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Website: www.readersshelf.com

*Email:*readersshelf@gmail.com, jvph@rediffmail.com

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1. AGRICULTURE EXTENSION

Information Technology and Farming

Arpita Vyas

Jodhpur

Introduction

The information technology (IT) has become an integral part now a day. The development in this field is enormous and everybody is now well versed with it. We can say that the present scenario is time of Information Technology and Communication. The IT industry has grown with a very fast speed and it has enabled everyone to communicate in the faster and quicker manner. The IT is more interactive and can provide information in accordance with the need. It not only provides information but also ensures that the users get and gather the information as per their needs very quickly. It is important to mention here that in addition to gathering the sharing, transmission and preservation of information has also become very easy. The IT has enabled the users to use information for the social and cultural betterment of the society. The growth of communication and IT has become main source of knowledge spreading across the globe. Today everybody has access to the global information with the help of computer and internet. It leaves multi-dimensional impact on all spheres of human activity as it has accelerated the process of information exchange, reduced the cost involved in achieving the ultimate objectives at farmers field. The introduction of AI too is contributing in this.

IT in Agriculture

The IT and the communication are useful, as stated, in every sphere and agriculture section is no exception. The IT has enabled experts to provide technical services in agriculture and allied sectors. There are numerous things in which the farmers need experts' services which include sharing of weather information, market information viz. demand of the products, prices at various places etc., global news, latest developments in the agriculture field etc. Besides, the information regarding state and central agricultural schemes formed for the welfare of the farmers can also be shared, very quickly. This could be possible with the various communication systems available with the help of IT. We know that in our country the use of IT is at a rising phase, so far as farmers are concerned, yet its growth may be more if proper infrastructural development is there in the remote areas and villages. Moreover, this can further be increased by providing proper education to farmers as to how to use the information available through computers and by using internet. They should be educated as to using right information at right time for carrying out the farming activities. This will certainly help them a lot to increase productivity and get better price of their products. They will not only be able to save the cost but also will find themselves capable to improve the productivity of agriculture commodity. The effectiveness of any sector will depend upon so many factors which include the effective communication and sharing of information too. Presently the information regarding agriculture and farm activity etc. is mostly done through information technology and communication systems.

Problems which the Development of IT and Communication face

The information may be shared smoothly and in effective manner if certain problems and limitations are removed. The country like India, which is geographically a very large country as compared to other developed countries, faces many problems in this regard. The main issues are:

- Poor infrastructure in initiating information in agriculture and allied sectors is main problem which needs to be addressed. There are hundreds of villages and small towns where the supply of electricity is a big obstacle which creates so many issues in information sharing ;

- Lack of proper education: The agricultural activities, as we all know, are carried out in villages and the farmers are small and marginal, they are poor and are not properly educated. This has become a major barrier in adopting IT and communication facilities. We also find that the farmers who are literate are not well versed with the computers and its functionality etc. ;
- Financial issues: Economical and financial conditions are not good so far as farmers are concerned. They do not find themselves able to afford the cost of information technologies.

Although these are major concerns yet they can be overcome in view of the fact that there are certain schemes in different parts of the country which enables them to gather the required information. The VOIP and WLL are cheaper source and now the internet facility in the country provides complete information at a very quick speed. Similarly, the state and the central Governments are emphasizing electrification in rural areas and for the purpose they have launched schemes. The farmers may get knowledge and information through internet services and take decisions accordingly.

Advantages of IT and Communication

There are certain advantages of Information Technology and communication to the farmers. These are as under:

- Farmers get increased productivity;
- They remain well informed for taking decisions;
- The IT and communication system enable them to have access to the source and resource;
- They get good price of their products;
- The IT and communication enable them to get good price at their own place so the interference of middle-men decreased which results into good margin for the farmers;
- As the margin increases so the financial position of the farmers get positive growth;
- The middlemen, who used to take benefit of lack of knowledge of farmers, are finding them helpless in using unethical practices to cheat the farmers;
- Thanks to communication and Information technology which has provided the options to the farmers to take their produce to long distances from their villages for getting good price of their produce.

Use of Global information by Using Internet

The internet service is considered to be as prospective tool to access global information. For exploiting the potentiality of Internet, Food and Agriculture Organization (FAO) has formulated Virtual Extension and Research Communication Network (VERCON). Under the project, it was intended to create a common web-based information sharing and communication platform for research and advisory institutions equipping them with efficient networking tools and capacities to help improve quality of the advisory services provided to farmers. This allows the experts and farmers to interact. The experts may interact with the farmers of distant or remote areas through videoconferencing. They may provide their expert services, knowledge about new schemes of the State or the Central government or development in research in agricultural sector through this facility. Innovations and new happenings in the field of agriculture may also be shared with the farmers.

The overall motive of VERCON is to improve agricultural advisory services so that the farmers and agriculturists in remote areas can get the latest information for improvement of productivity. They can also get information about new and latest development in agriculture which in turn would enable them to increase their income.

How the Communication system can be Expanded?

As discussed lack of education, poor infrastructure, financial and market illiteracy etc. are main reasons which have become hurdles in expansion of communication systems in rural areas. Thus, there is need to increase the same and for the purpose it is needed that the products, services and the technologies should be developed in such a way that the same can address the problems of farmers in:

- Farming activities;
- Distribution of agriculture produce;
- Procuring the best price of the commodity;
- Improving the fertility of soil;
- Providing proper nutrients to the plants;
- Improving the harvesting facilities;
- Flowing of produce to distant areas etc.

If the Governments (Centre and the state) take care of the various issues of agriculturists and provide proper solutions then the same may increase their social and economic conditions. Once this is achieved the use of information technology would increase automatically.

