and poor survival of the polychaete. Several types of algae can be used, but *Dunaliellasalina*, a green alga, and *Isochrysisgalbana*, a golden-brown alga, give adequate nutrition, and they are easy to maintain in culture.

LIFE CYCLE OF POLYCHAETES

Life cycle of polychaetes includes trocophore, metatrochophore, nectochaeta. Bristle worms, also known as polychaetes, have separate sexes. Each worm produces either sperm or eggs. To reproduce, many adult polychaetes of the same species gather near the water's surface at the same time and release their gametes into the water. This synchronized release increases the chances of sperm meeting eggs. The fertilized eggs hatch into trochophore larvae. These larvae are tiny, transparent animals that can move around in the water. Early-stage trochophore larvae are shaped like pears and are about 300mm long. They have a ring of hair-like cilia around their bodies, which helps them to swim. As the larvae grow, their bodies become longer and they develop segments behind their heads. Each segment along their body develops a pair of fleshy flaps called parapodia. These parapodia will eventually become the legs of the adult worm. The larvae also develop a complete digestive system, including a mouth, stomach, intestine, and anus. Adult polychaetes typically live in areas like estuaries and below the low-tide line. In these soft-bottomed environments, polychaetes play a vital role by churning up the sediment. This process, called bioturbation, helps to keep the sediment healthy and allows oxygen to flow through it.

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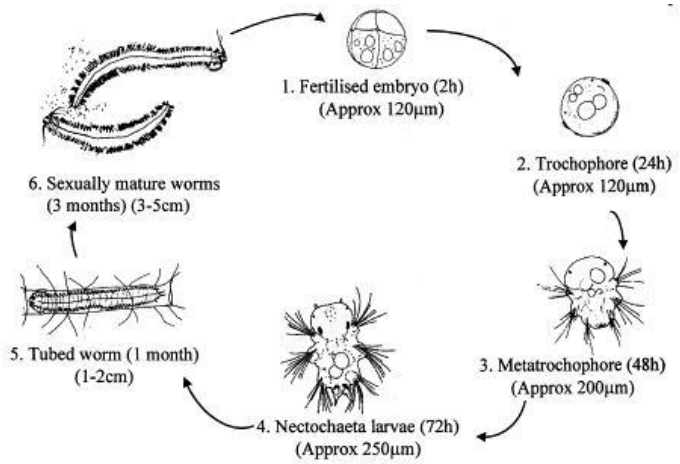

ADVANTAGES

- ✓ Their rich protein and lipid content, as well as essential vitamins and minerals, can contribute to the health and growth of cultured species.
- ✓ Other potential uses of "polychaetes" include being a food attractant in the diet of pets and fish due to the high concentration of glycosaminoglycans (GAGs).
- ✓ Their burrowing activities aerate sediments, facilitating the growth of microorganisms.
- ✓ *Hedistediversicolor* could be a potential species for biogas production, due to its nutritional characteristics.
- ✓ Numerous studies suggest that "polychaetes" have medical applications for humans.
- ✓ Polychaetes act as bioremediators, helping to remove organic waste and excess nutrients that can pollute the water.
- ✓ Polychaetes participate in nutrient cycling and sediment stabilization.

DISADVANTAGES

Countries that harvest these species without any management plans result in overexploitation and modification of the biotic and abiotic characteristics of their habitat and environment, such as with the release and exposure of ammonium and phosphorus compounds that favour eutrophication.

CONCLUSION

Polychaetes have various advantages in terms of production, efficiency and susceptibility. Raising polychaetes to feed farmed fish is a great idea for the aquaculture industry. It can help them raise fish more efficiently and in a more eco-friendly way. Since the demand for these worms is growing, now is a good time to improve the techniques for raising them.

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SLOW AND CONTROLLED RELEASE FERTILIZERS: A PRECISEWAY TO MINIMIZE NUTRIENT LOSS FROM SOIL THROUGH INCREASING FERTILIZER USE EFFICIENCY

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Abstract

The adoption of advanced fertilizers presents a promising avenue to improve the efficiency of conventional fertilizer use while mitigating environmental impacts. This article explores about two special types of modern synthetic fertilizers: Slow-Release Fertilizers (SRF) and Controlled Release Fertilizers(CRF). While SRFs gradually release nutrients through a coating barrier, CRFs release nutrients in a controlled, delayed manner. Mechanisms of controlled release, such as the multi-stage diffusion model proposed by Liu and Shaviv, highlight the complexities involved. These advanced fertilizers offer advantages such as reduced nutrient loss, lower application frequency, and enhanced fertilizer use efficiency (FUE). Notably, CRFs have shown effectiveness in improving nitrogen use efficiency (NUE) and reducing nitrogen losses in rice cultivation. By addressing issues like nutrient leaching and volatilization, controlled and slow-release fertilizers contribute to sustainable agricultural practices and increased crop productivity.

1. Introduction

The adoption of advanced fertilizers has been touted as a rewarding pathway to both uplift the efficiency of the use of existing traditional fertilizer and minimize the detrimental environmental impacts. Contrasting to the conventional method, advanced fertilizers have plenty superior traits, such as reducing the rate of loss in fertilizer, lowering the frequency of applying the fertilizer, providing the nutrients in a sustainable manner, increasing Fertilizer Use Efficiency (FUE) and reducing the potential negative effects of overdose. Currently, there are two types of synthetic modern types of fertilizers need to be brought under limelight for precision agricultural purpose: **a. Slow-Release Fertilizers (SRF)**, and **b. Controlled Release Fertilizers (CRF)**.The terms "controlled release fertilizer" (CRF) and "slow release fertilizer" (SRF) are often considered synonymous. However, Trenkel and Shaviv have delineated distinctions between the two:

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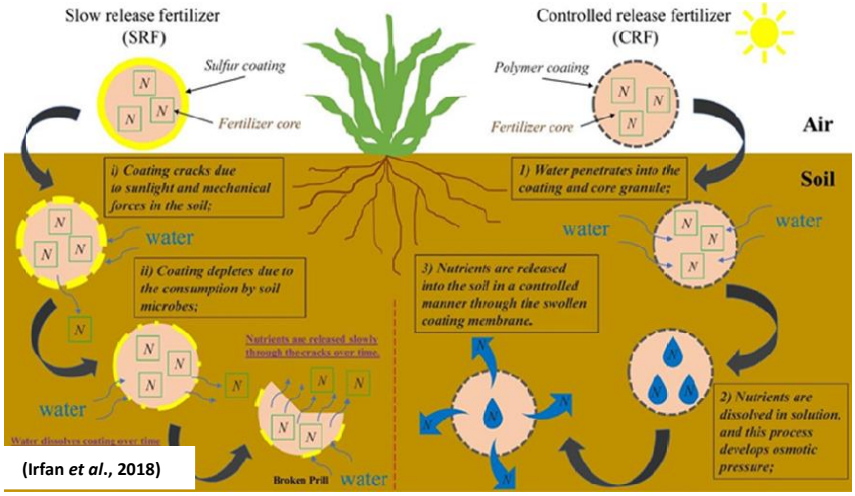


(Irfan *et al*., 2018)

2. Slow Release Fertilizer (SRF)

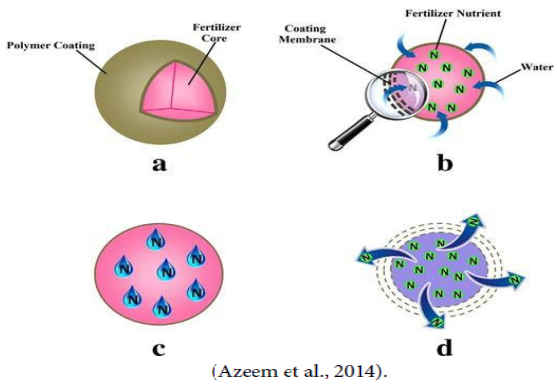
Slow Release Fertilizers (SRF) are granular fertilizers containing a nutrient core surrounded by a coating, which can be made of inorganic or organic materials. The coating material can also itself be a nutrient (i.e. Sulphur coated fertilizers etc.) This coating acts as a barrier to prevent rapid nutrient release upon application to the soil. Due to environmental factors such as sunlight, water, microbial activity, and by the action of mechanical forces in soil, the coating degrades over time, resulting in gradual nutrient release. The release of nutrients from SRFs is slower as compared to conventional water-soluble fertilizers, but it's release is unpredictable and influenced by soil and climate conditions as well as microbial activity. However, the nutrient release pattern, timing and duration aren't under strict control incase of SRFs. (Trenkel, 2010).

