AGRIALLIS

SCIENCE FOR AGRICULTURE AND ALLIED SECTOR

A Monthly "e" Magazine

VOLUME 5, ISSUE 11

NOV. 2023

Online ISSN 2582-368X

www.agriallis.com

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AGRIALLIS
Science for Agriculture and Allied Sector: A Monthly Magazine
Volume 5, Issue 11
www.agriallis.com

Article Id
AL04274

VALUE CHAIN FINANCING IN AGRICULTURE

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Value Chain Finance (VCF) refers to financial services and products strategically distributed throughout the various stages of a value chain to enhance investments, returns, and the overall competitiveness of the chain. It involves both internal financing within the value chain and external financing from foreign and domestic sources. Agricultural Value Chain Finance (AVCF) utilizes value chain finance principles to support agriculture, aiming to improve funding, loan repayment efficiency, and relationships among value chain members. The institutional framework for AVCF in India involves various ministries, government agencies, banks, and financial institutions. AVCF employs diverse financial instruments to meet the specific needs of chain participants, ranging from product financing and receivables financing to risk mitigation products and financial enhancements. Different models and strategies are explored, emphasizing the importance of strategic partnerships and risk control measures. The document also delves into AVCF models in practice, emphasizing the role of Farmers Producer Organizations (FPOs) as anchors. The case study explores the implementation of VCF in the transition of farmers from rice to maize cultivation in Odisha, India. The study reveals that internal and external financial institutions play crucial roles in facilitating funding for VC actors. The conclusion emphasizes the pivotal role of technology and collaborative efforts in strengthening AVCF and fostering sustainable agricultural development.

Value Chain Finance

Value chain finance is the term used to describe financial services and products that flow to or through any point in a value chain and allow investments that boost the returns on their investments as well as the chain's expansion and competitiveness. These include enhancing financing at particular stages of the value chain to boost the chain's overall

competitiveness and including several parties and utilizing connections to reduce or mitigate risk.It encompasses both foreign and internal financial sources.

•Financing that occurs within the value chain, such as when a lead company advances money to a market middleman or a supplier extends credit to a farmer, is known as **internal value chain finance.**

•Value chain interactions and processes enable funding from outside the chain, known as **external value chain finance**. An example of this would be when a bank lends money to a farmer on the basis of a contract with a reliable buyer or a warehouse receipt from an approved storage facility.

When using a value chain strategy, one must take into account both the risks and returns of the value chain actor requesting financing as well as the risks and returns of the finance provider. Financing for a value chain might come from value chain actors themselves, banks, microfinance organizations, other non-bank financial institutions, or a combination of these actors. These players may be involved in a value chain financing arrangement for a variety of reasons, and these factors influence the ways in which they are prepared to provide financial support for an investment in value chain upgrading.

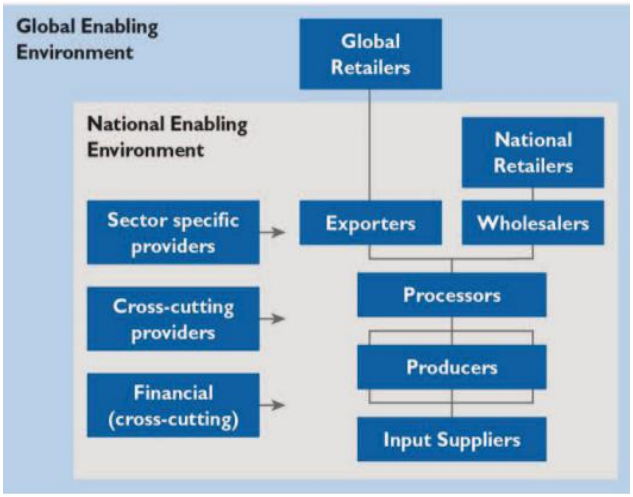


Fig.1 Normal value chain structure

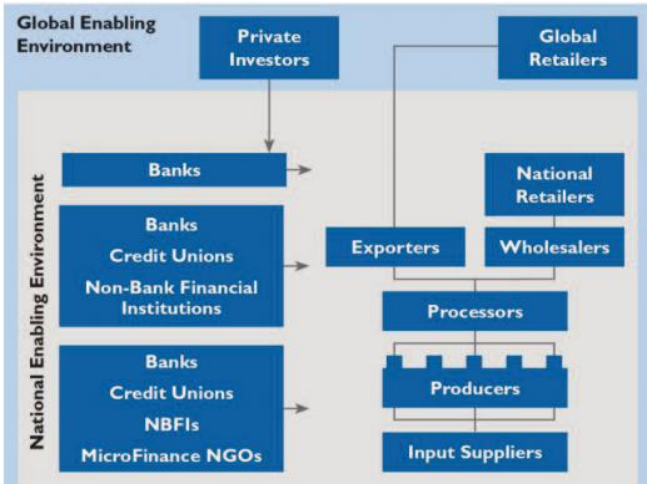


Fig. 2. Adding finance to the value chain

Agricultural value chain finance (AVCF)

VCF provides a chance to increase funding for agriculture, enhance loan repayment efficiency, and fortify or combine relationships between value chain members. Identifying the funding required to strengthen the chain, customizing financial products to meet the needs of chain participants, lowering financial transaction costs by directly discounting loan payments

at the time of product sale, and these are just a few of the ways it can enhance the quality and efficiency of financing agricultural chains.

A financial strategy and collection of tools known as AVCF can be used to finance agribusiness and agriculture. Reduced agricultural expenses and financing risks, as well as enhanced financial access, can all be facilitated by AVCF.

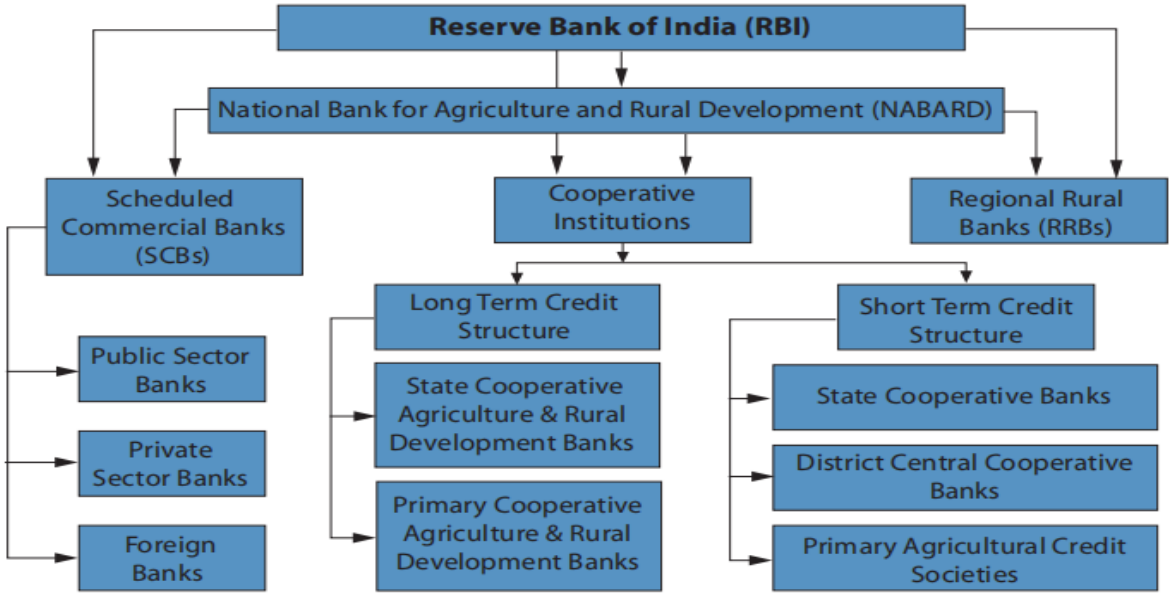


Fig.3: Institutional framework of Agricultural Value Chain

Institutional Framework of Agricultural Value Chain Finance in India

The institutional framework for agricultural value chain financing comprises of various ministries, government agencies, banks, financial institutions and apex bodies like Reserve Bank of India (RBI) and National Bank for Agriculture and Rural Development (NABARD). The framework indicates vast network of financing institutions across the country.

Instruments to promote agricultural value chain finance

AVCF is first and foremost a funding strategy. It ascertains the financial requirements of chain participants and the most effective way to finance them by applying an understanding of production, value-added, and marketing activities. It is possible to apply or modify a wide range of cutting-edge financial tools to satisfy certain financial needs. Financial instrument categories that are frequently utilized in agricultural value chain financing includes:

Category	Instrument
Product financing	Trader credit • Input-supplier finance • Marketing and wholesale company finance • Lead-firm financing
Receivables financing	• Trade-receivables finance • Factoring &Forfaiting
Physical-asset collateralization	• Warehouse receipts finance • Repurchase agreements (repos) • Financial leasing (lease–purchase)
Risk mitigation products	• Insurance • Forward contracts &Futures
Financial enhancements	Securitization instruments • Loan guarantees • Joint-venture finance

Types of Value Chain Finance

1. Giving value chain participants credit, savings, guarantees, or insurance

- Seasonal loans or advances from buyers to farmers
- Agro-processors providing credit to farmers
- Input providers supplying in-kind of loans to producers
- Buyer out-grower schemes that involve credit (often alongside inputs)
- Short-term, medium term loans as working capital from microfinance institutions
- Long-term fixed asset loans from large financial institutions
- Financial firms providing partial guarantees to leverage lending to value chain actors

2. The formation of strategic partnerships via funding provided by a mix of value chain participants and financial establishments

- Market facilitators partner with banks fordeveloping credit franchise
- Commodity exchange links future buyers and sellers to reduce producers' price and marketing risks
- Bank lending to cooperatives and farmers' associations based on forward contracts with farmer groups
- Market facilitator links buy-back arrangements as a guarantee for fixed assets (such as drip irrigation)
- Financial institutions create a 'risk-sharing model' through a trust fund.

3. Providing instruments or services to control risks related to pricing, production, or marketing

- Screening and/or collection services for banks interested in lending to affiliated producers
- Warehouses that use 'receipts' for secured products, which producers can use as collateralfor loans
- Insurance companies that manage production risk for producers and lenders.