Constraints

However, nothing is possible if the execution and implementation of things are not streamlined. Theoretical success may be shown on papers and write-ups but unless working is done on ground level nothing positive may happen. There are, therefore, certain limitations due to which the expected increase in the use of internet or the information technology could not happen in our country nor the technology could be transferred to the farmers. These constraints are as under:

1. Lack of focus on rural areas communication;
2. Inefficient and unorganized market for agricultural products;
3. Inability of Government :
   a. in dealing with the natural resources,
   b. in management to integrate new technology into their operation, and
   c. badly structure approach towards economic reform in information technology sectors.

Future Prospects

The possibility of use of Information technology is very wide. Till now it has not been exploited to the extent to which it should have been. Thus, there is a need to exploit the information technology and the communication system in such a manner that they increase the personalized services so far as the agriculture and allied sectors are concerned. This can only happen if the access of these facilities (information technology and communication) is more and more by the farming community. The proper education to the farming community should be provided so that they may find themselves able to reduce the cost of cultivation by using these services.

For the purpose the farmers and the agriculturists should be communicated that the information technology and the communication services shall be helpful to them in the following manner:

1. The development in the field of agriculture and allied sector shall be known to them in real time;
2. Their awareness in the latest technology will increase to a great extent;
3. They would very quickly know about the policies and programmes, the government has launched, which are beneficial to them;
4. Agricultural productivity can be increased with the help of IT;
5. With the help of communication technology the increased price realization/awareness can be availed at village level. The awareness will increase and dependency on middle-men will reduce which would increase their margin of profit;
6. Agricultural extension is also one of the important aspect which can be improved with the help of communication and information technology;
7. The best price realization can be achieved with this facility and the role of middlemen can be reduced to a great extent;
8. The dependency on middlemen would reduce to a great extent for sale of agriculture produce.

The above list is not exhaustive. In addition to above, the information and communication technology is helpful to the farmers and the farming community in so many other ways. In the present time many farmers, especially in southern and western areas of the country, have developed their own new package and practices. They have tied together and made their own groups. Such practice and togetherness have proved useful in increasing the agricultural productivity in their respective areas. Since most of the technologies remain in local use and are not spread globally so the people were not in a position to know the developments at global level or in different areas of same country. However, now, thanks to the information technology and the communication systems, the developments spread quickly and the farmers of other parts of the globe know these developments immediately. This helps them in increasing the agricultural productivity by using these techniques, practices etc.

As discussed earlier one of the main constraints which our country faces is very less literacy rates among the farmers. Even today many of them find themselves unable to read and write. Now with the help of information technology and communication system the audio video measures are there. With these devices the farmers can now listen or see the latest development and can understand with the audios or videos. Thus, the farmers and the agriculturists who cannot read or write can know the new developments and advancements in agricultural sector with the help of these audios/videos etc.

The technology has also resulted in removing the problem like improvement in extension services. We know that in order to improve the extension services the cost of man power required everywhere used to be very high. It used to be a costly affair. However, the use of communication system has helped in reducing the cost and improving the quality of extension. This happened with the help of Information technology and communication system as the farmers at distant or remote locations can know the developments etc. happened at a distant place.

Conclusion

In conclusion it can very well be said that Indian agriculture and allied sectors can generate higher productivity with higher income with the help of efficient and effective information technology and communication system. The IT and communication system enables farmers to manage the risks in a better way. Although the Government, Research organizations, NGOs, KVKs, Panchayats and Gram Panchayats have done a lot in the field yet there are so many other things which are to be done for increasing the knowledge of farmers and farming community. The establishment of VKCs in the villages and remote areas can be a good help of agriculturists.

These VKCs should be used

- To disseminate the new developments to the farmers so that they can use such new techniques while farming to increase the productivity with lesser cost;
- To show the result of use of new techniques in agriculture and allied sectors with the help of communication technologies;
- To educate them how to reduce cost and how to get better productivity etc.

2. HORTICULTRE

Role of Green Manuring in Fruit crops

Dhara P. Suthar [1] and Dr. N. I. Shah [2]

[1] Ph.D Scholar, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand-388110,

[2] Principal & Dean, College of Horticulture, Anand Agricultural University, Anand-388110

Introduction

Sustainable agriculture is essential to address the challenges of increasing food demand, soil degradation, and environmental concerns. Fruit crops, known for their high economic value and long cultivation periods, require consistent soil fertility and health to maintain productivity. Over the decades, the overuse of chemical fertilizers has led to soil exhaustion, reduced microbial activity, and environmental pollution. As a result, there is an increasing need to adopt sustainable practices that rejuvenate the soil and enhance crop productivity without degrading the ecosystem.

Green manuring is a traditional yet highly effective agronomic practice that involves growing specific plant species—typically legumes—and incorporating them into the soil while still green. These plants decompose rapidly, enriching the soil with organic matter and nutrients. The process is particularly beneficial for fruit orchards where soil health plays a critical role in determining yield, fruit quality, and tree longevity. Unlike annual crops, fruit trees depend on a stable and rich rhizosphere for many years, making soil management practices like green manuring a cornerstone of sustainable orchard management.

Incorporating green manures in fruit crop systems offers numerous agronomic, ecological, and economic benefits. They improve the physical structure of soil, increase its organic carbon content, stimulate microbial activity, and enhance nutrient cycling, particularly nitrogen. Moreover, green manuring helps in weed suppression, pest control, and reducing soil erosion, which are essential for maintaining orchard health, especially in rainfed or sloped terrains.