3. Controlled Release Fertilizers (CRF)

Controlled Release Fertilizers (CRF) consist of granules containing a nutrient core encapsulated in either inorganic or organic materials, such as polymers or non-polymers. This encapsulation forms a barrier, preventing the rapid release of nutrients which is known as the **'burst effect**.' Nutrients are released in a controlled and orderly manner based on the metabolic needs of the plant. The release rate is determined by the physical and chemical properties of the coating. CRF sare designed to release nutrients gradually and in sync with the plant's nutrient requirements. The term "**Controlled-Release Fertilizer**" asserted by Shaviv (2005), became popular to describe fertilizers where the rate, pattern, and duration of release are well-understood and manageable during production. An ideal CRF should be coated with an eco-friendly natural or semi natural macromolecule material that slows down nutrient release to fulfill a model crop's needs with a single application (Azeem *et al*., 2014).

4. Mechanism of controlled release:

Various mechanisms for the release of coated fertilizers have been proposed and are still being refined. Liu and Shaviv introduced the **Multi-stage diffusion model** to explain this process. According to this model, when coated fertilizer is applied and irrigated, water seeps into the coating, causing the solid fertilizer core to absorb moisture and partially dissolve. As a result, osmotic pressure builds up



(Azeem et al., 2014).

inside the granule, leading to two possible outcomes**: Catastrophic Release (Failure Mechanism)** or **Diffusion Release.** Catastrophic release occurs when the osmotic pressure exceeds the membrane's resistance threshold, causing the coating to burst and the core to be rapidly released. This typically happens with fragile coatings like sulphur. On the other hand, polymeric coatings such as polyolefin utilize the diffusion release mechanism. The core is gradually released through the intact membrane via diffusion as the membrane is capable of withstanding pressure buildup.

5. Role of Controlled Release Fertilizers in enhancing Fertilizer Use Efficiency (FUE):

The Fertilizer Use Efficiency (FUE) is a measure of the potential of an applied fertilizer to increase the productivity and utilization of the nutrients present in the soil/plant system. FUE indices are mainly used to assess the effectiveness of nitrogen (N), phosphorus(P), and potassium (K) fertilization. The most important nutrient in crop production is N. Hence, most scientific research focuses on improving the nitrogen use efficiency (NUE) (Barlog, 2023). The average nitrogen-use efficiency (NUE), especially through chemical fertilizers such as urea, in India ranges from 20 to 50% for rice. Currently, it is assumed that recovery of N from applied fertilizers is at the low level of just 30–50% (Fixen *et al*., 2015).

"Urea is the most commonly used fertilizer worldwide.". When applied to the soil, conventional urea undergoes a series of biological, chemical and physical transformations to produce plant available nutrients as follows -

$$(NH_2)_2CO + 2H_2O \xrightarrow{\text{Urease}} (NH_4)_2CO_3 \quad (1)$$

$$(NH_4)_2CO_3 + 2H^+ \xrightarrow{\text{Ammonification}} 2NH_4^+ + CO_2 + H_2O \quad (2)$$

$$2NH_4^+ + 3O_2 \xrightarrow{\text{Nitrosomonas/nitrosococus bacteria}} 2NO_2^- + 2H_2O + 4H^+ + \text{Energy} \quad (3)$$

$$2NO_2^- + O_2 \xrightarrow{\text{Nitrobacter bacterium/nitrification}} 2NO_3^- + \text{Energy} \quad (4)$$

$$NO_3^- \xrightarrow{\text{Microorganisms/}O_2\text{deficient soil}} N_2 + N_2O \quad (5)$$

$$NH_4^+ \xrightarrow{\text{Urease enzyme/Basic soil pH}} NH_3(g) + H^+ \quad (6)$$

The 2nd and 4th reactions produce required nutrients for plants. Since plants need only a small quantity of food during early growth, excess nutrients are lost due to leaching. In the 5th and 6th reactions, the nitrogen is lost through hazardous gaseous emissions. So the Nitrogen Use Efficiency get reduced. Under the circumstances , too improve the Nitrogen Use Efficiency with an enhanced crop productivity, a better form of Controlled/Slow Release Urea (CRU/SRU) rather than conventional urea is strictly required. The use of coated fertilizers help in delayed and synchronized release of nutrients, preventing:

i. The leaching losses of nutrients.
ii. Volatilization losses of nutrients.
iii. Fertility erosion of nutrient.
iv. Excessive application of fertilizers.

Zhang *et al.,* 2016 also reported that Controlled-release fertilizers have played significant roles in increasing grain yield and N use efficiency and decreasing N losses of rice.

6. Conclusion

The adoption of advanced fertilizers, specifically slow-release fertilizers (SRF) and controlled-release fertilizers (CRF), presents a promising pathway to enhance fertilizer use efficiency (FUE) while minimizing environmental impacts. While SRFs rely on the gradual breakdown of the coating material to release nutrients, CRFs employ a controlled, delayed release mechanism through various encapsulation materials. The mechanism of controlled release, proposed by Liu and Shaviv, involves a multi-stage diffusion model, offering both catastrophic release and diffusion release pathways. These advanced fertilizers hold potential in reducing nutrient losses, enhancing nutrient availability to plants, and mitigating environmental risks associated with conventional fertilizers. It is worth noting that CRFs have proven it's effectiveness in enhancing crop yield, Nitrogen Use efficiency (NUE), and reducing nitrogen losses from paddy field. Controlled and slow-release fertilizers contribute to sustainable agriculture practices by addressing issues such as nutrient leaching, volatilization losses, and excessive fertilizer application while increasing crop productivity and farmer's profitability.

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BACKYARD POULTRY FARMING IN INDIA

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Backyard poultry is an age-old practice in rural places of our country, wherein small numbers of native chickens are reared by farmers either for domestic consumption or for game purpose. Backyard poultry contributes about 17.8% (18.41 billion) of the total egg production (103.32 billion) of India (BAHS 2019). Of the total egg production, the native fowls produce about 11.9 billion eggs, the improved fowl lay about 5.19 billion eggs. India ranks 3rd in egg production and 5th in meat production in the world and the per capita availability is 79 eggs and 3.12 kg chicken meat per annum. The availability of eggs and chicken meat is highly variable in different parts of the country (Chatterjee and Rajkumar 2015). Indian states with the highest poultry population is Tamil Nadu (120.8 million) followed by Andhra Pradesh (107.9 million) while, West Bengal accounts to 77.3 million (Statista, 2023).