Models for AVCF

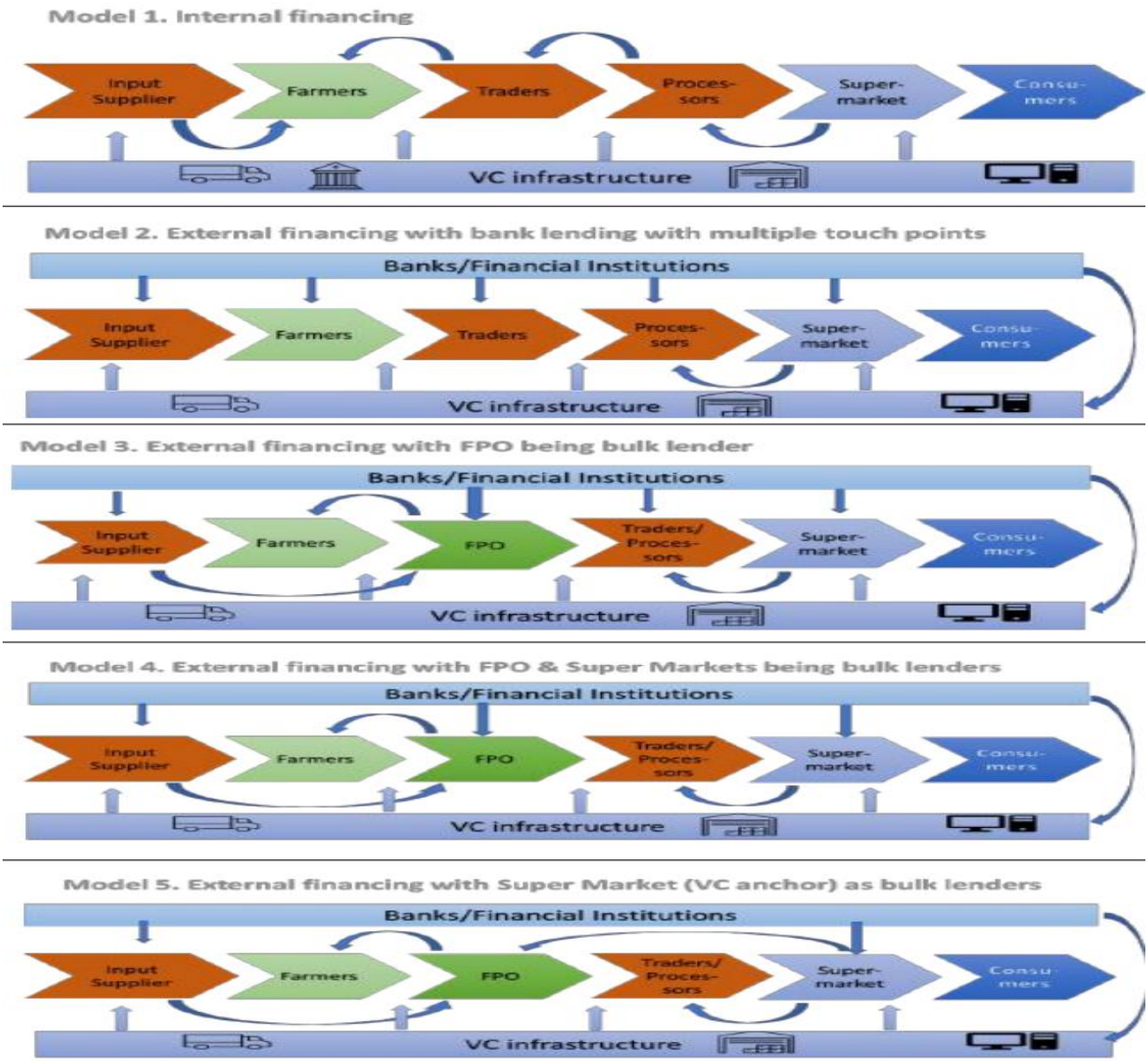


Fig.4 Different models present in AVCF

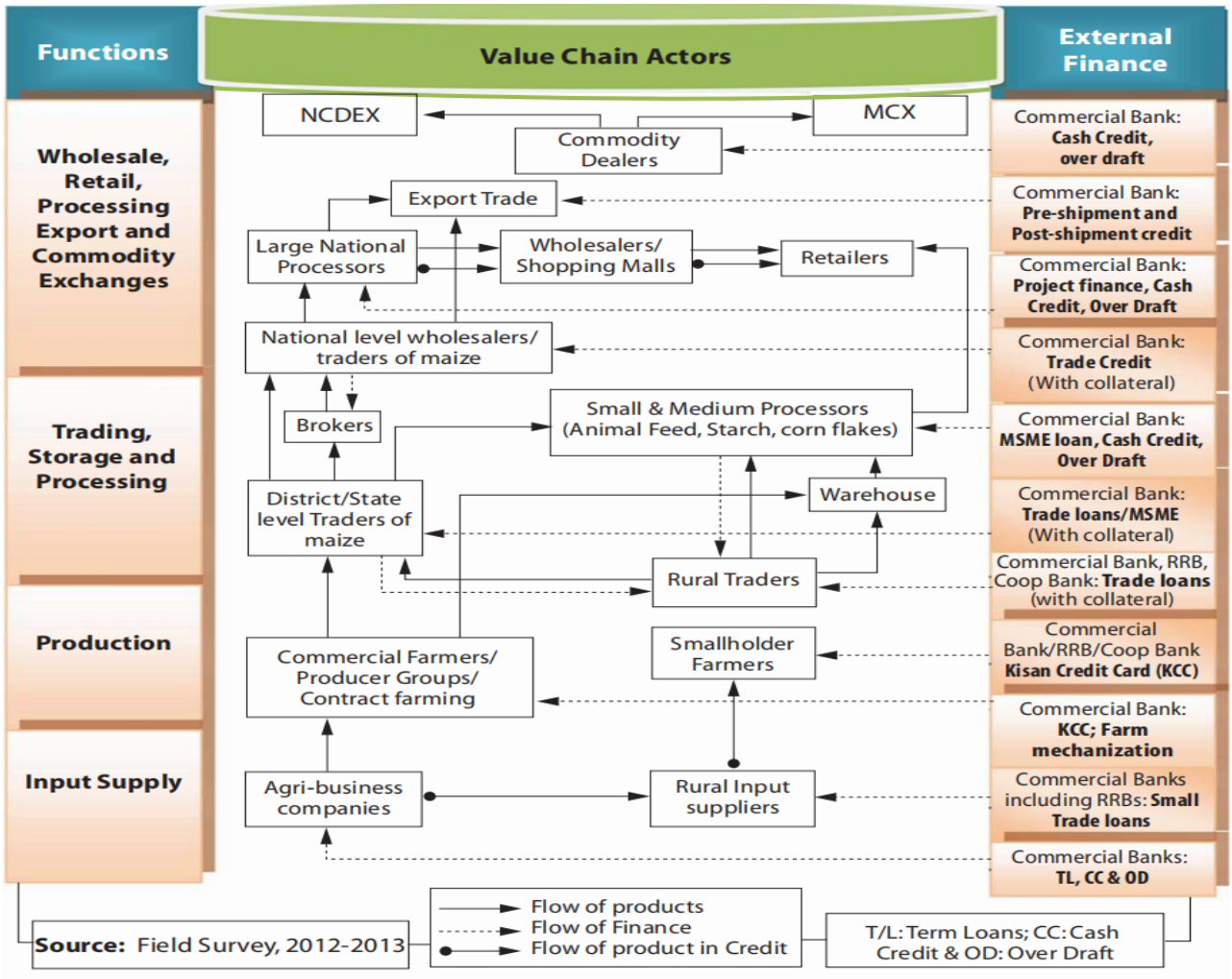
Parameter	Existing practice	FPOs as the anchor for farmers	With VC anchor (VCA)
Models	**Models 1 and 2**	**Models 3 & 4**	**Model 5**
Modus operandi	Business as usual approach. Banks give loans to whoever they can & informal lending happens. There is no anchor for the VC	Model 3. FPOs take bulk loan from banks & lend to members Model 4.FPO and Food retail company as two anchors	Financing through VCA which will aggregate the credit needs of the entire VC including producers and negotiate with bank
Pluses:			
Producers/VC partners	No specific benefits	Lower transaction costs, lesser hassles & cost of documentation, loans possible without individual security	TC of VC partners decline. Small players too can access credit easily. Certainty of supply, direct from farmers at lower cost
Banks	No specific benefits	Lower transaction costs, higher recovery probability	Lower transaction costs due to wholesale credit, Higher recovery probability
FPO Management/ VC anchor	Not applicable	FPO can earn commission on credit transaction	FPO/Anchor can earn commission
Minuses:			
VC nodes/partners	High transaction costs. Sub optimal, high cost borrowing. No coordination among players. Hence, duplication of efforts leading to inefficiency. Exploitative tie-ups among VC players	VC operators other than farmers will have to continue with existing credit arrangements; FPO management bears the accountability	VC Anchor/FPO management will bear additional accountability and load of financial transactions
Banks	High transaction costs. Sub optimal lending. Have to deal with multiple players. More effort per unit business	Concentration risk	Concentration risk
Other issues		Regulatory concerns to be addressed	Regulatory concerns to be addressed

Case Study

Value Chain Finance to Maize in Odisha State of India

The Odisha agricultural department initiated a project in 2010 to transition farmers from rice farming to maize growing. This is the variation of the special maize plan. This programme, which will cost INR 155 million, is another collaboration with private seed

enterprises for 2011. This represents a 26.6% increase over the INR 120 million spent the previous year on providing farmers with a comprehensive kit of insecticides, fertilizers, seeds, and bio fertilizers. The scheme's coverage area was 30,000 hectares in 2010, rising to 40,000 hectares in 2011, and staying the same in 2012.



Lessons Learned

The major lessons learned after detailed study of the maize value chain and access to finance by the actors of the chain:

- When it comes to the value chain actors' ability to obtain funding, both internal and external financial institutions play significant roles.
- The combination of trader's credit and commercial bank financing is the most effective source of funding for the Odisha maize value chain.

- Banks are more ready to lend money to value chain participants whose products are vertically linked with other players than to farmers since farmers do not assume as much risk.
- Banks prefer to deal with the group of farmers/producers/cooperatives that are bigger legal entities than directly with the farmers.
- Farmers with low levels of financial literacy pose a greater risk to financial service providers because they may misuse loans or occasionally worry that having credit could result in the seizure of their property.

Conclusion

An environment that supports infrastructure and shared facilities at competitive prices is necessary for the success of AVCF. All venture capitalists, for instance, require transportation or logistics, AI, ICT, IT-enabled services, and regular and cold storage, among other cutting-edge digital infrastructure services. The AVCF can be facilitated by the development of postharvest infrastructure through GoI programs like the Agri Infrastructure Fund (AIF) scheme, which can strengthen capacity at the PACS, FPO, agriculture entrepreneurs, and agri start-up levels.

Fin techs and agri startups have the potential to transform the AVCF. They can assist in giving the VC players experiences that are flexible, effective, affordable, and unique. They have the ability to democratize currently available services such as block chains, invoice-based trade, Trade Receivables Discounting System (TReDs), and digital connection within agri-value chains.

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Article Id
AL04275

EFFICACY OF PHYTO DRUGS AVAILABLE IN INDIA AS A DISEASE MANAGEMENT TOOL IN AQUACULTURE

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Aquaculture means, “farming in water”. It plays a prime role in Indian economy. India is the second largest aquaculture producer in the world next to China. With the increasing human demand, the use of chemicals in aquaculture increased during the past few decades and is still increasing. A variety of chemicals is used in the name of antibiotics, anaesthetics, vaccines, hormones, pesticides, fungicides, algicides etc. These leads to a great peril to the soil, water, fish, environment and the humans. As the use of chemicals have a variety of problems, it should be alternated with a substance that is nontoxic to the fish and humans. One such alternative is the plant extracts called the Phytochemicals. Phyto drugs, derived from India's rich botanical heritage, have emerged as promising tool for disease management. These can be derived from various plant parts such as root, stem, leaves, bar, fruits, seeds and flowers. The following summary discuss the list of plants and the phytochemicals that are used as a treatment measure in aquaculture.

India is home to a variety of herbal plants. The substance used by the Indian people knowingly or unknowingly have huge medicinal properties. The growing aquaculture sector is affected with bacterial, fungal, viral and parasitic infections. These problems can be treated by herbal plants which has antioxidant, antifungal, antiviral, antibacterial, immune stimulation, growth regulating properties etc.

Rise of Phytochemicals

The vast variety of the herbal plants are found and categorised in the country. There arises a question “why should we not use all these herbal plants in a different way?” Researchers started to make experiments with the herbal plants and found that using medicinal plants have many benefits beyond our knowledge.

Advantages of Usage of Phytochemicals

- It is less toxic to fish and more toxic to harmful microorganisms.
- Improve the immune status of fish.
- Reduce the environmental impact.
- Enhance the growth of fish.
- It is cheap, cost-effective.
- It is easily available.
- Naturally present.
- Phytochemicals are much effective than chemotherapeutics.

Phytochemicals

Phytochemicals are substance that are naturally present in the plants for their protection from predators. Phytochemicals are classified into different classes such as flavonoids, alkaloids, saponins, phenolic acids, tannins, anthraquinones, saccharides, glucosinolates, nitrile glycosides and terpenoids, etc. Some of these major classes are discussed below.

1. Flavonoids:

Flavonoids are class of polyphenolic secondary metabolites present in the plants. Generally, flavonoids have a chemical structure of 15 carbon skeleton, which consists of two phenyl rings and a heterocyclic ring. It possesses a number of medicinal benefits such as antiviral, antibacterial and antioxidant properties.

Table 1 Flavonoids available from plants and their antimicrobial activity

Plants and its active compound	Special antimicrobial property
Anacardium occidentale **(catechin)**	Retard the growth of methicillin resistant *Staphylococcus aureus* (MRSA) & methicillin susceptible *S.aureus* (MSSA).
Ricinus communis **(Epicatechin)**	Acts against the parasitic activity of *Paramphistomum cervi.*
Rhizopora apiculate **(Genistein)**	Have shown antibiotic response against bacterial strains
Punic granatum **(Pelargonidin)**	Have potent scavenging activity for superoxide radicals.

2. Alkaloids:

Alkaloids are organic nitrogen containing bases that are found in the plants. It is present in the plants to give protection from predators and involved in the growth regulation. It is bitter in taste. According to a report, it was found that more than 40000 alkaloid compounds are present in plants.

Table 2 Alkaloids available from plant and their antimicrobial activity

Plant and its active compound	Special antimicrobial property
Datura stramonium **(Pyridazine)**	Have antibacterial effects against *Escherichia coli, Staphylococcus aureus, Klebsiella pneumonia.*

3. Phenolic compounds:

Phenolic compounds are carboxylic acid group which are present in the plants. It plays a major role in induction of resistance to the plants. These compounds have good bioavailability, lipid & water solubility. Phenolic compounds are advantageous over flavonoids because it will be easily absorbed by the stomach.

Table 3 Phenolic compounds available from plant and their antimicrobial activity

Plant and its active compound	Special antimicrobial property
Eucalyptus globulus **(Gallic acid)**	Have antibacterial activity especially against *S.aureus*.

4. Terpenoids:

Terpenoids, also known as isoprenoids, are a class of chemical compounds produced from isoprene. Isoprene, a 55-carbon molecule, and terpenes are examples of naturally occurring organic chemicals. Terpenoids present in plants, gives defence against biotic and abiotic stresses.

Table 4 Terpenoids available from plant and their antimicrobial activity

Plant and its active compound	Special antimicrobial property
Rosamarinus officinalis **(Diterpenoids)**	Carnosic acid and carnosol: exhibited a significant increase in antibacterial activity against *Listeria monocytogenes* and *Staphylococcus aureus* strains.

5. Saponins:

Saponins, also selectively referred as triterpene glycosides. Saponins are bitter in taste. These are bioorganic compounds. These produce soap-like foam when agitated in water. These have the potential to provide a platform for the development of drugs based on natural products.