Types of Green Manures Green manures are crops grown primarily to be incorporated into the soil to enhance its fertility and structure. They can be classified into:

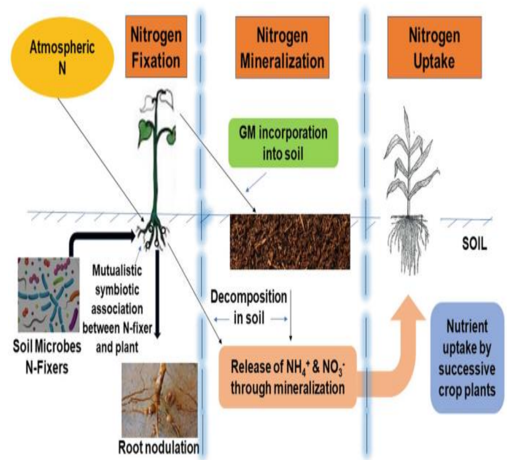
Leguminous Green Manures: e.g., sunhemp (*Crotalaria juncea*), dhaincha (*Sesbania spp.*), cowpea (*Vigna unguiculata*)

Non-Leguminous Green Manures: e.g., mustard, sorghum, buckwheat

Tree-based Green Manures: e.g., Gliricidia sepium, Leucaena leucocephala

Mechanisms of Action Green manures improve soil and fruit crop productivity through multiple mechanisms:

- **Nitrogen Fixation:** Legumes fix atmospheric nitrogen, enriching soil nitrogen content which is crucial for vegetative growth in fruit crops.
- **Organic Matter Addition:** Enhances soil physical properties, water holding capacity, and microbial activity, supporting sustained fruit development.
- **Weed and Pest Suppression:** Certain green manures act as bio-fumigants, reducing pest and disease incidence in orchards.
- **Soil Structure Improvement:** Enhances aeration and root penetration, critical for perennial fruit tree root systems.



Role in Fruit Crops

Fruit crops have long growth cycles and deep-root systems, making soil fertility crucial for their productivity. Green manuring in fruit orchards supports:

- **Improved Nutrient Cycling:** Supplies macro- and micronutrients essential during flowering and fruit setting.
- **Enhanced Microbial Activity:** Boosts rhizosphere interactions vital for root health and nutrient absorption.
- **Increased Organic Carbon:** Builds long-term soil fertility and enhances fruit size and flavor.
- **Reduced Soil Erosion and Compaction:** Maintains orchard floor health, especially in high-rainfall or hilly areas.

Common Green Manure Practices in Fruit Orchards

- **Inter-row Sowing in Young Orchards:** Particularly effective in banana, papaya, and citrus plantations.

- **Strip Planting Between Tree Rows:** Used in mango, guava, and apple orchards.
- **Cover Cropping in Off-Season periods:** Useful for maintaining soil fertility and reducing weeds in orchards like pomegranate and fig.
- **Mixed Cropping with Legumes:** Enhances biodiversity and provides nitrogen benefit to fruit trees.

Case Studies

- **Banana (Musa spp.) – Tamil Nadu, India**
  In banana orchards in Coimbatore district, the incorporation of sunhemp and dhaincha as pre-planting green manures significantly increased yield by 18%. Farmers reported improved soil texture and reduced fertilizer needs. Soil analysis showed a 22% increase in nitrogen levels and a 15% increase in organic carbon content.
- In Navsari, Gujarat, a field trial at ASPEE College of Horticulture investigated single, double, and triple dhaincha green manure along with varying nutrient regimes in banana cv. Grand Nain. Triple green manuring with significantly boosted vegetative growth, bunch weight, fruit quality (TSS, sugars), and shelf life, outperforming all other treatment combinations
- **Citrus (Citrus spp.) – Maharashtra, India** In Nagpur mandarin orchards, cowpea was grown during the kharif season and plowed into the soil. Results showed a 12% increase in fruit set and better juice quality, attributed to improved microbial diversity and soil nutrient status.
- **Mango (Mangifera indica) – Andhra Pradesh, India** In semi-arid mango orchards, Gliricidia was interplanted and lopped regularly. Farmers observed a 10–15% reduction in weed incidence and improved soil moisture retention, resulting in higher flowering and fruiting rates over three seasons.

Challenges and Limitations

- **Land and Labor Requirement** for growing green manures, especially in closely spaced orchards.
- **Timing and Crop Selection** critical to avoid competition with the main fruit trees.
- **Management of Biomass** for effective incorporation and decomposition in different climatic zones.

Future Prospects

- Development of climate-resilient and pest-resistant green manure species suitable for various fruit crops.
- Integration with precision agriculture for targeted soil health improvement.
- Policy support and incentives for adoption in commercial fruit orchards.
- Farmer training programs and field demonstrations specific to regional fruit crops.

Conclusion

Green manuring offers multifaceted benefits for fruit crop production, ranging from soil fertility enhancement to environmental sustainability. Its strategic integration into orchard management practices can significantly improve soil health, crop resilience, and long-term productivity. Tailored approaches based on crop type, region, and management goals can help maximize the benefits of green manuring in fruit farming.

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3. AGRICULTURAL ENTOMOLOGY

Root Grubs in India (Scarabaeidae: Coleoptera): Taxonomy, Distribution and Management

Sowmya, E [a]nd Arunkumar Hosamani

PhD. Scholar, Department of Entomology, UAS, Raichur-584 104

Professor, Department of Entomology, UAS, Raichur-584 104

Systematic Position of Root Grubs

Scarabaeoidea is one of the largest superfamilies of Coleoptera that include largest family Scarabaeidae. Scarabaeoidea includes approximately 31,000 species worldwide of which the family Scarabaeidae is comprised of 27,800 species (Jameson and Ratcliffe, 2001). Scarabaeidae consist of 13 subfamilies, of which Melolonthinae and Rutelinae are the largest that are widely distributed throughout the world. More than 2000 species of white grubs are known from the Indian subcontinent, of which over 40 species cause severe damage to a wide range of agricultural and horticultural crops, turf, meadows, lawns and forest trees (Veeresh *et al.,* 1991).