Backyard Poultry

Backyard poultry farming comprise of basically low or no input, primarily depending on scavenging feeding system, little supplementary feeding, minimum health care and mere night shelter (Islam et al. 2020) in turn are slow growers and lay few eggs. The birds are raised in small units (10–20 birds per household) primarily for family consumption and gaming purpose. The birds resembling the native varieties have long shanks multicolored plumage, good adaptability, and better immunity. Plumage color and comb type are the important traits, which determine consumer acceptability and market demand (Rajkumar et al. 2010). Some of the morphological features plumage colour, comb pattern, adaptability and growth performance have been identified as breeding goals for development of rural chicken varieties (Neeteson *et al.* 2023). These have been achieved through selective breeding of indigenous breeds and crossbreeding of selected lines to develop rural chicken varieties (Haunshi *et al*. 2015a). Crossbred chicken varieties like *Gramapriya, Vanaraja* etc. have been developed using selective breeding of exotic germplasm and are being successfully propagated to rural and tribal backyards for sustainable production and incomes (Rajkumar *et al*. 2018b). Some of the chicken breeds suitable for backyard poultry farming are given below.

Table 1: Some of the popular crossbred varieties for backyard poultry farming

Aseel	Multicolored plumage with black glossy tail feathers. The males and females weigh 1841±20.7 and 1381±18.2 gms at 20 weeks old. Females lay around 64 eggs at 72 weeks old (Rajkumar et al., 2017)
Ankleshwar	Found in the Gujarat region, these birds are white and light grey to brown color with golden-colored tail feathers. **Body weight at 72 weeks-**1.6 to 1.7 kg, **annual egg production of** 81 eggs
Kadaknath	Black-colored plumage weighing 769.1±12.4 gms in females. They are good layers laying 105 eggs at 52 weeks old (Haunshi et al., 2011)
Bursa	Found in Gujarat-Maharashtra border are popular chicken breeds in India due to their exceptional meat quality
Chittagong	Are found in North Eastern states are **gaming bird. C**ock weighs about 3.5 to 4.5 kg, and the hen around 3 to 4 kg **at 72 Weeks**
Gramapriya	It is developed by ICAR- Project Directorate on Poultry, Hyderabad; layer type variety with a production potential of lay 256 eggs in free-range conditions
Haringhata Black	It is found in West Bengal, having compact small body with an annual **egg production-** 130 eggs, The cock weighs around 1.5 kg, and the hen around 1.2 kg a**t 72 Weeks**
Swarnadhara	Developed by Department of Avian Production and Management (DVPM), Hebbal, Bangalore. Hardy birds having high egg production potential along with better growth, suited for mixed and backyard farming, lay about 180-190 eggs in a year
Nicobari	It is found in Nicobar group of islands. The **annual egg production is** 150 eggs, cock weighs around 1.2 kg, and the hen around 0.9 to 1 kg **at 72 weeks**
Giriraja	It was developed by Karnataka Veterinary, Animal, and Fishery Sciences University in Bangalore. The hens lay 130-150 eggs per year with good hatchability
Ghagus	Its native tract is located in Kolar district of Karnataka and adjoining border areas of Andhra Pradesh and Karnataka. It is a medium size bird with good mothering ability and broodiness character mainly meat type game purpose birds. It has Brown plumage with black and white feathers. The hens lays 15 to 20 eggs in a laying cycle of 25 to 30 days
Punjab Brown	It is a dual purpose breed in rural areas of Punjab and Haryana. The males weigh 2.50 kg and the females weigh 1.57 kg. Females lay around 60 to 80 eggs.
Tellicherry	Tellichery breed is native to Malabar region of Kerala wit back to grey plumage colour. Eggs are tinted having brown shell and lays around 60 to 80 eggs annually.
Vanraja	It was developed by ICAR- Project Directorate on Poultry Hyderabad. Males weigh about 1.2 to 1.5 kg at 10 wks and females lay about 120-140 eggs in laying year, lays large brown eggs
CARI NIRBHEEK (Aseel Cross)	It was developed by ICAR- Central Avian Research Institute (CARI), Izatnagar. Aseel is well known for its pugnacity, high stamina, and majestic gait, standard weight varies from 3- 4 kg for cocks and 2 - 3 kg for hens, Age at sexual maturity (days) 196 days, annual egg production of 92 eggs

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CARI SHYAMA (Kadakanath Cross)	It was developed by ICAR-Central Avian Research Institute (CARI), Izatnagar locally known as "Kalamasi" meaning the fowl having black flesh, reared by tribals. It has black and silk white feathers with a body weight at 20 weeks of 920g, age at sexual maturity is 180 days and annual egg production is 105 eggs
HITCARI (Naked Neck Cross)	This was also developed by ICAR-Central Avian Research Institute (CARI), Izatnagar. Larger in built with long cylindrical neck which is fully naked or only a tuft of feathers is seen on the front of the neck above crop, body weight at 20 weeks is 1.00Kg , age at sexual maturity at 201 days and annual egg production of 99 eggs

Rearing of Birds

There are two phases of backyard poultry rearing, i.e., nursery and free-range rearing activity.

1. *Nursery rearing:* The chicks are raised artificially by providing warmth and feed. Rearing is done till until they grow enough to scavenge which is usually practiced up to 4–6 weeks of age. Since the chicks will be raised under confinement, balanced feed containing required protein, energy, essential amino acids, vitamins and minerals should be provided to ensure optimum growth of the birds.

2. *Free-range rearing:* The chicks are left in the backyard at 4–6 weeks of age. The size of the birds depends upon the available area and natural food. However, a unit with 15 to 20 birds per household is ideal for the successful and effective management of birds. During the daytime the birds are left out for foraging and during the night time they are kept in houses. Supplementary feeding is essential for optimum productivity. Little amount of cereal grains like corn, broken rice, sorghum, and millets and oilcakes must be provided as their protein requirement are met through scavenging on insects, worms etc. If the bird is in a laying stage, calcium supplementation through shells or lime powder must be provided to avoid the production of shell-less eggs and broken eggs.

Production systems

In India, backyard poultry farming is practiced prominently in four different systems.

1. *Traditional backyard system*: This system is an age old practice in rural village with few number (less than 20) of birds and little or no inputs.

The eggs are used for hatching to provide replacement birds in this system however, the number of birds may be increased upto 50 provided that there are sufficient scavenging areas.

2. *Semi-intensive farming*: This system has a flock size of 50-200 or more where birds are reared under semi-scavenging type with supplementation of 30–40% of feed requirements. Supplementary feed is offered generally in the evening depending upon the availability of natural food reserve in a specific area. This type of system is practiced in orchards and gardens with a poultry house as night shelter or shade during sunny days and a free-range area for scavenging during day time.
3. *Small-scale intensive farming*: This Small-scale intensive farming comprises more than 200 to a few thousands of birds, which are reared by providing all the inputs like the intensive broiler farming till they attain a body weight of 1.5 kg. This kind of farming is for meat purpose using fast-growing varieties like Krishibro, Vanaraja, Srinidhi and Rainbow Rooster.
4. *Native chicken farming* : These are the indigenous birds raised for meat and eggs fetching good price for meat and eggs. Though they are slow growers and poor layers, they are ideal mothers and good sitters, excellent foragers, hardy, and naturally immune to common diseases (Rajkumar et al. 2017). The birds are reared upto 3-5 months under intensive farming with a run are and provided complete ration.