Table 5 Saponins available from plant and their antimicrobial activity

Plant and its active compound	Special antimicrobial property
***Chenopodium quinoa* (Quinoa saponins)**	Have anti bacteriostatic and bactericidal effects on Gram positive bacteria such as *Staphylococcus aureus* and *Bacillus cereus.*

Extraction Methods of Phytochemicals from Plants

Phytochemicals, also referred to as phytobiotics or phytogenetics. These are extracted from the plants and incorporated into the animal feed (fish feed). Phytochemicals can be extracted by two ways. One is the traditional or conventional extraction method (Soxhlet method, maceration, percolation and decoction). Even the traditional method is a slow and time-consuming process, it is used widely. Another way is the advanced extraction method (Microwave -assisted extraction, ultrasound-assisted extraction, enzyme-assisted extraction and superficial fluid extraction). The name itself implies that they are advanced technique discovered recently and used everywhere nowadays due to the reason of fast extraction process.

Plants Available In India and Their Use in Aquaculture

Quillaja saponin, a plant that is added to the feed of fishes has increased protein efficiency ratio, apparent energy utilization, apparent lipid utilization, specific growth rate and reduced the feed conversion ratio (Francis et al.2001; Francis et al.2002a and Francis et al. 2002b). Ahmad and Tawwab (2011), found that the tilapia (*Oreochromis niloticus)* fed with feeds having cumin have increased specific growth ratio, protein efficiency ratio, apparent energy utilization, apparent lipid utilization. Medicinal plants such as *Curcuma longa, Azadirachta indica, Ocimum sanctum* have the ability to act against *Aeromonas hydrophila* as an antimicrobial agent in goldfish (Harikrishnan and Balasundaram 2008). In the study conducted by Chitmant et al.(2005a), it was found that the *Terminalia catappa* have antiparasitic, antibacterial and antifungal effects in tilapia (*Oreochromis niloticus).* In

another study conducted with plants such as garlic (*Allivum sativum) and* sea almond *(Terminalia catappa)* in tilapia the antiparasitic effect of the plants were found. Suzuki et al. (2006) observed that the raw extract of green tea (*Camellia sinensis)* had a strong potential to control *Ichthyobodo necator* in salmon & chum salmon. Herbal extracts have shown a total protein, albumin and globulin increase in fish (Goda 2008 and Xie et al. 2008). Some substances present in plants are functionally similar to that of animal testosterone and are collectively known as Phyto androgens (Turan & Akyurt 2005a).

Diosgenin, a steroid sapogenin constituent of fenugreek seeds: daidzein, an isoflavone present in soy. These compounds have potential to act as phytoandrogens (Raju et al.2004; Chen & Chang 2007: Ong & Tan 2007). Phyto androgens have been found to have a sex-reversal properties in fish (Godwin et al.2003). *Origanum heracleoticum* contains phenolic compounds of thymol and carvocrol, act against bacteria in channel catfish, *Ictalurus punctatus* (Zheng et al.2009). Balasubramanian et al. 2007) found that the plants such as *Aegle marmelos, Cyanodon dactylon, Lantana camara, Momortica charantia* and *Phyllanthus amarus* have antiviral effect against WSSV. Amaryllidaceae family plants are distributed in the Uttarkhand Himalayan region of India. These family plants have an active compound called lycorine and it was reported that it has antibacterial effect against *Flavobacterium columnare.* A well-known plant that is *Eichornia crassiceps* -"terror of Bengal" is an exotic species which forms a thick mat like structure by growing monstrously. It is a remarkable aquatic weed in aquaculture which retard penetration of sunlight and its overgrowth leads to clogging. But this monstrous plant shows antibacterial activity against *Vibrio harveyi* and it increased bacterial resistance of *V.harveyi* in *Channa punctatus* culture. Papaya leaf meal have an active compound called papain which increases the growth performance in fish. Leaves of the *Ocimum sanctum* (Thulasi) contains eugenol, caryophyllene which acts as an immunostimulant. These compounds give resistance against *A.hydrophila* and also gives specific and nonspecific immunity to the fish. Amla fruit pulp have high vitamin C and found to act as an immunostimulant. In addition to this *Phyllanthus emblica* (Amla) has antioxidant, antimicrobial, antifungal activity. *Cassia auriculata* (Avaram) have phytocompounds such as terpenoids, tannin, steroids and saponin. Fish meal containing *C. auriculata* leaf have proven to show increased growth in milkfish. *Cinnamomum cassia* has resistance against myxozoan species in goldfish farming. *Piper guineense* (pepper) act against *Dactylogyrus extensus. Glycyrrhiza glabra* (liquorice), which is mainly cultivated in Himachal Pradesh. It has a growth promoting effect in *Cirrhinus*

mrigala. Moringa oleifera, Allium sativum and Zingiber officinale have potential to improve growth performance in aquaculture species. Oregano, a hardy plant found in temperate Himalayas from Kashmir to Sikkim has antimicrobial properties and used in aquaculture.

Conclusion

The plains, valleys and mountain ranges of the Indian region is found with diverse vegetation. Most of the plants that are found in India are medicinal plants with idiosyncratic characteristics. The medicinal plants are generous and diversified. But these herbaceous plants are underutilised. Many researches have done to investigate the medicinal properties of plants and their usage in aquaculture. Yet usage of these compounds in the aquaculture is not popular among the farmers. Most of the money spent on the aquaculture goes to the chemicals such as antibiotic, vaccines etc., in the name of prophylactic measures. Use of antibiotics in aquaculture is banned in many countries as it leads to the development of antibiotic resistant bacterial strains and consequently results in disease outbreak in humans. Use of Nitrofurans is strictly prohibited in aquaculture. Instead of antibiotics, plants with active compounds can be used. The usage of plants in the place of antibiotics have long lasting effect & also leads to better economic management. The usage of these compounds in aquaculture can improve productivity, disease resistivity and maintain environmental sustainability with less toxic effects. It is estimated that the global antimicrobial consumption in 2017 at 10259 tons in aquaculture is expected to increase 33 percent between 2017 and 2030. Before this threat happens, use of antibiotics ought to be diminished by the use of phytochemicals. It is the only way to the betterment of both aquaculture and the humans.

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Article Id
AL04276

FEEDING THE FUTURE: NUTRITION-SENSITIVE EXTENSION- A KEY INGREDIENT FOR GLOBAL FOOD SECURITY

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Small-scale farmers are assisted by extension advisory services (EAS) in making decisions about the future of their businesses as well as increasing the production and efficiency of their farms. Public and private EAS work with smallholders to increase the production of a single or small number of lead crops that are either exported or used as staples in the local diet. These crops have a substantial market demand and produce relatively high profit margins. But in addition to being cash poor, the smallholders and households targeted by EAS are frequently food insecure and are subject to chronic or acute forms of malnutrition. Children's physical and intellectual development is impacted, and family members' productivity and capacity for agricultural work is decreased. Malnutrition and food insecurity can be caused by a lack of money or income that is excessively changeable. But better nutrition does not always follow from increased incomes.Poor eating habits, ignorance about healthy nutrition practices, and restricted access to a variety of foods are other significant variables. Agri-food systems should not only produce enough food, but also a variety of safe, nutritious foods, increase rural incomes and resilience, and make foods that support healthy diets available and accessible at both the national and subnational levels.

Why Should Extension and Advisory Services be Nutrition- Sensitive?

A large part in boosting nutrition and NSA can be played by agricultural extension and advisory services (EAS), thanks to their technical expertise, network of field personnel, and relationships with producers. EAS actors today include a wide range of groups in addition to public extensionists, such as civil society, producer organizations, development initiatives, agri-input dealers, and many more. This plurality allowed them to offer a variety of essential services, such as: Sustainable and nutrition-sensitive production and supply chains

- Food and nutrition education
- Food safety
- Enhancement of incomes and improved market access
- Women empowerment
- Coordination with other actors delivering nutrition specific programs etc.

What is Nutrition?

In addition to what happens to nutrients in the body, nutrition also has to do with how people can obtain the correct foods for growth and good health. People need to consume a nutritious diet in order for their bodies to function correctly and to be able to fend off illnesses and disorders. A healthy diet is one that provides the daily nutritional needs of an individual. Foods that are high in macronutrients and micronutrients and low in superfluous fat and sugar are the foundation of any healthy diet. Individuals of all ages need to consume a variety of macro- and micronutrients in order to maintain healthy growth and brain development, but additionally newborns and children have a special requirement for these nutrients. While micronutrients are required in relatively lower amounts to sustain a healthy body, macronutrients are required in relatively larger levels to support normal bodily processes and health.

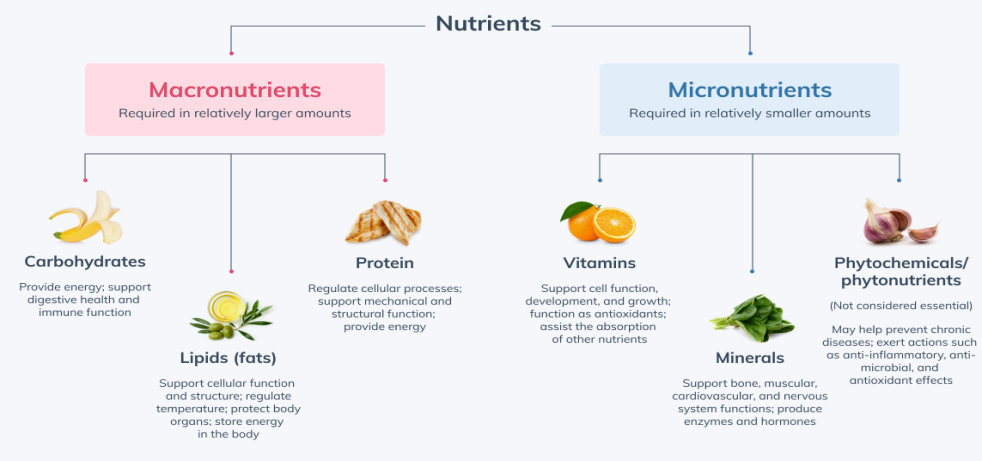
A. Macronutrients -

Carbohydrates, proteins, fats, and oils are macronutrients. The body needs energy from carbohydrates to move, breathe, and carry out daily tasks. Foods that contain significant carbohydrates include sweet potatoes, cassava, and rice. Protein-rich diets aid in wound healing and muscular growth. Beef, seafood, lentils, and cowpeas are a few examples of proteins. The body uses fats and oils for energy, to maintain brain function, and to protect organs (such as the liver, heart, and skin). Because they give more energy than proteins and carbs, fats must be consumed in moderation. Butter, plant and vegetable oils, nuts, and seeds are a few examples of fats and oils.

B. Micronutrients -

Vitamins help the body grow, maintain the immune system, and convert food into energy. Vitamin intake is frequently inadequate, particularly for vitamins A and C. Vitamin A improves vision and prevents sickness. Carrots, squash, dark leafy greens,

and animal liver are all sources of vitamin A. Vitamin C promotes wound healing and supports bone and tooth health. Bell peppers, dark leafy greens, papaya, and tomatoes are all sources of vitamin C. Minerals help regulate pulse, healthy neuron function, and bone formation. Iron and zinc are the most frequent minerals that people do not consume enough.



(Source- https://fullscript.com/blog/macronutrients-and-micronutrients)

Food group	Examples	Importance
Staples	Maize, bread, tortilla, rice	Provides energy for the body to move, breathe and perform daily activities (cook, work in the fields, etc.).
Fats	Vegetable oil, butter,nuts	Provides the body with energy and protects the organs (heart, liver, skin).
Fruits	Papayas, mangoes, bananas, avocados	Helps protect the body from diseases and illnesses.
Vegetables	Pumpkins, potatoes, leafy greens, tomatoes	Helps protect the body from diseases and illnesses
Legumes	Cowpeas, kidney beans, lima beans, black beans	Helps strengthen the muscles, repairs wounds and protects against heart disease and diabetes
Meat and eggs	Chicken, beef, mutton, organ meats, eggs, fish	Helps strengthen the muscles and repairs wounds
Dairy	Milk, yoghurt, cheese	Helps strengthen bones

Table 1: Common food groups and examples of their nutritional importance

(Source-https://www.g-fras.org/en/component/phocadownload/category/70-new-extensionist-learning-kit-nelk.html?download=713:module-16-nutrition-sensitive-extension)

Nutritional Indicators

A person's height and weight are typically measured in order to determine their levels of nutrition, and those results are then compared to the norms or permissible ranges for that person's age and sex. Children's nutritional indicators are particularly crucial because they are still developing. Underweight, wasting, stunting, overweight, and obese are the most often used indicators of malnutrition.

- **Underweight:** Weighing less than is considered healthy for one's age, height, and body type.
- **Wasting:** A type of acute malnutrition characterized by a rapid loss of weight brought on by insufficient food intake.
- **Stunting:** Decreased growth and development brought on by chronic malnutrition.
- **Overweight:**Weighing more than is typical for one's age, height, and physique.
- **Obese**: An extreme case of overweight. Chronic: Persistently occurring over time.
- **Acute:** An abrupt start or rapid rise.