Taxonomic Characters of Root Grub Larvae

The root grub larvae exhibit great similarity, usually sub cylindrical resembling 'C' shaped structure with three pairs of thoracic legs and these are difficult to identify at species level. The anal slit and raster pattern (last abdominal ventral portion) with pallidium which form species specific characters at field level in order to delineate the third instar larvae of *Holotrichia sp*. (Sreedevi *et al*., 2014). Kumar *et al*. (2017) conducted survey on diversity of root grub and recorded twelve major species of root grubs associated with groundnut crop in Andhra Pradesh and Rajasthan and these are identified by illustrative keys that can be used at field level, where the identification of the species is very important from management point of view. Among twelve species, six species belonged to Melolonthinae, five species to Rutelinae and one species to Dynastinae.

Distribution of Root Grubs

A total of 16 species were recorded during the study period under eight genera distributed in three sub families *viz.,* Melolonthinae, Rutelinae, Dynastinae and five tribes. The collected beetles were identified at All India Network Project on White Grubs and Other Soil Arthropds, Banglore, Karnataka. The results show that beetle emergence was started after receiving first pre monsoon showers in May and June month onwards. The present findings were in conformity with the results of Kumar *et al.* (2009) and Shivanna *et al.* (2014). Among all the genera, *Holotrichia* was found to be most abundant and dominant. The results were in agreement with Theurkar *et al.* (2013). The species *Adoretus versutus, Anomala ruficapilla, Sophrops karschi* was newly observed in Western Maharashtra. The white grub species *Leucopholis lepidophora* was observed to cause damage to sugarcane near the rivers bank of Western Maharashtra.

Management of Root Grubs

Rakesha (2007) conducted the experiment on evaluation of bioagents and plant products against arecanut root grub *Leucopholis lepidophora*. The mixture of soap nut and neem oil 5% and *Metarrhizium anisopliae* $2x10^8$ conidia per gram @ 20 g per palm recorded 50 per cent and 26.67 per cent mortality of third instar grubs respectively after 60 days of treatment. Patel *et al.* (2018) evaluated different methods of insecticides application (Seed treatment, Drenching, Chemigation and Broadcasting) in groundnut against the white grub, seed treatment of clothianidin 50% WDG @ 250 gm per ha and chlorpyriphos 20% EC @ 4000 ml per ha were found most effective treatments against white grub in groundnut.

Root grub is a nationwide pest, detailed knowledge about their taxonomy, biology, distribution and their host plants is very much necessary for better management. Owing to the polyphagous nature, subterranean habit, high species richness and diverse feeding habits of immature and adult stages, management of white grubs is a hard task. The integrated management strategies that include community basis collection and destruction of root grub beetles, seed treatment, soil application, foliar application of chemical insecticides, entomopathogens and entomopathogenic nematodes (EPNs) widely followed to lessen the white grub menace becomes futile at times in severe cases.

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4. GENETICS AND PLANT BREEDING

Novel Approaches of Crop Improvement: Speed Breeding- Early Developments and Background

Deepayan Roy[1]

Department of Genetics and Plant Breeding, GBPUAT, Pantnagar-263145

Introduction

In order to breed new varieties of crop faster and to offer hope for food security throughout the globe a new and exciting methodology called 'Speed Breeding' is conceptualized. The initial framework of the method was outlined by US National Aeronautics and Space Administration (NASA) later on many researchers from various corners of the world are adopting and modifying the method to develop new varieties rapidly. Speed breeding is a form of accelerated breeding. It is an extra toolkit available to Plant breeders to accelerate crop improvement. The concept of accelerated crop improvement was first tested by NASA in collaboration with Utah State University in wheat. This was done for evaluation of food production in space with the aid of continuous illumination. These kind of experiments were initially done in crops involving cereals viz.,wheat. This methodology of crop improvement was further expanded to other crops by group of researchers in other institutes as well. Further experimenters' went on to add more and more growth parameters in their study of speed breeding.

Speed breeding methods can be extended to complement other innovative technologies, including high-throughput genotyping, genome editing and genomic selection in orphan crops as well to accelerate the rate of crop improvement. Speed breeding greatly concise the time required for generation time and hence subsequently speed-up the process crop breeding. Some of the very basic approaches of speed breeding includes continuous illumination (20-22 hours) of growing plants so that they can photosynthesize for a prolonged duration and hence can grow faster. This technique of plant breeding allows for breeders to grow many generations (4 to 6) for a crop wherein under normal circumstances two generations can be grown per year. This has been done in several crop species viz., spring wheat (Triticum aestivum), durum wheat (T. durum), barley (Hordeum vulgare), chickpea (Cicer arietinum) and pea (Pisum sativum) and canola (Brassica napus).(**Ghosh et al. 2018; Watson et al. 2018**). So, Speed breeding in a nutshell are fully controlled and enclosed micro-environment growth coupes that can speed-up plant development for fulfilling various objectives namely, phenotyping plant traits, study of mutants and transformation studies. Speed Breeding is being increasingly applied to grass pea and wheat breeding in Africa which indicates that this methodology can be used for major as well as orphan crop breeding. Many advanced and high-throughput technologies have poor adoption rate in developing and financially-challenged countries but this technique has nothing much sophisticated technologies. It involves only simple and innovative techniques like use of artificial conditions viz., LED lights to prolong the day-length for crops to aid them in growing faster, making it a global tool for crop improvement throughout the globe in developed as well as developing countries. Crop Improvement has come a long way and improved a lot in terms of production, productivity, insect-pest resistance, quality and abiotic stress tolerance aspect. Still there is a need for continuous improvement in order to tackle the major challenges ahead like- global changing climate scenario, increasing world population, always evolving pathotypes of insects and other pathogens and some other major bottlenecks. To resolve all the bottlenecks quickly and efficiently methodologies like speed breeding can prove to be handy in complementing various crop improvement strategies under Nano-era.