Housing

Backyard poultry needs proper housing such as night shelter for protection from predators or adverse weather conditions. The typical poultry house is usually made with locally available materials like wood, bamboo, granite, mud, and thatched roof in India. Small-scale and intensive poultry shed have asbestos roof, concrete walls, and wire mesh for cross ventilation. The ideal floor space should be 1 sq.ft. during the growing phase and about 2–2.5 sq.ft. for the layers.

Health management

Vaccination of birds for common diseases should be advocated. However, the birds are exposed to many pathogens such as avian influenza, fowl pox, infectious bronchitis, infectious bursal disease, and Marek's disease that can cause significant mortality and morbidity. Bacterial diseases may also have a significant impact on the health and productivity of birds, which can be prevented by proper biosecurity and customized treatment. A pragmatic way is to immunize the birds with vaccination, which is again a constraint under the scavenging system. Veterinary services, vaccination, health management, and predator attack were some of the constraints experienced by the farmers in India (Rajkumar et al. 2010). The common diseases prevalent are Newcastle disease (ND) and fowlpox (FP), particularly in the hot and humid coastal regions for which periodic vaccination with local strains is advocated globally. The birds are exposed to a high degree of pathogen load under free-range scavenging conditions and need to be monitored for health disorders regularly. Considering the obvious limitations, it is recommended to practice mass/community vaccination with the help of NGOs, para vets, and other line departments for effective control of viral diseases. Another major health challenge are the parasitic (both external and internal) infestation due to constant exposure to the contaminated feed and water. Therefore, periodic mass de-worming is practiced at 6 monthly intervals to reduce internal parasites. Infestation with internal parasites and bacterial pathogens can be largely minimized by providing fresh drinking water during the early hours before the birds leave for scavenging. The

water, mostly from sewerage in the backyards is the potential source of parasites like nematodes, cestodes, and trematodes, which infect the poultry and cause substantial losses to the farmers. External parasitic infestation from lice, flies, fleas, bugs, and mites is very common in night shelters or poultry houses with a moist wet floor and poor ventilation (Calnek et al. 1991). Keeping the poultry houses dry with proper cross ventilation minimizes the risk of external parasites.

The backyard poultry farming has huge potential in enhancing the nutrition availability through eggs and meat in the rural and tribal areas, besides generating employment and a supplementary income, and empowering women. But there are few challenges for maintenance of emerging diseases, nutrient deficiencies, predation, marketing, and erosion of indigenous breeds. Community based approaches in taking care of the biosecurity, health care and creation of marketing channels would reap the maximum benefits from backyard poultry farming.

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THE ART OF MODEL HOPPING: A GUIDE TO REVERSIBLE JUMP MCMC

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Introduction

In statistics, Markov chain Monte Carlo (MCMC) is a class of algorithms used to draw samples from a probability distribution. Given a probability distribution, one can construct a Markov chain whose elements' distribution approximates it – that is, the Markov chain's equilibrium distribution matches the target distribution. The more steps that are included, the more closely the distribution of the sample matches the actual desired distribution.
Basic principles of MCMC:

- **Ergodicity**
- **Balance condition** : $p(x)T(y \to x) = p(y)T(x \to y)$

MCMC methods are incredibly powerful tools for sampling from complex probability distributions, especially when direct sampling methods are not feasible due to the complexity of the distribution or its high dimensionality. By constructing a Markov chain that converges to the desired distribution, MCMC allows us to generate samples that closely approximate the target distribution. This makes MCMC methods widely used in various fields including statistics, machine learning, physics, and Bayesian inference.

MCMC methods are primarily used for calculating numerical approximations of multi-dimensional integrals, for example in Bayesian statistics, computational physics, computational biology and computational linguistics.

In Bayesian statistics, Markov chain Monte Carlo methods are typically used to calculate moments and credible intervals of posterior probability distributions. The use of MCMC methods makes it possible to compute large hierarchical models that require integrations over hundreds to thousands of unknown parameters.

Some common MCMC algorithms are

1. Metropolis Hastings Alogrithm
2. Gibbs Sampling
3. Hamiltonian Monte Carlo
4. Reversible Jump

Reversible Jump MCMC

MCMC methods for Bayesian computation have until recently been restricted to problems where the joint distribution of all variables has a density with respect to some fixed standard underlying measure. Reversible Jump Markov Chain Monte Carlo (RJMCMC) is an extension of traditional MCMC methods that allows for model selection in a Bayesian framework. It's particularly useful when the number of parameters in the model is unknown or variable, as it enables the exploration of different model spaces. It is a generalization of the MH algorithm with dimension

jumping moves allowed. It is used where the dimensionality of the parameter vector is typically not fixed. It is wide applicable in model determination problems.

Procedure

We want to make a move from x ∈ℝk to x′∈ℝk′. We will again use random variables W and W′ and a function h that takes (x, w) to (x′,w′) in a smooth, continuous bijection. To this end, we may need to "Pad out" w or w′ with auxiliary variables to final lengths of d and d′, respectively.The following dimension matching requirement holds: **k + d = k′ + d′**

RJMCMC (Bayesian Model Selection) Example

Suppose that we have some count data $X_1, X_2, \dots, X_n$ that we believe is either from a Poisson distribution or a negative binomial distribution. In a Bayesian context, we may want to select the appropriate model based on some prior expert opinion about which model should be used and its parameters. Alternatively, if we reparameterize one or both models so that they have parameters with common interpretations, our Bayesian selves might want to return an estimate of parameter means, weighted by posterior model probabilities.

- Model 1: $X_1, X_2, \dots X_n \sim Poisson(\lambda)$ with
  $P(X_i = x) = \frac{e^{-\lambda}\lambda^x}{x!} I_{\{0,1,2,\dots\}}(x)$; mean (λ)
- Model 2: Negative binomial distribution with
  $P(X_i = x) = \binom{r+x-1}{x} p^r (1-p)^x I_{\{0,1,2,\dots\}}(x)$; $0 \leq p \leq 1$ and

r∈ {1,2, …} ; mean $\left(\frac{r(1-p)}{p}\right)$

- This can be generalized to non integer r > 0 by writing the pdf as
  $$P(X_i = x) = \left(\frac{\Gamma(r+x)}{x!\,\Gamma(r)}\right) p^r (1-p)^x I_{\{0,1,2,\dots\}}(x)$$

In order to force a common parameter, which is only necessary if we want to give a model averaging result, we will take **p = r/(λ + r).** Model 1 parameterized by λ > 0 has mean λ and Model 2 parameterized by λ > 0 and r > 0 also has mean λ. Thus, we have a parameter with an interpretation that is the same for both models.Let K ∈ {1, 2} denote the model number. We have likelihoods given by $\pi(\vec{x}|k, \overrightarrow{\theta_k})$. When k = 1, we are in the Poisson model with $\overrightarrow{\theta_1} = \theta_1 = \lambda$. The likelihood is

$$\pi(\vec{x}|1, \overrightarrow{\theta_1}) = \pi(\vec{x}|1, \lambda) = \prod_{i=1}^{n} \frac{e^{-n\lambda}\lambda^{\sum x_i}}{x_i!} = \frac{e^{-n\theta_1}\theta_1^{\sum x_i}}{\prod x_i!}$$

When k = 2, we are in the negative binomial model with $\overrightarrow{\theta_2} = (\theta_{21}, \theta_{22}) = (\lambda, r)$. The likelihood is

$$\pi(\vec{x}|2, \overrightarrow{\theta_2}) = \pi(\vec{x}|2, \lambda, r) = \prod_{i=1}^{n} \frac{\Gamma(r+x_i)}{x_i!\Gamma(r)} \left(\frac{r}{\lambda+r}\right)^r \left(\frac{\lambda}{\lambda+r}\right)^{xi}$$