Factors Affecting Food Choice

A person's dietary preferences and choices are influenced by a combination of their physical, sociocultural, political, and economic environments and conditions. The following are some elements that influence someone's eating preferences:

- **Food availability:** Many people will only select food that is offered in their local markets.
- **Accessibility:** Manageable distance from their home or place of employment is usually the food that most individuals prefer.
- **Affordability:** Particularly in poor and subsistence sections, the cost of food plays a significant role in influencing food choices.
- **Desirability:** People's beliefs of the health advantages of various foods as well as their social, cultural, and ethnic origins all have a significant impact on what foods they choose to eat or refrain from eating.
- **Convenience:** Most people will opt for a convenient substitute over a particular food item if it is hard to obtain or cook.

Women's Role in Nutrition

Women make dinner for their families in a large number of households all around the globe and are typically the last to eat. As a result, they occasionally fall short of satisfying all of their dietary requirements because they prioritize the needs of the family over their own. Women of reproductive age (usually between the ages of 15 and 49) need to eat a very nutritious diet, especially if pregnant or breastfeeding. The body needs more nutrients during pregnancy not just to sustain the mother's health but also the health and brain development of the fetus. For a mother who is breastfeeding, nutritional needs are much higher. Children under two years old also need lots of attention y towards their nutrition. For a variety of factors, including women's reproductive biology, poor social standing, poverty, and lack of education, women are more likely than men to experience nutritional deficiencies. Women frequently produce and prepare the majority of the household's food, so their understanding of nutrition may have an impact on the overall health and nutritional condition of the family.

Understanding Food Systems

According to the FAO, a food system is made up of the people, organizations, and procedures used to produce, process, and distribute agricultural products to consumers. Understanding the food system in which people and families make decisions about what to cultivate and eat can help us better understand how agriculture affects nutrition. Consuming a varied, healthful diet requires a food system where:

- Enough food is available for collection or purchase to satisfy dietary requirements.
- Food is easily accessible in the sense that people can buy it, along with fruits and vegetables, at their local markets, and women are not prohibited from doing so.
- People can afford to purchase food and the inputs required to prepare it.
- People are willing to prepare and eat food since it is safe and acceptable.

Need of Extension Service to Strengthen Nutrition in India

According to FAO, extension agents are the best person to teach rural people on nutrition aspects –

- **Established infrastructure:** In a nation like India, the public extension system is already established; all that needs to be done is to "topping-up" its portfolio with straightforward nutrition-related activities and messages.

- **Reach**: Each extension worker in a rural area can reach 1159 people. Extension specialists have close ties to farming communities in rural and isolated places, sometimes even on a long-term basis. These connections are based on established processes and structures that apply to the majority of farming households.
- **Community trust**: Extension personnel keep in touch with the individuals and communities in their operational area on a regular basis and have built relationships with them. Communities that already have established relationships and a sense of trust make it much easier to discuss nutrition issues.
- **Cultural awareness:** The local social customs, culture, and belief systems that accompany and surround food are frequently known to extension personnel. Agents typically come from the area in which they operate, giving them a thorough knowledge and comprehension of the circumstances there. Extension workers are better equipped to display empathy and understanding because they are more familiar with the circumstances and context in which the farmers work, as well as the accompanying constraints and opportunities.
- **Empathy with the farmers**. Extension agents are better equipped to help farmers overcome obstacles thanks to their expertise of the local food production system, market accessibility, and household nutrition status.
- **Family approach:** Family is the foundation of society, and by fostering relationships and introducing cutting-edge technologies to the farming community, we can improve the family as a whole economically and socially. He is, nonetheless, the ideal individual to impart nutritional knowledge to rural residents.

Actions that Extensionists Can Take To Improve Nutrition

- Promote increase production of more varied and nutrient-dense foods that meet local nutrient deficits and those people don't eat enough of.
- Encourage safe farming techniques and technology for food processing, preservation, and storage in order to maintain nutritional value, increase the availability of seasonal foods, decrease food losses, and enhance food safety.
- Preserve natural resources by using productive farming methods that increase soil nutrients and restore biodiversity.
- Encourage people to practice appropriate sanitation and hygiene habits, especially while handling manure, insecticides, and fertilizers.

- Offer engaging nutrition instruction to motivate people to cultivate and consume a healthy diet. This could be suggestions for picking vegetables that are nutritious, enhancing meals with ingredients that are readily available nearby, or minimizing intake of excess fats, sweets, and salt.
- Increase markets for healthy foods and market accessibility for disadvantaged people. This could involve facilitating access to seeds, pest control techniques, improved livestock breeds, and market price data for farmers.
- Improve food's nutritional content by working across the value chain to promote supply and demand for healthy foods. Encourage input dealers, agricultural technology salesmen, food processors, wholesale purchasers, and others to expand their selections to support a variety of foods.
- Assuring that women in agriculture have access to employment possibilities, social networks, and financial services will empower them.
- Adopt a food-system perspective as opposed to concentrating solely on production.
- Promote dietary knowledge in accordance with national food-based dietary recommendations (where available).

Promote both on- and off-farm income creation activities while facilitating access to markets. Having more money can enhance access to wholesome foods that are not farm-produced and smooth out consumption.

Conclusion

The health, intelligence, strength, and size of an individual are significantly influenced by their dietary status. Good nutrition requires a nutritious diet, yet many people lack the knowledge, abilities, resources, or drive to do so. Each food group in a healthy diet provides the body with unique nutrients that are necessary for optimum nutrition. Healthy diets include a variety of foods from several food categories. In order to improve public health and produce a variety of healthy foods, nutrition-sensitive agriculture and extension services can be very helpful. Diversification and sustainable intensification of agricultural production, post-harvest handling, storage, and processing, nutrition education, and behavior change communication, as well as women's empowerment and gender equality, should be the main objectives of nutrition-sensitive agriculture and extension activities.

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Article Id
AL04277

THE IMPORTANCE OF ISSR PRIMERS

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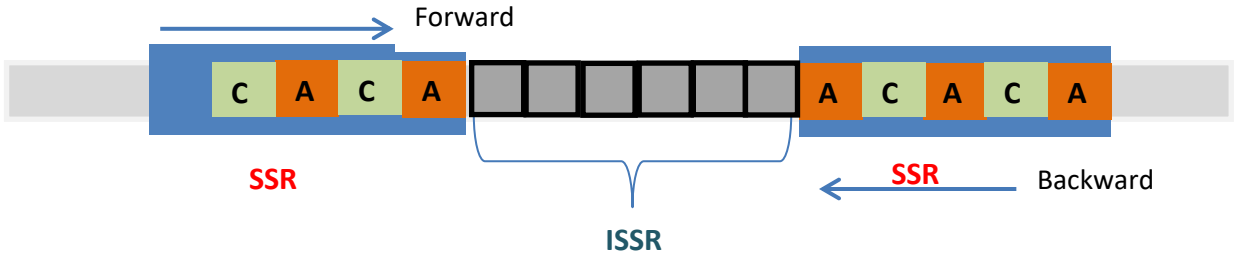
The genetic diversity of their populations must be considered while developing an approach for the protection of rare and endemic organisms. ISSR analysis (Inter Simple Sequence Repeats), is a PCR based molecular technique which uses primers typically 16 to 25 bp long and consists of tandem short 2-4 nucleotide repeats and is anchored at the 3' or 5' end with 1 to 4 degenerate bases extended into the flanking sequences. This is one of the most popular methods for detecting genetic polymorphism in organisms that does not require knowledge of the nucleotide sequences of the genome. According to studies, ISSRs offer a potent, quick, easy, repeatable, and affordable way to access genetic variation among closely related cultivars, characterize accessions, and identify cultivars and varieties (Kumar et al., 2016).

ISSR are DNA fragments of about 100-3000bp located between two adjacent SSR repeats .



An ISSR primer is usually 16-25bp in length, comprising repeated DNA motifs 2-4bp each.

Types of ISSR Primers

Unanchored primer-Primer consist only of a repeated motif:

5’-anchored primer- Primer consist of a repeated motif with one or several non-motif nucleotides at the 5’-end

3’-anchored primer- Primer consist of a repeated motif with one or several non-motif nucleotides at the 3’-end

The markers generated by non-anchored primers are called single primer amplification reactions (SPARS) or microsatellite-primed PCR (MP-PCR).

The markers generated by anchored primers have been called inter-SSR PCR, anchored simple sequence repeats (ASSR), and anchored micro-satellite-primed PCR (AMP-PCR) or – amplification (ISA).

Modifications in ISSR Primers

Unanchored ISSR primers shows good band in gel when the motifs consist of tri or penta-nucleotides. But when they consist of dinucleotide motifs, smears will be formed on the band. Again in case of anchored ISSR primers, 5' and 3' anchored primersare used in both the ends of 5'anchored ISSR and 3'anchored ISSR respectively. To overcome such difficulties two modifications are made which are as follows –

- A 5' anchored SSR primer can be used in combination with a RAPD primer to yield markers termed as Randomly Amplified Microsatellite Polymorphism (RAMP or RAMPO; Wu *et al*. 1994)
- Another modification is termed as Selective Amplification of Microsatellite Polymorphic Loci (SAMPL), microsatellite based primers are combined with the AFLP primers in the AFLP procedure to yield markers that are regarded as improvement over SSRs

Advantages of ISSR Markers

- ISSR markers are more reproducible than RAPD
- These are easy to use, cheaper and have high throughput
- They yield multiple polymorphic loci
- A prior knowledge of the template DNA sequence is not required
- Generally, ISSR markers are dominant, but the use of a larger 50 anchored primer can yield co dominant ISSR marker.

Disadvantages of ISSR Markers

- They aren't highly reproducible
- Some primers generate poorly reproducible band patterns
- Dominant markers

Designing of ISSR Markers

ISSR are amplified by PCR using microsatellite core sequences as primers with a few selective nucleotides as anchors into the non-repeat adjacent regions (16-18bp). About 10-60 fragments from multiple loci are generated simultaneously, separated by gel electrophoresis and scored as the presence or absence of fragments of particular sites.

Application of ISSR markers

- Studying genetic identity
- Studying parentage
- Clone and strain identification
- Taxonomic studies of closely related species
- Gene mapping studies

Conclusion

The abundant microsatellites that are present throughout an organisms genome are the target of the ISSR primers (Wang et al. 1994). Due of the higher annealing temperature and lengthier primer sequences, these markers have been shown to be more repeatable than RAPD markers and generally display higher degrees of polymorphism (Qian et al. 2001). Like SSRs, they don't necessitate prior understanding of flanking sequences. They are also less expensive, and easier to utilize than AFLPs (Reddy et al. 2002).

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Article Id
AL04278

LOOP-MEDIATED ISOTHERMAL AMPLIFICATION (LAMP)

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The invention of the polymerase chain reaction (PCR) method by Kary B. Mullis in 1983, enabling genetic study to be carried out even with small amounts of the targeted biological material, is one of the most notable achievements of molecular biology. The demand for a high precision thermal cycler in PCR prohibits this potent technology from being utilised extensively, such as in private clinics as a routine diagnostic tool, despite the simplicity and the attainable volume of amplification. Lately a unique technique was developed that can amplify a few copies of DNA to 10^9 in less than an hour while maintaining improved specificity, calledloop-mediated isothermal amplification (LAMP).

Loop Mediated Isothermal Amplification (LAMP)

LAMP is an isothermal nucleic acid amplification technique designed and developed by Notomi*et al* which helps in the diagnostic field, healthcare, agriculture, and food industries, with methods like the screening of viral and bacterial strain mutations, analysis of fungicide resistant mutations, analysis of micro RNAs, identification of herbal medicines, identification of plant pathogen vectors, single nucleotide polymorphisms analysis, and detection of genetic variants.

Principle: The LAMP technique is based on auto cycling and high DNA strand displacement activity mediated by *Bst* polymerase from *Geobacillus stearothermophilus*, under isothermal conditions. There are two steps in the reaction:

i) Initial step : At 65 °C temperature, the forward inner primer combines with the original reverse target sequence and synthesize of the new forward strand starts at the 3′ end. The synthesis of this new forward strand proceeds until the enzyme locates the 5′ end of the initial strand made with the usage of the inner primer, at which point the forward outer primer

hybridises once more with the identical original reverse target sequence. Using the forward inner primer results in the displacement of the first forward strand. Due to the complementarity of the reverse sequence from the inner primer to the target sequence, this split strand develops a self-hybridizing loop at one end. It also serves as a template for the reverse inner primer and the reverse outer primer, which, in a similar way, will produce the strand displacement of the forward strand, thus creating a dumbbell-like DNA structure.

ii) Combination of a cycling amplification step with an elongation/recycling step: In order to create a new strand with an inverted copy of the target sequence in the stem region and a loop on the opposite side, the forward inner primer hybridises to the loop of the strand generated during an initial step. The two products of self-primmed strand displacement DNA synthesis are a complementary strand and a second strand with a double-elongated stem that is the same length as the first and the loop on the opposite site. The ensuing elongation and recycling stages utilise both strands as templates for the reverse-primed strand displacement synthesis. As a result, the target sequence can be amplified three times during each half of the cycle. Due to the *Bst* DNA polymerase's strong displacement activity, a significant quantity of DNA with a high molecular weight is quickly produced. As a result, target DNA may be amplified up to 10^9 copies in less time. Finally, several looped stem-loop DNAs with varying lengths are created to resemble cauliflower-like formations.