Early Developments and Background of Speed Breeding

The initial idea of growing plants in controlled conditions with artificial illumination came up to cope with unfavorable and unpredictable climatic changes in different regions around the globe. Such fluctuations in environmental conditions can result in failure of crops and poor yield. So, controlled and artificial conditions can resolve such issues of environmental fluctuations effectively. Mangon (1861) and Prilleux (1869) in early 1860s were the pioneers to use artificial illumination in the form of powered lamps to supplement growth and development of plants. Electric arc lamps and incandescent lamps were used to complement natural sunlight for growth and development of plants by Siemens (1880). The significance of influence or period of artificial lighting on olant constituents was established by Pfeiffer (1926). Moreover in tissue culture labs and in greenhouses artificial lights were used to make up for the insufficiently low lights in such enclosed chambers (Mpelkas 1980).

In 1990s Light-emitting diodes (LEDs) specifically blue diodes was utilized for growth and development and during the same time NASA in collaboration with Utah State University worked on wheat on space station and eventually developed a new dwarf variety 'USU-Apogee' (**Bugbee and**

Koerner 1997). The term 'speed breeding' was coined by researchers at University of Sydney, the John Innes Centre and the University of Queensland, Australia after several refinements and fine-tunings of the above techniques. In speed breeding the generation time is actually shortened by manipulating day-length and temperature in growth chambers using artificial illumination of specific intensity and quality that actually accelerates different physico-chemical processes in plants and this methodologies aided in growing wheat in space, early flowering, more photosynthesis and shortening breeding cycles as well.

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5. CROP PHYSIOLOGY

Role of Elicitors/Phytohormones to Enhanced Stress Tolerance

Afsanabanu Manik[1] Umesh Babu B S[2], Surekha S[3], and Manjunath S[4]

UASR, Raichur, Karnataka-584104

INTRODUCTION

One of the most successful techniques for increasing the production of beneficial secondary metabolites has been elicitation. Elicitors have been used to accelerate secondary metabolite product production in plant cell cultures by shortening the process time to accommodate larger culture volumes and higher product concentrations. To produce biotic and abiotic stresses on plants, several elicitors such as chitosan, ß-glucan, and yeast extracts, as well as plant hormone compounds such as jasmonic acid (JA) and methyl jasmoic acid (MeJA), have been employed. An important component of evaluating productivity-boosting solutions is to ensure that all challenges are viewed holistically. In any case, significant progress has been achieved in increasing secondary metabolite synthesis from plant cell cultures in recent years. These new technologies will help to extend and improve higher plants' continuing usefulness as renewable suppliers of chemicals, particularly therapeutic molecules. We believe that continued and increased efforts in this field will result in the controlled and effective biotechnological synthesis of unique, valuable, and hitherto unknown plant compounds.

Though elicitation increases secondary metabolism in plant cells/organs cultured in vitro, the specific mechanism of elicitation is yet unknown. Furthermore, the molecular and biochemical pathways of secondary metabolites must be studied, and considerable study must be conducted to discover the best circumstances for each medicinal plant to boost secondary metabolites. As part of many mechanisms of induced resistance in plants, viral attenuation, and cross protection for plant viruses, most elicitors interfere with pathways, signalling, cross-talk, plant defensive signalling Pathways, and plant immune system, as well as gene silencing.

What is Elicitors?

- Elicitors are chemicals that cause physiological changes in plant cells.
- Plant cells respond to these stresses by activating a variety of pathways, comparable to pathogen infections or environmental influences.
- They influence metabolism and increase the production of phytochemical/plant secondary metabolites.

Plant hormones as Elicitors

Several plant hormones that function as Elicitors. Common plant hormones such as Salicyclic acid and Jasmonic acid are key signals for defence gene expression. SA regulates resistance to pathogens such as bacterial, fungal, and viral pathogens. JA regulates protein production via the octadecanoid pathway. SA and JA are both synthetic mimics that can be applied externally to induce the same metabolic changes that regulate resistance against pathogens.

Use of Elicitors

1. Ecological safety because the method is based on inducing the native immune potential of genes
2. A systemic and prolonged protective effect
3. Involvement of multiple defence systems in induced resistance, making pathogen adaptation to protected plants nearly impossible
4. Induction of nonspecific resistance to a variety of fungi, bacteria, viruses, and nematodes

Elicitors Have Unique Properties

- The chemicals that accumulate in plant cell cultures as a result of elicitation may be antibacterial in nature. Elicitors can be used as a replacement for manufacturing media.
- In suspension cultures, cells may respond to elicitation in the following ways:
    - Various products may accumulate at higher levels in a particular cell line at different times and stages of development.
    - Product buildup may be found in cell lines when the synthesis region and process are unknown.
    - When given to cells in production medium, elicitation may not have an additive impact.
- In growth medium, product buildup owing to elicitation has also been reported.

Why should we Pay Attention to Elicitors?

- There is no danger of developing resistant pathogen strains.
- Fruit phenolic content is increased.
- Plants and fruits are protected from biotic and abiotic stressors.
- There is no environmental impact.
- Pre-harvest spraying can also help to reduce post-harvest losses.