Let π(k) denote a prior distribution over models. For example, we may a priori believe that

$$\pi(k) = \begin{cases} \frac{1}{2}, & k = 1 \\ \frac{1}{2}, & k = 2 \end{cases}$$

Let $\pi(\overrightarrow{\theta_k}|k)$ denote a prior distribution for the parameters for Model k. For example, we may have a priori that $\pi(\overrightarrow{\theta_1}|1) = \pi(\vec{\lambda}|1) = \Gamma(\lambda; \alpha_\lambda, \beta_\lambda)$ where Γ(x; α, β) denotes the gamma density with shape parameter α and inverse scale parameter β.Similarly for model 2 also.The target distribution for our RJMCMC simulation will be the posterior distribution:

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$$\pi(k, \overrightarrow{\theta_k}|\vec{x}) \propto \pi(\vec{x}|k, \overrightarrow{\theta_k})\,\pi(\overrightarrow{\theta_k}|k)\,\pi(k) = \begin{cases}\pi(\vec{x}|1, \overrightarrow{\theta_1})\,\pi(\overrightarrow{\theta_1}|1)\,\pi(1), & k=1\\ \pi(\vec{x}|2, \overrightarrow{\theta_2})\,\pi(\overrightarrow{\theta_2}|2)\,\pi(2), & k=2\end{cases}$$

The Moves

We will propose a move from x = (k, $\overrightarrow{\theta_k}$) to x′ = (k′ , $\overrightarrow{\theta_k}'$) in a way that assumes that holds. To this end, we will assume that the transition density q(x, x′) = q((k, $\overrightarrow{\theta_k}$), q)(k′, $\overrightarrow{\theta_k}'$) has the form

$$q((k,\overrightarrow{\theta_k}), q)(k', \overrightarrow{\theta_k}') = q(\overrightarrow{\theta_{k'}}|\ \overrightarrow{\theta_k}, k, k') \cdot q(k'|k)$$

Transitions from the current state x = (k, $\overrightarrow{\theta_k}$) will be proposed as follows:

i. Choose k′ from q(k′|k)

ii. Choose $\overrightarrow{\theta_{k'}}$ from q($\overrightarrow{\theta_{k'}}$| $\overrightarrow{\theta_k}$, k, k′).

Model 1 to Model 2

Model 1 to Model 2 (i.e. k = 1 and k′ = 2).

x = (1, θ) = (1, λ) to x′ = (2, θ′) = (2, λ′, r′).

The proposed transition is our choice and we will choose to keep the λ for x′ as it was in x (i.e. to set λ′ = λ) and to propose an independent r′∼exp(rate = 1). We can generate r by the inverse cdf method by generating w ∼unif(0, 1) and setting r = − ln w.

θ′ = (λ′, r′) = h(λ, w) = (λ, − ln w)

Note that (λ, w) is two-dimensional and (λ′, r′) is two-dimensional. (Dimension matching check!).The reverse move would be to set (λ, w) = h′(λ′ , r′)= (λ′ , $e^{-r'}$)

Stepwise Procedure for RJMCMC

i. Draw w ∼unif(0, 1).
ii. Set (λ′, r′) = (λ, − ln w).
iii. Compute the Jacobian

$$\frac{\delta(\lambda',r')}{\delta(\lambda,w)} = \begin{vmatrix}\frac{\delta\lambda'}{\delta\lambda} & \frac{\delta\lambda'}{\delta w}\\ \frac{\delta r'}{\delta\lambda} & \frac{\delta r'}{\delta w}\end{vmatrix} = \begin{vmatrix}1 & 0\\ 0 & 1/w\end{vmatrix} = \frac{1}{w}$$

iv. Accept the move from x = (1, λ) to x′ = (2, λ′ , r′) with probability

$$\alpha((1,\lambda),(2,\lambda',r')) = \min\left\{1,\ \frac{\pi(2,\lambda\prime\,,r\prime\,|\vec{x})\ q(k|k\prime\,)}{\pi(1,\lambda|\vec{x})\ g(w)\ q(k\prime|k)} * \left|\ \frac{\delta(\lambda',r')}{\delta(\lambda,w)}\right|\right\}$$

v. Otherwise, stay at x = (1, λ).

Applications of RJMCMC:

a. **Variable Selection**: In regression analysis or machine learning, RJMCMC can be used to determine which variables are most relevant for predicting the response variable. The algorithm explores different models with varying sets of predictor variables and their coefficients.
b. **Model Comparison**: RJMCMC can compare different models to identify the one that best fits the data. This is useful in fields such as economics, where various economic models may be compared to understand their predictive power or explanatory ability.
c. **Phylogenetics**: In evolutionary biology, RJMCMC can be used to infer the evolutionary history of species by exploring different phylogenetic trees with varying branch lengths and topologies. This helps researchers understand the relationships between different species.

d. **Signal Processing**: In signal processing, RJMCMC can be used for tasks such as deconvolution or source separation, where the number of sources or the underlying model may vary. By exploring different model configurations, the algorithm can estimate the underlying signals more accurately.
e. **Bayesian Nonparametrics**: RJMCMC is also used in Bayesian nonparametric methods, where the number of clusters or components in the data is not fixed. It can be employed in clustering tasks or mixture modeling, where the number of clusters is inferred from the data itself.
f. **Genetics and Genomics**: RJMCMC can aid in genetic linkage analysis, where the goal is to identify regions of the genome associated with particular traits or diseases. It allows for the exploration of different genetic models and their associations with phenotypic traits.

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RICE WHEAT CROPPING SYSTEM THREATS IN INDIA

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Abstract

The rice-wheat cropping system, a cornerstone of agricultural practice in India's Indo-Gangetic Plains (IGP), faces a myriad of threats jeopardizing its long-term sustainability and productivity. This system, spanning over 10.3 million hectares, has been pivotal in meeting food demands, yet its viability is challenged by declining soil health, groundwater depletion, pest and disease pressures, climate change impacts, and other multifaceted challenges. Continuous cropping pattern of rice-wheat has degraded soil quality, leading to nutrient depletion, erosion and compaction, diminishing crop yields over time. Intensive irrigation, particularly for rice, has exacerbated groundwater depletion, resulting in water scarcity and increased energy costs. Pest outbreaks and diseases, exacerbated by climate change, further threaten crop yields and increase production costs. Additionally, poor residue management, market dynamics, soil salinization, loss of biodiversity, labour shortages, input cost escalation, and land degradation contribute to the system's vulnerability. Furthermore, water pollution from agrochemicals poses risks to human health and aquatic ecosystems. Addressing these threats demands a holistic approach, integrating sustainable practices, balanced fertilizer use, crop rotation with legumes and policy interventions. Collaboration among stakeholders, government agencies, research institutions, and civil society is crucial to safeguarding the resilience and viability of the rice-wheat cropping system in India.