LAMP Primers

In LAMP, a set of four specific primers, which can recognize six distinct regions on the target region. Basically, the LAMP primers consist of two outer primers (F3 and B3) and two inner primers, termed forward inner primer (FIP) and backward inner primer (BIP). Each inner primer of LAMP includes two regions; F2 and F1c on FIP, and B2 and B1c on BIP; in which F2 and B2 are complementary to F2c or B2c on the target, while F1c and B1c have similar sequences to the target.

Limitations of LAMP

Despite its brilliant advantages, there are some limitations like using of 4-6 primers for detecting a particular target can be a challenging especially for the short target sequence containing high mutation points such as RNA viruses or micro RNA. Primer dimers may occur when four to six long-sequence primers are used in high quantities, which might lead to a false-positive LAMP result. Due to carry-over contamination, the large yield of dsDNA

produced following amplification in conjunction with the test's high sensitivity may provide false positive findings in the LAMP assay.

Conclusions

In the future it has every chance of becoming a full-fledged alternative to PCR in the field of molecular diagnostics of pathogens, and new modifications of LAMP will certainly help this interesting amplification method find its unique scope of application.

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AGRIALLIS
Science for Agriculture and Allied Sector: A Monthly Magazine
Volume 5, Issue 11
www.agriallis.com

Article Id
AL04279

LOW COST MANAGEMENT PRACTICES TO TACKLE MELON FRUIT FLY INFESTATION IN CUCURBITS

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Cucurbits are cucumber, muskmelons, watermelons, squashes, gourds and pumpkins are common to be cultivated all over world but the sustainable production is lowering down. Because of these crops were infested by a variety of insects pests from seedling until harvest. In cucurbits one of the most destructive and economic threat pest all over world is melon fruit fly (*Bactrocera cucurbitae* Coquillett.) to ensure healthy cucurbit production. Fruit flies of the tephritidae family are a globally important group of agricultural pests that target a wide range of fruits and vegetables (White and Elson-Harris, 1994). The extent of loss varies between 30 and 100 per cent, depending upon the cucurbit species and season (Dhillon *et al.* 2005). The infestation increases at temperature around 32^0C with relative humidity range between 60% to 70%. It prefers to infest young, green and soft skinned fruits.

Now a days demand of consumer for cucurbits are being increased so that sustainable production should be occur. In order to achieve continuous production of healthy cucurbits, lot of resources are going to invested to reduce losses caused by insect pest and should be kept at minimum by using some management practices those should be Sustainable, economically feasible and environmental friendly measures play important role for management of this pest.

Fruit fly

It is a polyphagous pest remains active throughout the year on one or the other host and it completes 8 to 10 generations in a year. Adult flies are reddish brown in color they feed on honey dew and juice of ripe injured fruits. Adult female fly thrust around 50-100 eggs as group into tender fruits with the help of sharp ovipositor. The egg hatch in 1-9 days and the maggot bore into the pulp forming galleries. The full grown larvae came out by

making one or two exit hole and fall down by hoping movement on soil for pupation. The larvae pupate in the soil at depth of 0.5 – 15 cm and the adults get pupate out in 6-15 days.

Nature of Damage

The adult females lay eggs with the help of its hard and sharp ovipositor, they prefer to lay the eggs in soft tender fruit tissues. After two days emerged maggots start feeding inside the fruit by making galleries. Young larvae leave the necrotic region and move to healthy tissue, where they often introduce various pathogens and hasten fruit decomposition. Once they laid egg it's difficult to manage this pest.

Damaging Symptoms

The damaged regions become watery and brown colored fluid oozes out from the puncture, which becomes slightly concave with seepage of fluid, and transforms into a brown resinous deposit. This reduces the market value of the produce. The fruit subsequently rots or becomes distorted.

- Aborted flowers beneath the crops in the field.
- Maggots feed on the pulp of the fruits
- Deformed and hollow of fruits.
- Damaged fruits turn yellow in colour.
- Necrosis (black or brown colour) lesions around the ovipositional stings
- Oozing of resinous fluid from fruits
- Distorted and malformed fruits
- Premature dropping of fruits and also unfit for consumption

Management Practices

a) Sowing time, method of sowing and spacing

To produce quality fruits of cucurbits and to mitigate the infestation early sowing should be practiced. This may be attributed to seasonal cycle of melon fruit fly. Melon fruit flies remain inactive in the form of leks, among litters/in the form of pupae in the soil. In the month of March, when temperature increases the hibernating population starts to emerge and shows little activity, while, its peak activity starts in the month of April/May-July. However early sowing by Feb 15 and 45 cm plant spacing was comparatively better as this resulted in a

higher marketable yield/plant (Gogi *et al.*,2014). Hang sowing method (HSM) is best method for sowing cucurbits (Bitter gourd) has been recorded (Gogi *et al*., 2014) due to the fact that there was proper ventilation and more fruits were directly exposed to sun; hence these fruits are not preferred for oviposition. Similarly, in the HSM more marketable fruits and yield per plant is attributed due to the fact in this method least number of fruits come in contact with the soil; hence deterioration of fruits due to scavenger like *Drosophila melanogaster* (Dhillon *et al.*, 2005) or other factors is avoided, which results in more marketable yield.

b. **Bagging**

The bagging of fruits was done (Fig.1 a) by using polythene bags or any other durable cheaply available material and make holes with an ordinary pin for proper aeration of fruits. Wrapping materials can be newspaper, paper bags (Fig.1 b) or Polythene sleeves in the case Long/thin fruits (Sarker *et al.*, 2009). The bagging has to be done during morning hours; the pollinated female flowers were bagged by hand at two days after anthesis and left for seven days. The mouth of the bag was wrapped and closed by thread near peduncle of the fruit. After 7 days, the polythene bags were removed. This system also provides physical protection from mechanical injuries (scars and scratches) and in some cases, reduced fungal spots on the fruits. It minimizes the fruit fly infestation and increases the net return by 40 to 50% and this is also found to be as a superior method in controlling the damage by fruit fly (Amin *et al.*, 2008).

Fig.1 a) Bagging b) Bagging Material

c. **Field sanitation**

This method is to break the reproduction cycle and minimize pest intensity. To achieve this various ways are there, among one the most effective method in fruit fly management is removal and destruction of infested fruits. Growers need to remove all infested and unharvested fruits from plant and bury them deep into the soil. Burying damaged fruits 0.46 m deep in the soil prevents adult fly eclosion and reduce population increase Klungness *et al.*,2005).

d. **Soil disturbance**

Plowing (raking) and ground flooding are two methods for disrupting the life cycle of fruit flies by disturbing the soil. Because the pupal stage of fruit flies is found in soil. There is no likelihood of adult emergence and egg laying on fruits if this stage is damaged. The fall plowing after harvesting to a depth of at least 30 cm and flooding the fields are the recommended methods. As a result, some of the pupae are eaten by birds. In the spring the flies do not flies out of the pupae, found in deeper layers of soil.

e. **Pheromone lure or Cue lure Traps:**

The principal of this particular technique is to deny female flies the resources they needed for lay eggs, such as protein food (protein bait control) or pheromone lures, which eliminate males. The number of commercially produced attractants (cue lure®, Eugelure®, Flycide®) are available in the market and can be used efficiently in management of this pest. For trapping male flies, installation of old used water bottle baited with cue-lure saturated wood blocks (ethanol/ cue-lure/carbaryl in a ratio 8:1:2) at 25 traps/ha prior to flowerinitiation is quite effective.

Fig.2 a) Cue lure trap b) Trapped flies

Conclusion

Today's pest management still makes extensive use of chemical pesticides. Chemical pesticides continue to be the mainstay of pest management today, which disturbs the balance between pests and their natural enemies and pollutes the environment. It also encourages pest recurrence and resistance. These vegetables contain long-lasting insecticide residues that pose serious risks to both human health and the environment. The melon fruit fly can be controlled or repressed locally at growers' fields, taking into account the pests and crop value. Any combination of available options, such as fruit bagging, field cleaning, and cue-lure traps.

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Article Id
AL04280

PRODUCTION TECHNOLOGY OF QUALITY PLANTING STOCK: AN OVERVIEW

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The QPS refers to the extent to which this stock effectively fulfils the objectives of forest management, whether it be sustaining through the entire rotation period or realizing specific desired benefits, all while minimizing costs. Essentially, quality equates to the fitness of the planting stock for its intended purpose. In a broader context, when a batch of planting stock successfully serves its intended purpose, it can be considered to have a quality rating of 100%. Conversely, the degree to which a batch of planting stock falls short of achieving the management objectives, regardless of how they are defined, represents the deficiency in the quality of that stock. Importantly, if planting stock with specific attributes can meet these management objectives, it is most advantageous to produce such stock as cost-effectively as possible (Mattsson et al., 2010). Optimizing the cost of production while maintaining quality is pivotal in the realm of forestry and afforestation, as it ensures efficient resource allocation and maximizes the benefits derived from the planted stock.

A Measure of Quality

The primary objective in cultivating superior seedlings is to maximize growth potential and optimize the yield of desired products. These products can encompass a wide array, from timber, food, fuel, and fodder to applications like site enhancement. Assessing seedling quality hinges on a dual appraisal system: the genetic constitution inherited from the parent stock and the physical development influenced by the immediate nursery environment. The selection of desirable genetic traits is a field operation that takes place at seed collection sites. When executed effectively, this process yields the highest quality seeds, preserving the desired inherent characteristics found in the parent stock. Diligent care in seed selection and

collection also minimizes the production of subpar stock originating from physically compromised or damaged seeds. Apart from genetic traits, seedlings manifest a range of physical attributes, including robustness, proper form, health, and vigor, many of which can be influenced by nursery practices under the forester's purview.

The pivotal role played by management objectives in determining quality cannot be overstated. These objectives must be realistic and consider site-specific factors, cultural practices, such as site preparation and planting methods, and the inherent traits of the species in question. Introducing new techniques into existing large-scale planting systems should ideally commence with a comprehensive problem analysis, followed by a series of interrelated steps, with each step feeding back information to its predecessors. These steps, often requiring varying timeframes, represent a transition from high to low control over environmental variables. Early steps may comprise components that ultimately culminate in an integrated system considered in later stages. Attempting to circumvent this process by omitting steps is, in most cases, a recipe for unfavorable outcomes. Seeking a deep understanding is imperative for the widespread application of results.

Post-planting stock evaluation serves two distinct yet interconnected purposes. Firstly, it allows scientists to gauge plantation performance and determine the relative significance of controlling factors to guide improvement efforts. Secondly, forest managers employ it to determine the necessity of further operational adjustments. The timing of evaluations should be such that the essential information is both obtainable and timely, considering that species and site characteristics significantly influence the evaluation schedules.

Strategic Planning: An Essential Component

Achieving success in nursery establishment and operations hinges on the seamless flow of well-coordinated steps, each of which directly caters to the specific needs of the plants to ensure optimal growth upon out planting. Central to this endeavour is the essential role of careful planning and vigilant plant monitoring. In the absence of a well-defined plan, foresters can find themselves struggling to keep pace with unforeseen challenges that demand immediate attention. The upcoming sections delineate a comprehensive three-part planning guide dedicated to the cultivation of top-quality seedling stock. These sections delve into the intricacies of container selection, the strategic planning of the nursery, and the effective organization of its day-to-day operations.

Nursery site selection, preparation: Tree nurseries come in two main types, each catering to specific project needs. Temporary nurseries are ideal for short-term projects like erosion control or windbreaks. They often employ basic materials like cut thorn bushes for protection. Regardless of nursery size, plant care remains paramount. Permanent nurseries, on the other hand, support long-term endeavors such as reforestation, commercial plantations, or agroforestry. When choosing a nursery site, central location, easy access to project areas, road access, reliable water sources, and proximity to settled areas are crucial considerations. Topography should be level or gently sloping to aid water drainage and prevent water accumulation, which can attract pests and diseases.

Soil quality is pivotal for bare-root nurseries, with preference for loose, deep sandy clay loam soils and a drainage system to prevent water stagnation. In case of poor soils, manual or mechanical soil improvement methods and compost materials can enhance soil quality. In contrast, containerized nurseries offer more flexibility in location, as potting mediums can be sourced from various places and mixed on-site or off-site with the necessary ingredients.

Assessing Soil Texture by Hand: To differentiate soil types, a simple test involves gently compressing a small soil sample between the thumb and forefinger. Sandy loam soil has a high sand content but contains enough silt and clay for some cohesiveness. Individual sand grains are visible and, when dry, the sample easily crumbles. In its moist state, it forms a stable cast. Loam soil has a balanced mix of sand, silt, and clay, offering a slightly gritty yet smooth texture. When dry, it forms a manageable cast. In contrast, clay soils, when moist, can be molded into pliable ribbons. It's advisable to avoid such soils, as they hinder proper root development and moisture absorption.