Effect of Elicitors

- The effect of ABA in the regulation of lateral root development in three plant species, Arabidopsis thaliana, Medicago truncatula, and Oryza sativa (Harris, 2015).
- Nitrogen-mediated legume root architecture includes local and systemic regulation by various N-sources, as well as modulation by phytohormones and small regulatory molecules. The nitrogen-mediated root development process begins with soil nitrogen sensing, followed by signal transduction pathways including phytohormones, microRNAs, and regulatory peptides that together control the root system's growth and form (Mohd-Radzman *et al*., 2013).
- Auxin transport system is a directed and active pathway from cell to cell employing membrane integrated transport proteins. Therefore, this method is better appropriate to the fine-tuning of the auxin concentration in individual cells. This system's regulation of auxin transportation is known colloquially as "polar auxin transport." The flow starts at the shoot

apex, travels to the plant's base, and eventually reaches the root tip (Overvoorde et al., 2010). Auxin is reversely delivered in a shootward manner through the lateral root cap and epidermis, allowing for loop flow.

The auxin flow is recycled into the stele just below the start of the elongation zone. The concentration of auxin in these fluxes is highest in the quiescent centre, lowest in the endodermis and cortex, and weakest in the epidermis (Blilou et al., 2005 and Petersson et al., 2009). Elicitors bind to a particular receptor, which is most likely found in the plasma membrane. The elicitor receptor contacts create signals, which then activate nuclear genes involved in plant defensive responses including phytoalexin production. Local and systemic signal molecules, as well as potential plasma membrane receptors, begin the process.

Polygalacturonic acid, chitosan, physical signals, abscisic acid, and systemin are all wound signal molecules. A -glucan-elicitor-binding protein, a systemin binding protein of 160 kDa, and an undiscovered oligosaccharide elicitor receptor are all plasma membrane receptors. A lipase converts the wound signal and releases linolenic acid from membrane phospholipid, a process aided by ABA, volicitin, and - glucosidase from insect oral secretion is transformed to jasmonic acid via the octadecanoid pathway.

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6. GENETICS & PLANT BREEDING

Breeding for Cooking Quality Traits in Rice

Umesh Babu B S[1], Afsanabanu Manik[2] Manjunath S[3], and Surekha S[2]

UASR, Raichur, Karnataka-584104

Introduction

Rice is the most important source of calories for at least 50% of the world's population. Breeding for consumer-preferred grain qualities have thus become a major goal for breeding programs around the world. The rice grain is basically composed of the lemma and palea which form the hull, the bran, embryo and the endosperm (white rice). These characteristics are controlled by starch physicochemical properties comprising of apparent amylose content (AAC), gelatinization temperature (GT), gel consistency (GC) and paste viscosity properties.

Starch makes up about 90% of the rice grain. Rice starch is composed of two classes of glucose polymers—amylopectin and amylose. Amylose content is usually referred to as apparent amylose content (AAC) in literature because the iodine-based assay used for measuring it often detects long-chain amylopectin in addition to the 'true' amylose. The AAC of rice is known to play a crucial role in determining its cooked texture. It is directly related to water absorption, volume expansion, fluffiness and separability of cooked grains and inversely related to cohesiveness, tenderness and glossiness.

Gelatinization temperature (GT) is the range of temperature wherein at least 90% of starch granules swell irreversibly in hot water with loss of crystallinity and birefringence. Amylose content is the primary measure of the texture of cooked rice, but it fails to describe precisely the texture of certain types of rice. Gel consistency (GC) is, therefore, used to complement AAC.

Genetics of Amylose Content

AAC is the most important element influencing the cooking, eating and processing characteristics of rice. Conventional genetic studies have revealed that AAC is controlled by one major gene with several modifiers. High amylose content was reported to be dominant over low and intermediate amylose content. AAC is reported to be mainly controlled by the *waxy* gene locus (*Wx*) on chromosome 6, which encodes the granule- bound starch synthase (GBSS). Minor QTLs for AAC have also been detected on chromosomes 1, 3, 4, 7, 8 and 11.

Genetics of Gelatinization Temperature

Monogenic, digenic and polygenic inheritance for gelatinization temperature or ASV, have been reported. The inheritance of GT was found to fit into additive-dominance with dominance effects being predominant. GT is reported to be mainly under the control of the *alk* locus on chromosome 6 that encodes soluble starch synthase II *(SSIIa*). Four minor genes including the *Wx* gene—*Wx*, *SBE3, ISA* and *SSIV-2*—have been reported to act additively with *SSII-3* (also referred to as *SSIIa* by other authors), the major for GT, to affect the trait.

Genetics of Gel Consistency

Some conventional genetic analyses have reported that GC is under the control of one major gene, several minor genes and monogenic control. GC was found to fit into an additive-dominance model of inheritance with dominance being predominant. Transgressive segregation has been observed for GC. Many QTLs for GC have been mapped using molecular markers. A single locus in the *Wx* region and some modifier genes control GC.

Inheritance of Aroma

The use of molecular markers to study the inheritance of fragrance appeared to favor monogenic recessive inheritance of fragrance. A gene associated with fragrance was originally mapped to rice chromosome 8, where it was associated with the RFLP marker, RG28. Scientist identified a gene encoding betaine aldehyde dehydrogenase 2 (*BADH2*) as the likely cause of aroma in Basmati and Jasmine styled rices.

Marker-Assisted Breeding for Grain Quality in Rice

The scientific community has map/clone many QTLs/genes for various quality traits and developed molecular markers to facilitate selection for specific grain quality types. Most fragrant rices including Jasmine and Basmati types have the 8-bp deletion on exon 7 of the *BADH2* gene and an allele-specific marker has been developed for selecting rice with this mutation. This marker is being used widely for selecting for aroma. It is a co-dominant marker and thus very useful for marker-assisted backcrossing for recessive trait such aroma because selection of lines carrying the aroma gene can done in the heterozygote state without progeny testing.