Keywords : Rice-wheat, cropping pattern, threats, Indo-Gangetic plains, soil health and yield

Introduction

In Asia, rice is planted in sequence with other rice crops or upland crops like wheat, maize, or legumes on more than half of the acreage used for cropping. Millions of people rely on agricultural systems centered on rice for livelihood and food security. India's Indo-Gangetic Plains (IGP) rice-wheat farming systems alone occupy 10.3 million hectares (Sharma *et al.,* 2022). Green revolution prompted rice yield, growth and area in this region which has been the primary reason for high agricultural output. This region has been able to keep up with the nation's population demand for food during the past many years. Nonetheless, this opportunity to augment the quantity of cultivable land and natural resources is fleeting (Eliazer Nelson *et al.,* 2019).It is vital to protect the land and water resources for the agriculture of the Indo-Gangetic Plains. Most agricultural scientists agree that this region's natural resources are being stressed by the rice-wheat cropping system and additional inputs like high fertilizer rate than recommended dose of fertilizer are needed to achieve the same yield levels due to degradation in soil fertility (Kumar *et al.,* 2021). The rice-wheat cropping system is a cornerstone of agricultural practice in India, particularly prevalent in the fertile plains of the Indo-Gangetic region. This system involves the sequential cultivation of rice and wheat crops within the same plot of land during a single agricultural year. Typically, rice is sown during the kharif season, utilizing abundant monsoon

rains, followed by wheat cultivation in the subsequent rabi season. This rotation not only optimizes land use but also helps in national food security. However, the rice-wheat system faces challenges such as declining soil health, groundwater depletion and climate change impacts which needs to be addressed as soon as possible.

Threats facing in the Rice-Wheat cropping system

The following significant problems are beginning to pose a danger to the long-term viability of the rice-wheat system:

Declining Soil Health: Continuous monocropping of rice and wheat has led to soil degradation, including nutrient depletion, soil erosion and compaction. This diminishes soil structure, soil fertility, productivity over time and reducing crop yields.

Groundwater Depletion: Intensive irrigation practices, particularly for rice cultivation, contribute to the depletion of groundwater resources. Over-extraction of groundwater for irrigation has led to water scarcity, lower water tables and increased energy costs for pumping, affecting the viability of the cropping system.

Pest and Disease Pressure: Continuous cultivation of rice and wheat makes crops more susceptible to pests, diseases, and weeds. Pesticide resistance, pest outbreaks and disease epidemics like problems can lead to yield losses, increased production costs and environmental pollution.

Climate Change Impacts: Rising temperatures, changing rainfall patterns and extreme weather events associated with climate change pose significant challenges to the rice-wheat cropping system. Erratic weather conditions can reduce crop yields and increase the incidence of pests, diseases and droughts. For example, CCS Haryana Agricultural University report showed that incidence of leaf folder was much higher than normal in some districts like Karnal, Kaithal and Kurukshetra due to change in rainfall pattern and time in *Kharif*, 2023 (Review of research schemes 2023-24, Rice Research Station, Kaul).

Crop Residue Management: The practice of residue burning after rice harvest contributes to air pollution, greenhouse gas emissions and soil degradation. Inadequate management of crop residues can also hinder seedbed preparation for the subsequent wheat crop, affecting germination and growth.

Market Dynamics: Fluctuating prices, input costs and market demand for rice and wheat can impact farmer profitability and economic viability. Farmers may face challenges in accessing fair prices for their produce and managing price volatility. For example, basmati, which is exported generally, is sold on bid by farmers. Sometimes export of basmati is influenced by internation market decisions which lead to uncertain prices for farmers.

Soil Salinization: In regions where irrigation water contains high levels of salts, continuous rice cultivation followed by wheat can lead to soil salinization. Excessive salt accumulation in the soil hinders plant growth, reduces crop yields and limits agricultural productivity.

Loss of Biodiversity: Monocropping of rice and wheat reduces crop diversity, which can have negative implications for biodiversity and ecosystem health. Loss of biodiversity may increase the prevalence of pests and diseases, disrupt natural pollination processes and diminish the resilience of agroecosystems.

Labour Shortages: Labour shortages, particularly during peak agricultural seasons such as planting and harvesting, pose challenges for timely farm operations in the rice-wheat cropping system. Migration of rural laborers to urban areas in search of better opportunities exacerbates this issue.

Input Cost Escalation: Rising costs of inputs such as seeds, fertilizers, pesticides, and machinery impact the profitability of rice-wheat cultivation. In India mostly farmers are smallholder farmers, in particular, they may struggle to afford expensive inputs, leading to reduced yields and farm incomes.

Land Degradation: Intensive agricultural practices including excessive tillage, chemical inputs and irrigation contribute to land degradation and loss of soil fertility. Land degradation reduces the long-term productivity and sustainability of agricultural land, posing a threat to food security and rural livelihoods.

Water Pollution: Unbalance and imprudent use of agrochemicals such as fertilizers and pesticides in rice-wheat cultivation can lead to water pollution, contaminating surface water and groundwater sources. Pollution of water bodies poses risks to human health, aquatic ecosystems and biodiversity.

Mitigating these threats requires a multi-dimensional approach that addresses environmental, social, economic and policy dimensions of agricultural sustainability. By implementing sustainable practices, balance fertilizer use, crop rotation with legumes and promoting certain policies can ensure the long-term viability and prosperity of the rice-wheat cropping system in India.

Conclusion

The rice-wheat cropping system in India faces a myriad of threats that collectively endanger its long-term sustainability and productivity. From declining soil health and groundwater depletion to pest outbreaks, climate change impacts and market dynamics, all these challenges pose significant risks to both agricultural productivity and farmer livelihoods. Moreover, issues such as soil salinization, loss of biodiversity, labour shortages, input cost escalation, and policy uncertainty further compound the complexities faced by farmers. Additionally, concerns related to land degradation, water pollution, social inequities, and global market fluctuations underscore the multifaceted nature of the challenges confronting the rice-wheat cropping system. Addressing these threats requires coordinated efforts from stakeholders, government agencies, research institutions, farmers and civil society organizations. Implementing sustainable agricultural practices, balance fertilizer use, organic manures use and promoting certain policies are essential for safeguarding the resilience and viability of the rice-wheat cropping system in India while advancing the goals of food security, environmental sustainability and rural prosperity.

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THE ROLE OF AI IN INSECT TAXONOMY

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Abstract
Insect taxonomy, the science of classifying and identifying insect species, has been profoundly influenced by the integration of artificial intelligence (AI). This comprehensive article explores the various applications of AI in insect taxonomy, highlighting recent advancements, methodologies, and potential future impacts on the field. From species identification to phylogenetic analysis and biodiversity monitoring, AI technologies such as machine learning (ML) and deep learning are revolutionizing how entomologists understand and categorize insect diversity. Through a synthesis of recent studies and developments, this article provides insights into how AI is reshaping insect taxonomy and offers perspectives on future directions and challenges.

Introduction
Insect taxonomy plays a pivotal role in comprehending the biodiversity and ecological dynamics of our planet. However, traditional methods of classifying insect species have often been laborious and time-consuming, relying heavily on manual examination and expert knowledge. With the emergence of artificial intelligence (AI), particularly machine learning (ML) and deep learning, the landscape of insect taxonomy is experiencing a profound transformation. AI technologies offer novel opportunities to automate and enhance taxonomic processes, from species identification to evolutionary analysis and conservation efforts.

This article offers a comprehensive overview of how AI is revolutionizing insect taxonomy. It examines the applications of AI in species identification, phylogenetic analysis, and biodiversity monitoring, highlighting key studies and recent advancements. By leveraging AI algorithms, researchers can process large datasets of insect images, genetic sequences, and environmental data with unprecedented speed and accuracy. These technological innovations not only streamline taxonomic workflows but also provide new insights into the evolutionary history and ecological roles of insects. Through a synthesis of recent research and developments, this article aims to elucidate the transformative potential of AI in insect taxonomy. By embracing AI technologies and interdisciplinary collaborations, entomologists can advance our understanding of insect diversity and ecology, ultimately contributing to more effective conservation strategies and sustainable management of ecosystems.