The Case for Root Trainers in Tree Nurseries: Root trainer systems represent a revolutionary approach to tree nursery management. These systems utilize rigid or semi-rigid containers with internal vertical ribs designed to guide root growth in a straight downward direction, preventing spiralling. Additionally, containerized plants are elevated on frames above the ground, promoting air-pruning of roots as they emerge from the containers. These containers are engineered to stimulate lateral root development, and these lateral roots can be managed through air or chemical pruning. Research demonstrates that seedlings grown in root trainers exhibit more robust and rapid root growth compared to those in poly-bags. This

not only results in improved survival rates upon transplanting but also ensures the long-term health of the trees.

Root trainer systems offer numerous advantages that simplify nursery operations and improve overall outcomes. These advantages include:

1. Disease and Insect Control: Root trainers provide better protection against diseases and pests, as the controlled environment helps reduce the risk of infestations.

2. Transportation and Handling: The design of root trainers makes it easier to transport and handle seedlings, reducing the risk of root damage during transit.

3. Monitoring and Sampling: Root trainer systems facilitate better monitoring and sampling of plant growth and health, allowing for timely adjustments in care.

4. Reusability: While root trainers may have higher initial costs than poly-bags, their reusability offsets this expense over time, making them a cost-effective choice in the long run.

Effective Nursery Design: The nursery layout comprises essential elements, including a water storage facility with provisions for siltation if necessary, shaded areas for young seedlings and staff, ample space for nursery beds and pathways, well-planned driveways and turnaround zones, storage areas for tools and equipment, stockpiles for soil mix ingredients, sturdy fencing and gates, fire buffers, and clear zones. In any nursery planning, having a "materials-flow-chart" or comprehensive plan outlining the entry, movement, and exit of essential materials is vital. These materials typically encompass water, tools, seeds, containers, potting mix ingredients, and more. Additionally, extra areas should be allocated for potential expansion and cutting orchards, especially when propagating planting stock vegetatively.

For containerized nurseries, it's advisable to arrange pots on raised beds with side supports for the plants. However, if ground-level beds are chosen, they should be constructed using gravel or a similarly free-draining material. Pots can be organized in rows of 12 to 15 pots, depending on pot diameter or ease of access to the center of the bed for weeding and other operations. The use of plastic pots or poly-bags is discouraged due to potential severe issues that can jeopardize projects at the nursery stage or later. For optimal results, employing root trainers is the preferred method. Root trainers encompass more than just a container;

they constitute an entire system that fosters proper root development and growth. When using root trainers, raising beds well above ground level facilitates aerial root pruning and simplifies growth monitoring.

Carbon Enrichment Techniques in QPS

In recent years, the use of an enriched CO_2 atmosphere has gained prominence as a nursery technique for manipulating seedling quality in response to environmental stresses. This approach is becoming increasingly popular because an elevated CO_2 atmosphere not only enhances nursery productivity by reducing seedling growth time but also offers the potential for seedlings to exhibit a preferential allocation to root development, thus increasing their root-to-shoot ratio. As the concentration of CO_2 in the atmosphere rapidly approaches 450 ppm, it is poised to have a significant impact on forest conditions, affecting their area, composition, and overall health. This phenomenon has the potential to boost growth rates in some areas while posing a threat to the survival of certain species and forest communities in others. The CO_2 fertilization hypothesis suggests that the rising atmospheric CO_2 levels positively influence tree growth by providing increased carbon availability.CO_2 plays a pivotal role in connecting the atmosphere with the biosphere, serving as an essential substrate for photosynthesis. Elevated CO_2 levels stimulate photosynthesis, leading to increased carbon uptake and assimilation, resulting in enhanced plant growth.

However, the response to elevated CO_2 varies depending on the photosynthetic pathway of the plant. C3 plants tend to exhibit a more significant growth response compared to C4 plants due to competitive inhibition of photorespiration by CO_2. The effects of CO_2 can also be influenced by the leaf habit of the species, where differences in leaf lifespan can result in varying responses to environmental cues like CO_2. Evergreen species typically show lower responsiveness to environmental changes, such as elevated CO_2, due to trade-offs between traits that reduce nutrient loss and those that promote high rates of dry matter production. On the other hand, deciduous species, with their lower specific leaf weight, tend to exhibit a more substantial response to CO_2 enrichment. Some studies have indicated that under elevated CO_2 conditions and with adequate nutrient supplementation, seedling diameter growth can increase by up to threefold (Salimath *et al.*, 2023). Total height growth also shows a significant increase under elevated CO_2 conditions. Moreover, the application of nutrients in combination with elevated CO_2 positively influences the volume index and biomass increment of seedlings. This implies that, in the context of climate change, where

atmospheric CO_2 concentration is doubled, species can adapt to the available nutrients, leading to enhanced seedling growth.

Integrated Nutrient Management in Nursery (INM)

Integrated Nutrient Management (INM), combining chemical fertilizers, microbial inoculation, and organic manures, outperforms other fertilization methods in citrus cultivation. INM requires fewer applications, typically once or twice, to modify the physico-chemical and microbial environment, unlike conventional fertilization, which necessitates 3-4 applications synchronized with growth stages or even up to 15-20 times using fertigation. Dual-function microbes like *Trichoderma harzianum/viride*, *Pseudomonas fluorescens*, *Bacillus polymyxa*, and *Arbuscular mycorrhizae*, when coupled with 75% of recommended fertilizer doses, effectively address multiple nutrient deficiencies on diverse soils, cultivars, and climates (Srivastava, 2009). The recent years have witnessed a growing recognition of the effectiveness of bio manures and biofertilizers in producing high-quality planting stock in forest nurseries. These bioresources have proven highly valuable in afforestation efforts and the reclamation of degraded lands, including mined overburdens and challenging terrains. Biofertilizers, encompassing biologically active products and microbial inoculants, play a vital role in promoting biological nitrogen fixation, phosphate solubilization, and nutrient mobilization.

INM is a relatively recent agricultural practice that emphasizes optimizing soil performance by enhancing both chemical and biological soil properties. In forestry, the adoption of INM holds substantial potential for increasing biomass productivity per unit area and unit time. Effective utilization of bioinoculants not only provides economic benefits but also sustains soil fertility and ecological balance within the natural soil ecosystem. The efficient use of these bioresources depends on the specific forest ecological environment and local availability, offering a cost-effective alternative to expensive chemical fertilizers. Different tree species favour specific combinations of beneficial microbes in their rhizosphere, which can improve seed germination and reduce seed dormancy through the production of growth-promoting substances. Mycorrhizal fungi, nitrogen-fixing bacteria, and phosphobacteria are examples of bioinoculants (biofertilizers) that play a crucial role in forestry programs by enhancing tree species' survival and growth. Inoculating nursery seedlings with selective bioinoculants holds promise for improving seedling quality, reducing transplanting periods, enhancing out planting performance, increasing resistance to diseases,

parasitic nematodes, and climatic stress. The application of bioinoculants also reduces the reliance on costly chemical fertilizers in plantation programs.

Currently, various biofertilizers are being used in forestry to enhance the growth of tree seedlings in nurseries (Kar et al., 2020). While biofertilizer benefits have been extensively studied in annual crops, information regarding their applicability in perennial crops or trees is limited in India. Nonetheless, some research reports in forestry demonstrate that biofertilizers stimulate growth, biomass, and nutrient uptake, leading to increased seedling survival rates. The application of both macro and micronutrients can significantly improve tree growth and productivity. The application of highly efficient biofertilizers not only ensures high-quality seedlings but also enhances outplanting performance, contributing to soil health and the sustainability of eco-friendly forestry practices.

Plant Quality Assessment Tool

The ever-growing demand for larger, superior, and faster-growing seedlings has driven ongoing advancements in forest seedling production technology for reforestation. Evaluating seedling quality is of paramount importance as it provides insights into seedling development in the nursery and their subsequent growth and survival in the field. However, the assessment of stock quality is inconsistent and often limited. While some nurseries and reforestation managers conduct comprehensive stock assessments annually, others only do so when issues arise. Despite the nurturing environment in nurseries, seedlings face various challenges during their journey from the sheltered nursery to their designated planting sites. From lifting and grading to storage, handling, and planting, seedlings encounter multiple opportunities for moisture stress, temperature stress, and physical stress. These stresses accumulate and can significantly impact field performance.

In cases of poor growth or survival post-planting, disputes may arise between the nursery and the landowner regarding the cause. Seedling quality data plays a crucial role in determining whether performance issues stem from nursery conditions, improper planting practices, or environmental factors post-planting. Seedling quality evaluation serves as a tool to establish benchmarks at specific stages, such as lifting or delivery, providing both the nursery and the customer with a quantitative assessment of a particular seedling lot. Furthermore, seedling quality data aids seedling producers and users in gaining a deeper understanding of seasonal patterns across various factors, including species, stocktypes, seed lots, and cultural treatments.

Seedling Quality Assessment*:* Seedling quality assessment encompasses two key categories: morphological and physiological evaluation, with both aspects contributing to a comprehensive understanding of seedling condition. Morphological quality assessment predominantly relies on physical attributes, with height and stem diameter being the primary parameters examined in forest seedling evaluation. Growing contracts often specify target values for these attributes, including acceptable minimum and maximum ranges. Height and stem diameter are quick and straightforward to measure, providing valuable insights into seedling quality and expected field performance. Nevertheless, relying solely on these measures falls short in fully assessing seedling condition. Root development, closely correlated with stem diameter, is seldom directly evaluated beyond casual observation during grading. Root quality assessments, while essential for assessing seedling health, are more time-consuming and necessitate a separate subsample evaluation. Additionally, seedling balance is crucial – even when height and stem diameter meet targets, an unbalanced seedling can hinder survival and growth after planting.

Physiological assessment of seedlings goes beyond their physical attributes and is vital for identifying stress-induced damage that may compromise seedling quality. Freeze damage, often hard to detect in dormant shoots during fall, can be assessed by potting a sample of seedlings, observing cambium and bud tissue for signs of browning after exposure to warmth and moisture. Cold hardiness testing is a valuable physiological assessment that gauges stress resistance. This test exposes seedlings to gradual freezing temperatures and evaluates the damage to foliage, cambium, and buds. Root growth potential (RGP) is another physiological test, though its predictiveness for field performance is debated. Additional physiological tests include Plant Moisture Stress (PMS), which measures xylem water potential and aids in irrigation scheduling and water stress monitoring, bud Development, which indicates dormancy and future shoot growth potential, chlorophyll fluorescence, reflecting photosynthetic activity, and nutrient status, which influences various metabolic processes within the seedling. Collectively, these assessments provide a holistic understanding of seedling quality, facilitating informed decisions for forest planting operations.

Indices for Seedling Quality Assessment: The evaluation of seedling quality in our country involves several key indicators. These measures play a vital role in determining the viability and performance of seedlings. Some of the significant indicators include:

1. *Collar Diameter:* Collar diameter serves as a valuable gauge of seedling growth. Seedlings with a collar diameter of approximately 2.50 - 3.00 cm (comparable to the thickness of a pencil) exhibit superior establishment potential in the field compared to taller, lankier seedlings.

2. *Root-to-Shoot Ratio*: The root-to-shoot ratio is another reliable indicator of seedling quality. Typically, a seedling with a root-to-shoot ratio falling within the range of 1.0 to 2.0 demonstrates better survival prospects in the field. A ratio greater than 1.00 signifies a robust root system capable of supporting shoot growth, while a ratio less than 1.00 suggests an insufficient root system, negatively impacting seedling survival, growth, and development.

$$\text{R: S ratio} = \frac{\text{Rootdryweight(g)}}{\text{Shootdryweight (g)}}$$

3. *Sturdiness Quotient:* The sturdiness quotient, as defined by Ritchie (1984), is a valuable measure of a seedling's strength, particularly regarding its ability to withstand wind. Young seedlings are often vulnerable to strong winds, which can lead to uprooting or bending. Bending can adversely affect the quality of timber produced by the tree. Seedlings with a sturdiness quotient falling in the range of 10 to 15 are considered ideal for ensuring better survival, growth, and development in the field. The sturdiness quotient is calculated using the formula:

$$\text{Sturdiness Quotient} = \frac{\text{Shoot length (cm)}}{\text{Collar diameter (cm)}}$$

4. *Seedling Quality Index*: Developed by Dickson in 1960, the Seedling Quality Index is a comprehensive measure that takes into account various morphological traits and seedling biomass. This index offers a holistic assessment of seedling quality. A seedling lot with a higher index value is more likely to perform well in the field. The formula for calculating the Seedling Quality Index is as follows:

$$\text{Seedling quality Index} = \frac{\text{Total seedling dry weight (g)}}{\frac{\text{Plant height (cm)}}{\text{Collar diameter (cm)}} + \frac{\text{shoot dry weight (g)}}{\text{Root dry weight (g)}}}$$

These indicators collectively provide valuable insights into the quality and potential of seedlings for successful field performance.

Conclusion

The production of high- QPS in forestry plays a crucial role in achieving reforestation and afforestation goals. It involves a complex interplay of genetic traits, nursery practices, and environmental factors. Key elements in this process include careful seed selection, the use of root trainers to promote proper root development, integrated nutrient management, and the assessment of both morphological and physiological seedling quality. Moreover, the adoption of modern techniques such as carbon enrichment to enhance growth and the use of biofertilizers have the potential to further improve seedling quality and subsequent field performance. Effective planning, site selection, and ongoing evaluation are essential for successful QPS production, contributing to sustainable and eco-friendly forestry practices.