Functional markers for a *waxy* gene SSR called RM 190, and *waxy* SNPS on intron (In1), exon 6 (Ex6) and exon 10 (Ex10) are used to select for AAC and RVA around the world. The haplotype across these three SNPs in the *waxy* gene (*waxy* SNP haplotypes) have been found to be more efficient in selecting for AAC and RVA than the RM 190. Across the *waxy* SNP haplotypes (In1-Ex6-Ex10) TAC, GCC, GAC and GAT is highly associated with low AAC, intermediate AAC, high AAC and high AAC accompanied with high RVA paste viscosity.

The *alk* gene has been cloned and validated as being the major gene for GT through genetic transformation. Two SNPs (GC/TT and G/A) in the *alk* gene was found to be highly associated with GT. These two functional SNPs have been used to developed DNA markers for selection of GT. Functional markers have also been developed for grain size. These markers are very highly associated with the C-A SNP mutation in exon 2 of the *GS3* gene which is responsible for 80–90% of the variation in kernel length. These validated markers will facilitate marker-assisted breeding for grain quality in rice. Various alleles of these important genes can be pyramided together to obtain the different consumer preferences for grain quality across countries and regions.

Conclusion

Since rice is eaten mainly by humans as whole grain in cooked form, its grain quality is extremely important. Breeding for these specific consumer demands can be challenging because grain quality is phenotyped using subjective, biochemical analyses that can be very expensive. Marker assisted selection is thus a very good option for breeding for grain quality. Functional molecular markers have been developed that are highly efficient in selecting for grain size, aroma, AAC, GT and paste viscosity parameters. Modern genome-wide marker technologies which will take care of genes with small effect and allow breeders to simultaneously select for grain quality, yield and stress tolerance are recommended for future rice breeding work.

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7. TOPIC - HORTICULTURE

Greenhouse Monitoring by Wireless Sensors Using IoT Techniques

K.Sivakumar[1] K.Ramah[2] M.Tilak[3] and M.Prabu[4]

Tamil Nadu Agricultural University, Coimbatore and FC&RI, Mettupalayam

Green houses are structures where in the plants are maintained at controlled environmental conditions. Green houses helps to protect the plants from global warming or GHG's. Green houses have to be monitored regularly to control from parameters like soil moisture, temperature, Relative humidity, Air quality (or) CO_2 concentration, Light, soil pH, etc., Greenhouse not only shields plants from frosts and rains, it can also be fully automated. We can control a smart greenhouse remotely from your iOS or Android device. We should have sensors inside our greenhouse.

IoT is Internet of things which describes the network of objects which are embedded with sensors, softwares and technologies for the purpose of connecting and exchanging data with other devices and systems over the internet.

A Greenhouse Model

Sensors are key components of greenhouse monitoring systems. Each sensor continually measures a specific condition in a specific location and reports those measurements to the system. A sensor is connected to one of the base unit's input terminal strips. As every condition requires its own input, we have to match our needs with the number of inputs available.

Types of Sensors

1. **Soil Moisture Sensor:** Soil moisture sensors help in assessing the efficiency of the irrigation system. Sensors report the fluctuations in soil humidity levels and help to adjust the irrigation system to water the plants according to the actual water use. Thus we save water and accelerate the plant growth using the soil moisture sensor. Most of the times we need to take probes 3 – 4 inches deep in soil along the area where we are going to plant. Thus we will estimate the average soil moisture level.Ideally, soil moisture should be around 40 to 79 per cent. If our soil moisture content is 0 – 39 per cent, it is dry and 80 – 100 per cent is overwatered soil. Soil moisture monitoring is both accurate and long-lived as sampling has to be done few times per week. Soil Moisture Sensors are ideally installed in multiple areas for best coverage.
2. **Temperature Sensors:** It is extremely important to maintain ideal temperature in a greenhouse. The temperature has to be maintained in both the extremes during cold days or hot ones in summer. As the temperature directly affects plant growth, so having temperature sensors in a greenhouse is a must.
3. **Air Quality or Carbon Dioxide Sensors:** Air quality sensor is a must for any greenhouse grower who is using a gas

or paraffin heater. Paraffin and gas heaters produce carbon dioxide (CO_2) which stimulates plant growth, although we need to monitor that the levels of CO_2 don't go above or below the critical threshold.

4. **Humidity Sensors:** We have to maintain a relative humidity of 60-80 per cent. Humidity encourages fungus in a greenhouse and pest problem. Hence, a wireless hygrometer or humidity sensor will allow us to monitor humidity levels on a daily basis so we always know when to open vents.

   There are Long Range Wireless Temperature Humidity Pressure Air Quality Sensors which is referred as an all-in-one sensor and is ideal for indoor greenhouse monitoring applications, as it samples Temperature, Pressure, Humidity, and Air Quality.

5. **Light Sensor:** Light sensor is a tool to assess the plant's exposure to light. Most of the meters have the light sensor on the top of the meter and can display the following readings: Relative Light: 0-2000 lux (0-200 Low, 200-500 Low+, 500-1000 Normal, 1000-2000 High).
   Light intensity can be measured by placing the meter next to the plant and orient the center of the meter top toward the light source. The instant measure is helpful to know when to use the shade cloth or when we need to change the position of the plant to receive more light. Long Range Wireless Light Sensors have life time silicon sensors.

6. **Soil pH Sensors:** Soil pH sensor helps to determine and to reclaim the acidity or alkalinity of the soil. The pH scale ranges from 0 to 14 helps to differentiate between acidity and alkalinity. An environment is neutral when pH is 7. If the pH value is below 7, then the environment is acidic and pH value above 7 is alkaline. Soil's pH affects the plant growth. The alterations of soil's pH lead to nutrient deficiencies.Hence, soil pH is one of the important parameter and has to be monitored regularly.