Insect taxonomy, the science branch devoted to classifying and identifying insect species, has traditionally relied on meticulous manual work and expert knowledge. However, with the emergence of artificial intelligence (AI), this field is undergoing a significant transformation. AI technologies, particularly machine learning (ML) and deep learning, are increasingly used to automate and enhance the accuracy of taxonomic practices.

This comprehensive article explores the various applications of AI in insect taxonomy, highlighting recent advancements, methodologies, and the potential future impact on the field.

AI in Species Identification

Insect species identification has historically been labor-intensive, requiring extensive expertise and detailed morphological analysis. Entomologists often depend on microscopic examination of physical characteristics such as wing patterns, body segmentation, and antenna structure. While thorough, this process is time-consuming and prone to human error.

Image-Based Identification

One of the most promising AI applications in insect taxonomy is image-based species identification. Convolutional neural networks (CNNs), a type of deep learning algorithm designed for image recognition, have shown remarkable efficacy in this domain. These networks can be trained on large datasets of insect images to recognize and classify species based on subtle visual cues.

For example, a study by Scherhaufer *et al*. demonstrated the use of CNNs to identify bee species from images of their wings. The neural network achieved an accuracy rate comparable to human experts, significantly reducing the time required for species identification. This technology holds particular promise for rapidly identifying species in large collections and field samples.

Similarly, Valan *et al*. developed an AI system capable of identifying mosquito species based on wing morphology. This system utilizes high-resolution images and sophisticated image processing techniques to differentiate between visually similar species, which may have different roles in disease transmission. The accuracy and speed of this AI system make it an invaluable tool for vector control programs, particularly in regions prone to mosquito-borne diseases like malaria and dengue.

Acoustic Analysis

In addition to visual identification, AI has been applied to the analysis of acoustic signals produced by insects. Many insects, particularly those that are nocturnal or inhabit dense vegetation, communicate or can be detected through sound. Machine learning algorithms can analyze these acoustic signatures to identify species, providing a non-invasive and efficient method for monitoring insect populations.

Potamitis *et al*. conducted a study where machine learning techniques were used to analyze the sounds produced by different insect species. By training algorithms on recorded insect sounds, the researchers were able to create models that accurately identified species based on their unique acoustic patterns. This approach is particularly useful for studying insects that are difficult to capture or observe directly.

Phylogenetic Analysis and Evolutionary Studies

Phylogenetic analysis, which involves reconstructing the evolutionary relationships among species, has also benefited greatly from AI. Traditional methods of phylogenetic analysis rely on

the comparison of genetic sequences and morphological traits, a process that can be both complex and computationally intensive.

Genetic Data Integration

AI, particularly machine learning, can handle large genomic datasets with ease, making it possible to integrate genetic data with morphological observations to construct more accurate phylogenetic trees. This integration allows researchers to uncover evolutionary relationships that might not be apparent through traditional methods alone.

For example, Zhang *et al.* utilized machine learning algorithms to analyze the genetic sequences of beetles, one of the largest and most diverse groups of insects. By combining morphological data with genomic information, the researchers were able to produce a comprehensive phylogenetic tree that provided new insights into beetle evolution. This approach not only improves the accuracy of phylogenetic studies but also helps identify evolutionary patterns that might be overlooked when using a single type of data.

Evolutionary Insights

AI-driven phylogenetic analysis is also instrumental in studying the evolutionary history of insects and understanding how different species have adapted to their environments over time. During the COVID-19 pandemic, similar AI techniques were used to track the evolution of the virus, demonstrating the versatility and power of AI in evolutionary studies.

In entomology, these techniques can be applied to track the spread and evolution of pest species, helping to develop more effective pest control strategies. For instance, AI can analyze genetic data from agricultural pests to predict their spread and develop targeted interventions to mitigate their impact on crops.

Biodiversity and Conservation

Biodiversity studies and conservation efforts have greatly benefited from AI, particularly in terms of monitoring and assessing insect populations. AI systems can process vast amounts of data collected from various sources, including field cameras, acoustic sensors, and environmental DNA (eDNA) samples, to provide real-time insights into insect biodiversity.

Automated Monitoring Systems

Automated monitoring systems equipped with AI capabilities can track insect populations in real-time, offering significant advantages for ecological research and conservation. These systems can detect changes in population dynamics, identify emerging threats, and inform conservation strategies.

A pioneering project by Carranza-Rojas et al. developed an AI-based system to automatically classify and monitor butterfly species in tropical rainforests. Using images captured by field cameras, the AI system could identify different butterfly species with high accuracy, facilitating large-scale biodiversity assessments. This automated approach not only increases the efficiency of data collection but also enhances the precision of biodiversity monitoring, which is crucial for conservation efforts.

eDNA Analysis

Environmental DNA (eDNA) analysis is another area where AI is making significant contributions. eDNA refers to genetic material collected from environmental samples such as soil, water, or air,

which can be used to detect the presence of various species. AI algorithms can process eDNA data to identify insect species present in a given habitat, providing a non-invasive and highly sensitive method for biodiversity assessment.

AI-driven eDNA analysis has been used to monitor aquatic insect populations in freshwater ecosystems. By analyzing eDNA from water samples, researchers can detect the presence of rare or elusive species, track changes in community composition, and assess the health of the ecosystem. This approach is particularly valuable for monitoring species that are difficult to observe directly, such as those living in remote or inaccessible areas.

Future Prospects and Challenges

While AI has already made substantial contributions to insect taxonomy, several challenges and future directions need to be considered. The quality and quantity of training data are critical for the accuracy of AI models. Ensuring diverse and comprehensive datasets will be essential for improving AI applications in taxonomy.

Data Quality and Diversity

High-quality training data is paramount for the success of AI in taxonomy. This includes having well-documented and accurately labeled datasets that represent the diversity of insect species. Efforts to create and share large, standardized datasets will be crucial for advancing AI technologies in this field.

Collaboration between researchers, institutions, and citizen scientists can help build comprehensive datasets. Citizen science initiatives, where the public contributes data through platforms like iNaturalist, can provide valuable data points for training AI models. These contributions can help fill gaps in existing datasets, particularly for understudied regions and species.

Integration with Molecular Techniques

Integrating AI with molecular techniques such as DNA barcoding can enhance species identification and discovery efforts. DNA barcoding involves sequencing a short, standardized region of the genome, which can be used to identify species. AI algorithms can analyze these genetic sequences to automate species identification, making the process faster and more accurate.

Future research may focus on combining morphological, genetic, and ecological data to create more holistic models for species identification and phylogenetic analysis. Such integrative approaches can provide deeper insights into the evolutionary relationships and ecological roles of insects, helping to advance our understanding of biodiversity.

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SEED PRODUCTION OF MUDCRAB IN FRP TANKS

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Introduction

The mudcrab *Scylla serrata* is a commercially important indigenous portunid crab species aquacultured in South East Asian countries including India. An advantage with *S. serrata* for brackish water aquaculture is faster growth rate and attains large in size, which fetches high price in the domestic and International market. This species can be transported in live condition from one place to another under wet condition and is a suitable species for rural as well as industrialized aquaculture in India. The major problem associated with mudcrab aquaculture is low larval survival rate in the hatchery. Presently in Tamil Nadu, Rajiv Gandhi Centre for Aquaculture, Thoduvai, Mayiladuthurai District and Central Institute of Brackish water Aquaculture, Muttukadu, Chennai are undertaking seed production of mudcrab in FRP tanks. Mostly, wild brooders are used for seed production after appropriate quarantine treatment. In recent years, availability of good quality wild brooder is a challenging area in mudcrab seed production due to decline in wild population.