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Article Id
AL04281

SOCIAL MEDIA: A POWERFUL TOOL FOR GOVERNMENT COMMUNICATION AND ENGAGEMENT

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Social media is a powerful tool for government communication and engagement. It allows governments to reach a large audience quickly and easily, share information in a variety of formats, engage with citizens in a two-way dialogue, build relationships with citizens and communities, and promote transparency and accountability.The Indian government is at the forefront of this trend, rapidly adopting the latest digital technologies and embracing social media communication tools to discharge its governance and administrative duties. Most government departments and agencies now maintain an active presence on popular social media channels, sharing news updates, departmental notifications, and public announcements. Executive officers, bureaucrats, politicians, and ministers are also active on social media, cross-sharing each other's updates. The content shared can be in any form, but videos are often the most engaging format.

The use of social media to communicate with citizens during the COVID-19 pandemic is a good example of how the Indian government is using social media to engage and interact with citizens in a meaningful way. Social media allowed the government to reach a large audience quickly and easily, provide real-time updates on the pandemic, and address misinformation.

Overall, social media is a powerful tool that governments can use to communicate and engage with citizens in a more effective and efficient way. By using social media, governments can reach a larger audience, provide real-time updates, collect feedback, and build relationships with citizens.

The new-age social media tools are universal and pervasive, easy to install and use, and have a simplified user experience. While the physical world is constrained by the limitations of distances and boundaries, the virtual world is all-encompassing, making us all

part of a continuous global village. Governments across the globe have adopted social media to engage and interact with citizens. The Indian government is at the forefront of this trend, rapidly adopting the latest digital technologies and embracing social media communication tools to discharge its governance and administrative duties.

Most government departments and agencies now maintain an active presence on popular social media channels, sharing news updates, departmental notifications, and public announcements. Executive officers, bureaucrats, politicians, and ministers are also active on social media, cross-sharing each other's updates. The content shared can be in any form, but videos are often the most engaging format.

Social media is a powerful tool for government communication and engagement because it allows governments to:

- Reach a large audience quickly and easily.
- Share information in a variety of formats, including text, images, videos, and audio.
- Engage with citizens in a two-way dialogue.
- Build relationships with citizens and communities.
- Promote transparency and accountability.

Social media is a powerful tool for government communication and engagement because it is universal, pervasive, and easy to use. It allows governments to reach a large audience quickly and easily, share information in a variety of formats, engage with citizens in a two-way dialogue, build relationships with citizens and communities, and promote transparency and accountability.

Social media streams to improve services and communication with citizens

How Social Media is Used by Government for Communication and Engagement

Crisis communication: Social media is a valuable tool for government communication during crises, such as natural disasters, public health emergencies, and terrorist attacks. It allows governments to provide real-time updates to citizens, share safety information, and address misinformation.

Public service announcements: Social media is a great way for governments to raise awareness about important public service announcements, such as new laws and regulations, upcoming elections, and public health campaigns.

Feedback collection: Social media can be used to collect feedback from citizens on government policies and programs. This feedback can be used to improve government services and make more informed decisions.

Citizen engagement: Social media can be used to engage citizens in government decision-making. For example, governments can use social media to conduct polls and surveys, host virtual town hall meetings, and solicit feedback on draft legislation.

Building relationships: Social media can help governments to build relationships with citizens. By interacting with citizens on social media, governments can show that they are listening to their concerns and that they are committed to transparency and accountability.

Examples of How Governments Are Using Social Media for Communication and Engagement

The US Centers for Disease Control and Prevention (CDC) uses Twitter to provide real-time updates on public health threats, such as COVID-19 and the flu. The CDC also uses Twitter to share educational content about public health topics, such as vaccine safety and infectious disease prevention.

The Indian government is using the social media platform Koo to share official news updates and government announcements. The government is also using Koo to engage with citizens and address their concerns.

The Australian government is using the social media platform Facebook to share information about government services and programs. The government is also using Facebook to run public service announcements and to interact with citizens.

Social media is a powerful tool that governments can use to communicate and engage with citizens in a more effective and efficient way. By using social media, governments can reach a larger audience, provide real-time updates, collect feedback, and build relationships with citizens.

The Indian Government Has Adopted Social Media to Engage and Interact With Citizens in a Variety of Ways, Including

Providing news and information: The government uses social media to share news updates, departmental notifications, and public announcements.

Educating the public: The government uses social media to share educational content about government programs, public health issues, and other important topics.

Promoting citizen engagement: The government uses social media to conduct polls and surveys, host virtual town hall meetings, and solicit feedback from citizens on government policies and programs.

Resolving grievances: The government uses social media to respond to citizen grievances and provide support.

Building relationships: The government uses social media to interact with citizens and build relationships with communities.

The use of social media to communicate with citizens during the COVID-19 pandemic is a good example of how the Indian government is using social media to engage and interact with citizens in a meaningful way. Social media allowed the government to reach a large audience quickly and easily, provide real-time updates on the pandemic, and address misinformation.

Here Are Some Specific Examples of How the Indian Government Is Using Social Media to Communicate And Engage With Citizens

- The Prime Minister of India, Narendra Modi, uses Twitter to share his thoughts on current events, announce government policies, and interact with citizens.
- The Ministry of Health and Family Welfare uses Twitter to share updates on COVID-19 cases, vaccination rates, and other public health information.

- The MyGov platform is a government website that allows citizens to participate in government decision-making and provide feedback on government policies and programs.
- The Narendra Modi App is a mobile app that provides citizens with access to government services and information.
- The Indian government's use of social media is a good example of how governments can use this powerful tool to communicate and engage with citizens in a more effective and efficient way. By using social media, governments can reach a larger audience, provide real-time updates, collect feedback, and build relationships with citizens.
- The Indian Government's Use of Social Media to Communicate with Citizens During the COVID-19 Pandemic

The Indian Government Is Using Social Media to Promote Electric Vehicles in a Variety of Ways, Including

- Sharing educational content about the benefits of electric vehicles, such as their environmental friendliness, lower operating costs, and reduced noise pollution.
- Highlighting government incentives for purchasing electric vehicles, such as tax breaks and subsidies.
- Promoting success stories of people and businesses that have switched to electric vehicles.
- Addressing common myths and misconceptions about electric vehicles.
- Engaging with citizens on social media to answer their questions about electric vehicles.

Conclusion

The Indian government's use of social media to promote electric vehicles is a good example of how governments can use this powerful tool to raise awareness about important issues and to encourage people to take action. By using social media, governments can reach a large audience quickly and easily, share information in a variety of formats, and engage with citizens in a two-way dialogue.

The Indian government is committed to promoting electric vehicles as part of its efforts to reduce air pollution and greenhouse gas emissions. The government has set a target of having 30% of all vehicles on Indian roads be electric by 2030.

The government is offering a variety of incentives to encourage people to switch to electric vehicles, such as tax breaks, subsidies, and free parking. The government is also investing in the development of electric vehicle charging infrastructure.

The benefits of electric vehicles, such as their reduced carbon footprint, lower operating costs, and improved air quality. The post also includes a link to a website where people can learn more about electric vehicles and government incentives for purchasing electric vehicles.

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Article Id
AL04282

SOIL HEALTH INDICATORS: NEW TOOLS FOR ASSESSING AND MONITORING SOIL QUALITY

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Soil health is the bedrock of sustainable agriculture and ecological balance, playing a crucial role in supporting the growth of crops, maintaining biodiversity, and regulating various environmental processes. As global demands for food, fiber, and fuel continue to escalate, the need to preserve and enhance soil quality becomes increasingly imperative. In this pursuit, scientists and researchers have been diligently exploring innovative approaches to assess and monitor soil quality, with a focus on developing robust soil health indicators. The traditional concept of soil fertility, centered around the measurement of essential nutrients such as nitrogen, phosphorus, and potassium, while still essential, is no longer sufficient to provide a comprehensive understanding of soil health. Recognizing the multifaceted nature of soil ecosystems, modern soil science has explored the complex interactions between physical, chemical, and biological components that influence soil quality.

The advent of advanced technologies and data-driven approaches has revolutionized the field of soil science, allowing for a more holistic and dynamic assessment of soil health. Soil health indicators have emerged as valuable tools, providing valuable insights into the overall condition and functioning of soils. These indicators go beyond mere nutrient levels, encompassing a range of parameters that offer a deeper understanding of soil structure, nutrient cycling, microbial diversity, and ecological resilience.

The Significance of Soil Health Indicators

Healthy soil harbours a thriving community of organisms, ranging from microorganisms like bacteria and fungi to macrofauna like earthworms. It also exhibits a balanced nutrient composition, proper physical structure, and a stable pH level. Soil health indicators are crucial as they allow us to assess these attributes, providing valuable insights

into the overall health and functionality of the soil ecosystem. By understanding soil health better, farmers and land managers can implement targeted strategies to optimize agricultural practices, minimize environmental impacts, and foster soil regeneration.

Major Soil Health Indicators

1. **Physical indicators:** Soil texture, structure, compaction, and porosity play pivotal roles in determining water infiltration rates, aeration, and root growth. Assessing these indicators helps identify soil conditions that may hinder plant growth and water retention.

2. **Chemical indicators:** Soil pH and nutrient content are vital chemical parameters that influence nutrient availability to plants. Cation Exchange Capacity (CEC) is a measure of the soil's ability to hold and exchange essential nutrients. Monitoring these indicators allows for proper soil nutrient management.

3. **Biological indicators:** The soil's biological component, including the diversity and abundance of microorganisms, is a reflection of its fertility and overall health. Monitoring soil microbiomes and earthworm populations helps understand nutrient cycling and biological activity.

Emerging Technologies for Soil Health Assessment

Advancements in technology have brought forth innovative tools that enhance soil health assessment:

- **DNA sequencing and metagenomics:** Genetic techniques like DNA sequencing provide deep insights into the diversity of soil microorganisms. Metagenomics allows us to understand the functional potential of these microbes, uncovering their role in nutrient cycling and plant health.

- **Remote sensing and GIS applications:** Satellite-based soil moisture monitoring and high-resolution soil mapping using drones enable large-scale and real-time data collection. This technology helps identify variations in soil health across vast agricultural landscapes.

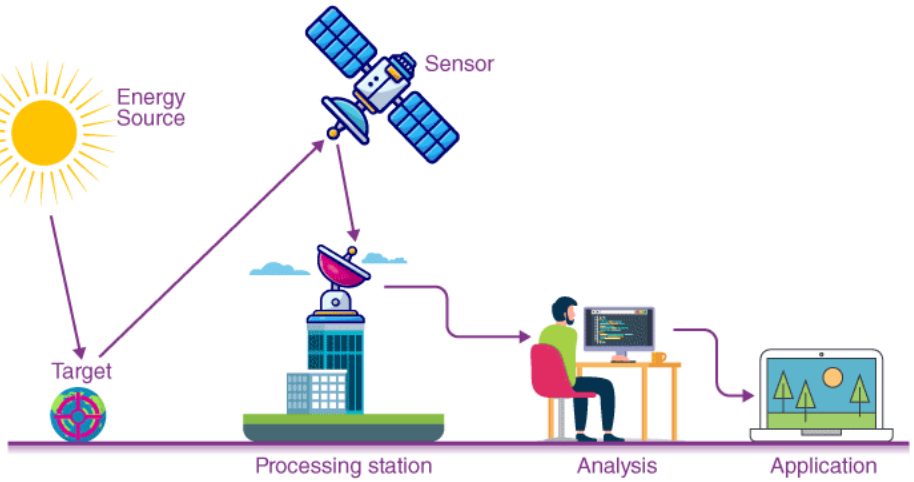

Fig. 1: The Remote Sensing Process

- **Sensor technologies:** Internet of Things (IoT)-based soil moisture and nutrient sensors offer real-time data collection. These sensors enable farmers to optimize irrigation schedules and nutrient applications, reducing resource wastage.

Integrating Data for Comprehensive Assessment

Soil Health Indices and Scoring Systems

Soil health assessment involves the integration of various soil health indicators to create comprehensive indices and scoring systems. These indices and scores provide valuable insights into the overall health and quality of the soil, helping farmers and researchers make informed decisions about agricultural practices and land management. The process of creating soil health indices typically involves the following steps:

1. **Selection of relevant indicators:** Scientists and researchers carefully choose a set of soil health indicators that are relevant to the specific region and the crops being cultivated. These indicators can include physical, chemical, and biological properties of the soil, such as organic matter content, nutrient levels, microbial diversity, soil structure, water-holding capacity, and erosion potential.

2. **Data collection:** Extensive data collection is carried out to quantify the selected indicators in the soil samples taken from different locations within the study area. Modern technology, such as remote sensing and advanced soil testing methods, may be employed to gather accurate and high-resolution data.

3. **Normalization and standardization:** As soil health indicators often vary significantly in their natural ranges, normalization and standardization techniques are applied to ensure fair comparison and equitable contribution of each indicator to the final soil health index.

4. **Weighting and aggregation:** To create a comprehensive index, each indicator is assigned a specific weight based on its relative importance in influencing soil health. The weighted indicators are then combined using a suitable mathematical model to generate an overall soil health score for a particular area.

5. **Interpretation and communication:** The final soil health index is interpreted to provide meaningful insights to farmers, land managers, and policymakers. The results are communicated in a user-friendly manner to facilitate practical applications in agricultural decision-making processes.

Soil Health Indicators with Crop Performance and Yield

The success of any soil health assessment lies in its ability to correlate soil health indicators with crop performance and yield. Understanding the relationships between soil health and crop productivity is essential for farmers to optimize their agricultural practices and maximize sustainable yields. Several methodologies are employed to establish these correlations:

1. **Field Trials and Experiments:** Controlled field trials and experiments are conducted to monitor and evaluate crop performance and yield under different soil health conditions. By varying specific soil health indicators, researchers can observe the impact on crop growth, health, and overall productivity.

2. **Long-Term Observational Studies:** Long-term studies involving continuous monitoring of soil health parameters and crop yields provide valuable insights into the sustained effects of certain soil health practices on agricultural productivity.

3. **Statistical Analysis:** Sophisticated statistical techniques are utilized to analyze the data collected from field trials and observational studies. This analysis helps identify significant correlations between specific soil health indicators and crop performance, enabling the development of predictive models.

4. **Machine Learning and AI:** Advancements in machine learning and artificial intelligence have opened up new possibilities for analysing vast datasets, leading to more accurate predictions and correlations between soil health indicators and crop productivity.

Regional Variations and Their Impact on Soil Health

Soil health varies across different regions due to variations in climate, geology, land use, and management practices. Understanding these regional variations is crucial for tailoring soil health management strategies to specific environments. Some important considerations include:

1. **Climate and weather patterns:** The amount and distribution of rainfall, temperature fluctuations, and other climatic factors greatly influence soil health. Regions experiencing different climates will have unique challenges and opportunities for improving soil health.

2. **Soil types and geology:** Different soil types, such as clay, silt, sand, and loam, have distinct properties that affect their capacity to retain nutrients and water. Geology also plays a role in determining soil mineral content and overall fertility.

3. **Land use and management:** The history of land use and management practices, including the use of fertilizers, pesticides, and tillage, significantly impacts soil health. Sustainable agricultural practices can help mitigate negative impacts and improve soil health over time.

4. **Biodiversity and ecosystems:** The presence of diverse plant and microbial communities can enhance soil health through increased organic matter, nutrient cycling, and disease suppression. Understanding the regional biodiversity is essential for supporting and preserving soil health.

Conclusion

Soil health indicators and monitoring tools represent a significant leap forward in understanding the dynamic nature of soil ecosystems. By harnessing these advancements, we can foster sustainable agriculture, protect the environment, and ensure a prosperous future for generations to come. Researchers, policymakers, and farmers must work together to promote

the widespread adoption of these tools and safeguard the invaluable resource that lies beneath our feet-the soil.

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AGRIALLIS
Science for Agriculture and Allied Sector: A Monthly Magazine
Volume 5, Issue 11
www.agriallis.com

Article Id
AL04283

TWINS AND ITS ROLE IN CROP IMPROVEMENT

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Twins in animals, can be either monozygotic (identical) or dizygotic (fraternal), depending on whether they develop from a single fertilized egg or two separate eggs fertilized by different sperm cells. This phenomenon is well-known in humans and many other animal species. In plants, the occurrence of twins or polyembryony is less common but still fascinating. Just like in animals, plant twins can be either genetically identical or fraternal. The process of fertilization and embryogenesis in higher plants is indeed complex and tightly regulated, similar to animals. The role of dehydroascorbate reductase (DHAR) in producing twin and triplet seedlings in plants is an intriguing discovery. DHAR is an enzyme that plays a crucial role in recycling vitamin C in both plants and animals. Increasing the level of DHAR can result in higher levels of vitamin C in plants, leading to the production of multiple seedlings from a single seed (Chen and Gallie, 2012). This has significant implications for agriculture and crop production, as it could potentially be used to increase the yield of high-value crops. Additionally, having multiple seedlings from a single seed may also enhance the survival chances of some plant species, as it provides a form of redundancy and resilience in case some of the seedlings encounter unfavorable conditions. Overall, the parallels between the production of twins in plants and animals, as well as the potential applications of DHAR in agriculture, highlight the fascinating complexity of biological processes across different species and the potential for scientific discoveries to benefit various fields, including crop production and genetics.

Biology of Twining

Regarding spontaneous or natural monozygotic twinning, a recent theory posits that monozygotic twins are formed after a blastocyst essentially collapses, splitting the progenitor cells (those that contain the body's fundamental genetic material) in half, leaving the same genetic material divided in two on opposite sides of the embryo. Eventually, two separate

fetuses develop. Spontaneous division of the zygote into two embryos is not considered to be a hereditary trait, but rather a spontaneous or random event.

Occurrence of Twining in Plants

In the context of plant reproduction, twinning refers to the formation of twin seedlings. These twin seedlings can arise in two main ways:

a. Division of Single Zygote: Similar to how twins can develop in animals, one way twin seedlings can form is when a single zygote divides into two distinct embryos.

b. Apomixis: Apomixis is another way in which twin seedlings can develop. Apomixis is a form of asexual reproduction in plants where embryos develop without the need for fertilization.

Embryo Development: In plants, embryo development begins with the transverse division of a zygote into two distinct cells—an apical cell that becomes the proembryo and a basal cell that gives rise to the suspensor. Mutations or changes in cell division during this process can lead to the development of twin embryos.

Role of Vitamin C (Ascorbic Acid, Asc): Injecting plant ovaries with vitamin C (ascorbic acid) can induce twinning in some plant species (**Figure 1**). Vitamin C appears to regulate cell polarity during embryo development and can lead to the formation of genetically identical twin embryos. This process is similar to the role of the gene DHAR (dehydroascorbate reductase), which affects cell division and can induce twinning.

Developmental Timing: It's important to note that twinning induced by vitamin C or DHAR is developmentally limited to the early stages of plant growth, typically within the first two days after pollination.

Genetic Factors and Mutations: Mutations in genes like TWIN can result in the formation of additional embryos through the transformation of suspensor cells early in embryogenesis (Gunaga and Vasudeva, 2008). Abnormalities leading to twinning or polyembryony in plants can be attributed to various factors, including developmental errors during ovary development, fertilization, genetic factors, or mutations.

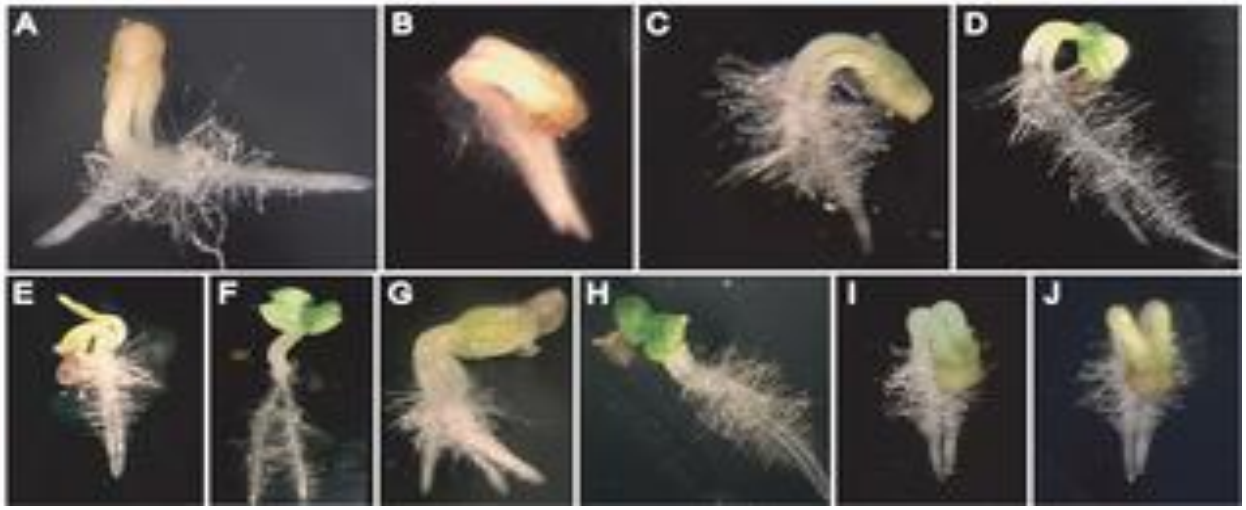

Fig. 1: DHAR induced twining in tobacco

Depending on their origin, twin seedlings may be diploid/diploid, diploid/haploid or haploid/haploid. The frequency of observed polyembryony is extremely low and species-dependent; for instance, the frequency was reported at 4% in soybean, 0.37% in Capsicum, 0.10% in maize, and 0.054% in grape (Chen and Gallie, 2012). Twin seedlings usually show one of the following combinations: diploid-diploid, diploid-haploid, haploid-haploid, and diploid-triploid. So far many reports recorded the polyembryony in several tropical tree species like *Acacia farnesiana, Robinia pseudocasia, Terminalia Arjuna, Tectona grandis, Santalum spicatum, Mangifera indica, shorea robusta, Dalbergia sissoo, Bombax ceiba, Putranjiva roxburghii, Nathopodytes nimmoniana, Saraca asoca, Garcinia indica* and *Mammea suriga*.

Another study, the loss of AMP1 (ALTERED MERISTEM PROGRAM 1) function; a gene required for synergid cell fate during Arabidopsis female gametophyte development leads to supernumerary egg cells at the expense of synergids, enabling the generation of dizygotic twins (Kong et al. 2015). Alternatively the artificial delivery of supernumerary sperm cells in tetraspore (tes) pollen, enabling the formation of twin plants. The twin-embryo phenotype of amp1 mutants also sheds light on the boundary conditions for double fertilization in plant reproduction, which involves two sperm cells and the four cells at the micropylar end of the female gametophyte: two synergids, one egg cell, and one central cell. Ovules with twin embryos but no endosperm as well as ovules with one developing embryo and endosperm plus one persisting unfertilized egg cell strongly suggest that the two sperm cells of a fertilizing pollen tube are free to choose their mating partners.

Recently, the researchers discovered that the injecting plant ovaries with vitamin C is sufficient to produce twins or triplets in many plant species (**Figure 2**). In tobacco, the vitamin C causes the zygote, the fertilized egg, to divide into two or even three fertilized egg cells before these cells proceed through subsequent stages of development to produce twins or triplets. The twins and triplets produced in tobacco plants when vitamin C was increased were true twins or triplets as they were genetically identical. Because the early stages of embryo development are so conserved among plant species, the vitamin C will have a similar effect in almost any plant. These study suggested that the critical effect of vitamin C is on the very first stage during cell division.

The formation of embryo without sexual process is called apomixis and seed is called apomictic seed, the condition is called polyembryony. Polyembryony is the occurrence of more than one embryo in a seed which consequently results in the emergence of multiple seedlings. The additional embryos result from the differentiation and development of various maternal and zygotic tissues associated with the ovule of seed. Polyembryony usually associated with nuceller embryony because it frequently results in polyembryonic seeds from which multiple seedlings germinate. Based on genetic composition the polyembryony classified into I. Gametophytic: multiple embryos arises from the gametic cells of the embryo sac (synergid, antipodal) after or without fertilization. In this case haploid embryos are formed. The second one is Sporophytic where the multiple embryos arise either from zygote or from sporophytic cells of ovule (nucellus, integument) and the resulting embryo will be diploid.

a. Normal seedling b. Twin seedling

Fig. 2: Vitamin C induced twining in Terminalia

Role of Twins in Crop Improvement

1. Genetic Uniformity: The ability to produce genetically identical seedlings from a single seed can be highly advantageous in crop improvement. It ensures that desirable traits in a crop can be preserved and propagated consistently across generations. This is especially important for maintaining the quality and characteristics of high-value crops.

2. Increased Fertility: Polyembryony can be particularly valuable when the natural fertility rate of a crop is low. By producing multiple embryos in a single seed, the chances of successful germination and plant establishment are enhanced. This is beneficial for crops where increasing yield or maintaining consistent production is a priority.

3. Nutrient Enhancement: In cases like corn, where the production of multiple embryos can significantly boost protein content, polyembryony can be instrumental in increasing the nutritional value of the crop. This can have a direct impact on the crop's suitability for human or animal consumption.

4. Survival Chances: Having multiple seedlings germinate from a single seed can also improve the per-seed survival chances for some plant species. It provides a form of insurance against adverse environmental conditions or pest attacks, as not all seedlings may be affected in the same way.

5. Crop Resilience: In situations where crops face challenges like diseases or pests, having genetically identical seedlings can make it easier to develop resistant varieties. This can aid in crop resilience and reduce the need for chemical interventions.

6. Resource Efficiency: Producing multiple seedlings from a single seed can be more resource-efficient than planting individual seeds. It can reduce the amount of seed required for planting and lead to cost savings in agriculture.

Conclusion

In conclusion, twin seedlings or polyembryony offer various benefits in crop improvement, including genetic uniformity, increased fertility, enhanced nutrient content, improved survival chances, and resource efficiency. These advantages can contribute to higher crop yields, improved crop quality, and more sustainable agricultural practices.

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