In addition to the above existing hatcheries, a new pilot scale mud crab hatchery was established recently at Pulicut Research Farm Facility of Tamil Nadu Dr J Jayalalithaa Fisheries University, Pazhaverkadu under PMMSY scheme “Empowerment of artisanal fisher folk of Pazhaverkadu area through mudcrab culture technology”. The hatchery consists of different units: water filtration systems, broodstock tanks, spawning tanks, larval rearing tanks and live feed culture tanks. This units will be used to produce crablets for the fisher folks of Pazhverkadu and ranching of crablets into Pulicut lake for enhancing the natural stock of mudcrabs. Additionally, crab fattening trials in open waters of Pulicut lake and cement tanks in Pazhaverkadu fishing villages were undertaken under the scheme. Moreover, socioeconomic status of fisherfolks are evaluated before and after adoption of crab fattening in Pazhaverkadu areas.

Seed production using wild caught matured female

Mud crabs collected from wild should be disinfected individually in 100 ppm formalin for 30 minutes before transferring them to the broodstock tanks. Female crabs are assessed for ovarian maturity by looking through the transparent membrane between the junction of the first abdominal segment and carapace (Quinitio et al., 2002). Mature female is characterized by the presence of dark orange ovaries. Mostly, the mature female crab collected from the wild would have undergone the mating process based on the fact that vitellogenesis in crab starts only after mating. Once the maturity is confirmed, the mature female is transferred to brood stock tanks (1500 l in our hatchery) for observation. The crab will not feed for 2-3 days. Once regular feeding

is noticed, eye talk ablation is performed to stimulate maturation and spawning. A water depth of 30-40 cm is maintained and about 80% of water is changed daily.

To stimulate spawning in the brood stock or spawning tank, sand placed inside the small trough need to be placed inside the tank. Generally, spawning event extends for 4-6 hours and the female crab should not be disturbed during this period. Maintaining dark condition is recommended during this period. Nutritionally rich clam, oyster meat, squid meat and annelid worms are fed to brooders at 10% of the body weight. Salinity of 32±2 ppt water and temperature in the range of 28.5-31°C give better results for crab seed production.

Seed production using berried females

In this case, berried females are transferred individually to 500 litre with aerated seawater (35 ppt). Berried crabs sometimes lose some or all of their eggs due to fungal infection. To counteract fungal and ciliate infections berried female crabs can be treated with 0.1 ppm Treflan (44% trifuralin) every three days in the hatching tank (Quinitio *et al*., 2002). The egg mass is bright orange in colour and then it turns into reddish brown and finally black on the day prior to hatching. Each spawning produces 0.8-2 million zoea in 400-600 g *Scylla serrata*. Hatching occurs 8-15 days after spawning at temperatures 26.5-31°C.

Based on our experience with berried female crab (3 nos.), egg development failed to finish complete development due to fungal infection and in another case, low water temperature prevented complete development in the hatchery. We are exploring methods to undertake seed production trial using the above two methods and the method will be transferred to fisherfolks of Pazhaverkadu for the adoption. A recent development in the seed production of mudcrab is the use of ovarian fragments with mature eggs to stimulate final oocyte maturation under in vitro condition using hormones like human chorionic gonadotoprin and other crustacean based hormones like ecdytseroids. However, a limitation with this method is less survival of successfully developing embryos in the hatchery.

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ZEOLITES AS A SOURCE OF FERTILIZERS FOR BETTER SOIL HEALTH

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Key points

Zeolites improved the water retention of soil.
Zeolites often have a favourable impact on plant development and yield.
Slow-releasing fertilizers can benefit from the addition of zeolites.

Introduction

Zeolites are hydrated aluminosilicates with an infinite three-dimensional crystal structure, containing cations of alkaline elements, alkaline soil elements, or, less frequently. Zeolites are crystalline aluminosilicates that are porous and have a system of interconnecting chambers and channels. One of the key elements influencing zeolites' ability to adsorb substances is their geometrical properties. Zeolites can therefore act as a reservoir of water and nutrients for plants (anions and cations), in addition to acting as a sorbent for environmental contaminants. Zeolites have grown in popularity recently due to their special qualities, and they are used in many different areas of the economy. The current study results demonstrate that zeolites are safe for the environment and living creatures, and their multidirectional application in agriculture is mostly due to their high porosity, sorption-ion exchange capability, and well-developed specific surface area. Direct application of zeolites to soil not only improves soil sorption capacity, but it also reduces soil acidity and boosts nutrient efficiency. Better nitrogen use from fertilisers results in increased yields while reducing nutrient dispersion in the environment. Another advantage of zeolites is that they may be synthesized from a variety of waste materials (such as ashes), resulting in a low production cost. This adheres to the principles of sustainable development, is part of the closed-loop economy, and slows the depletion of environmental resources. Given the abundance of research on zeolites, the current study was designed to provide a summary of the existing potential for employing these materials in agriculture, primarily for fertiliser manufacture.

Chemical composition of Zeolite

The aluminosilicate framework, in which silicon and aluminum are tetrahedrally coordinated, is the building block of all zeolites. Four oxygen anions surround the silicon and aluminum cations (O2-). Zeolite is made up of the tetrahedral structure of SiO_4 and AlO_4.

Characteristics of Zeolites

- Zeolites are extremely stable solids under a variety of environmental conditions. Zeolite hasan extremely high melting point, around 1000oC.
- They are insoluble in water and other inorganic solvents.
- They do not oxidize in the presence of air.
- The open cage-like framework structure of zeolite is what distinguishes it and allows it to capture water as well as potassium and calcium ions.

- The natural form of zeolite exists in random forms with non-uniform pore sizes, but synthetic zeolites are synthesized with very precise and uniform pore diameters.
- Alumina-rich zeolites attract polar molecules such as water, whereas silica-rich zeolites attract nonpolar molecules.
- Because zeolites are not reactive and are produced from naturally existing minerals, they have no negative environmental consequences. However, skin contact or inhalation may have a carcinogenic effect.

Uses of zeolite in agriculture

Excess fertilizer is washed away, leaving high levels of potassium, nitrogen, and phosphorus in surface water bodies (eutrophication) or groundwater nitrates. Because only a part of the fertilizer is absorbed by the soil, using too much chemical fertilizers creates major environmental problems. These issues can be addressed with slow-release fertilizers (SRFs). Zeolites have a number of beneficial effects on soil properties, including increased soil moisture, increased hydraulic conductivity, and increased yields in acidified soils; they are widely used as soil conditioners to improve soil physiochemical properties. Zeolites can be used to boost the soil's cationic exchange capacity. Zeolite is not acidic, but rather slightly alkaline, and its usage with fertilizers can assist buffer soil pH levels, minimizing the need for lime treatment.

Because of the enormous porosity of their crystalline structure, zeolites can hold water molecules up to 60% of the weight. Water in their pores could be gradually evaporated or reabsorbed without harming the crystalline formations. Zeolites improve water-use efficiency (WUE) by enhancing soil water-holding capacity and crop availability due to their extremely porous structure. Zeolites can absorb CO2 molecules and eventually release them into the biosphere.

Zeolite in Agricultural Benefit

- Soil conditioner
- Soil decontaminator
- Water and nutrient retention
- Eco safe pesticide
- Slow-release fertilizer
- Trace element
- Quality produce
- Ammonia filtration from aquaculture
- Heavy metal adsorption
- High carbon sequestration
- Low N_2O emission

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