7. **Equipment Monitors:** All the sensors that are available inside the greenhouse are connected to a controller and all the equipments are scanned using an equipment monitor.

The sensors are usually maintained by internet clouds. So the soil moisture sensor, temperature sensor, humidity sensor, air quality (or) CO_2 monitor, Light sensor and soil pH sensor have to be maintained in a greenhouse and all these sensors are maintained by automation techniques, machine learning techniques and AI techniques.

8. SUBJECT-HORTICULTURE- AROMATIC CROPS

MINT – An important dollar earning aromatic crop

Dharini Chittaragi

TNAU, Coimbatore-641-00

India is the world leader in mint oil in 2014 -15 and our production is around 35,000MT and exported over 25,000MT. Price – 1110 (*Mentha.arvensis.*) 2760 (*Mentha.piperita.*) 2040 (*M.spicta.*) 2280 (*M.citrata.*) **(CIMAP, 2017)**. A good crop can give as high as 48000 kg of fresh herb per hectare. However, the average yield from three cuttings is 20,000 to 25,000 kg which in turn may yield about 50-70 kg oil per hectare

Total Availability Of Natural Mentha Oil

Year	14-15	15-16	16-17	17-18	18-19*E
Carryover stock (MT)	5612	14948	13748	6720	1522
Production (MT)	48000	33600	30240	31000	38750
Total Availability	53612	48215	43988	37220	40272

The total availability of natural mentha oil in India, according to digital sansad records is as under from 2019-2020 to 2023-2024

Year	Area ('000 ha)	Production ('000 tones)
2019-2020	328.14	44.02
2020-2021	347.28	45.80
2021-2022	346.30	35.01
2022-2023	347.46	35.12
2023-2024	348.68	35.15

Origin

Mint has a long history, possibly originating in Europe and the Mediterranean, where it was regarded as the symbol of hospitality. Greek - legend of the nymph *Minthe*, who attracted the attention of Hades. The Romans brought mint and mint sauce to Britain; they strewed mints in feasts and banquets as a token of welcome to their guests. Mint was then taken to the USA by the pilgrims aboard the Mayflower. Early descriptions and analyses of the menthol in mint were carried out in the nineteenth century (Atkinson and Yoshida, 1882)

Distribution

In Asia, the Japanese had distilled peppermint oil for several centuries and the oil was used to produce menthol (Simonsen, 1947). During that time, the product was called Japanese mint and Japan was the only commercial producer. The cultivation of mint also began in other countries such as China and India in around 1960. Initially, India was an importer of menthol but, after the green revolution in 1986, mint took off as an agricultural commodity.

Economic Importance

Japanese mint is a primary source of menthol. The fresh leaves contain 0.4-6.0% oil. The main constituents of the oil are menthol (65-75%), menthane (7-10%) and menthyl acetate (12-15%) and terpenes (pipene, limonene and camphene). Generally, it is higher in tropical regions It is industrially used in the cosmetics, pharmaceuticals, food, confectionery and beverages. Medicinally, it is an excellent carminative and gastric stimulant when applied externally, it acts as a mild analgesic

Cultivated Species

Common name	Botanical name	Main constituents of mentha oil
Japanese mint	*Mentha arvensis*	Menthol (70-80 %)
Pepper mint	*M. Piperita*	Menthol (35-50 %)
Bergamot mint	*M.citrata*	Linalool and linalyl acetate (45 %)
Spear mint	*M. Spicata*	Carvone (60-95%)
Scotch spear mint	*M. cardiaca*	Carvone (53-68 %)
Garden mint	*M. viridis*	Carvone (very less)

Mint Revolution:

In 1952,RRL-few stolons from Japan. Handa et al (1954)-introduced to Jammu. DRL-jammu-Commercial farm-Chakrohi. In 1963, 26 kg. stolon of *Mentha arvensis* was raised from 0.2 ha of the land. The area was extended to 8ha. by 1964. Material worth Rs. 45,000/- was sold to M/s Richardson Hindustan, Bilaspur, Rampur (Uttar Pradesh). Besides producing 220 kg.With this start, oil of Japanese mint to the tune of 150 tons is being produced in Tarai since 1972. An estimated production of about 15 tons of Mentha oil (Worth about Rs. 13.0 lakhs) was achieved during 1972. The Kosi variety developed the increase in mint cultivation from 15 hectares in seventies to 1, 50,000 hectares in the beginning of 21st century in the country.

Development of Interspecific Hybrids

The Japanese mint has very smaller flower, crumpled all in a cluster which makes emasculation for controlled hybridization very difficult. It does not produce (viable) seed under tropical condition, even under controlled crossing. Neerkalka' developed by sexual crossing between improved Mother plant Mentha arvensis (cv Kalka) and pollen plant Mentha spicata (cv Neera). The hybrid is propagated vegetatively by suckers or stem cuttings and is stable for commercial cultivation.

Oil Recovery

The recovery of oil from the herb is 0.5-0.8% through steam distillation (2-2.5hr's). Golden yellow colour, containing not less than 75% menthol. About 80% of the oil is received in the receiver in about one hour's time. The oil that is received later is richer in menthol. PVC drums of good quality (20-200l capacity) and galvanized iron (GI) drums or aluminium containers are suitable for short and long term storage respectively. The containers should be kept in cool and dark place.

Menthol Production

The process involves the progressive chilling of mentha oil resulting in the separation of 63-65% menthol in crystalline form, The crystals are further processed to obtain bolder crystals. The left over dementholised oil is hydrolysed and fractionated Terpenes, menthone (90-93% purity) and liquid menthol are separated . Menthol crystals are further recovered tthereby improving the overall yield and economics.

Demand and Supply

The mint oil is obtained from *M.a, M.p, M.c* and *M.s*. Mint oil and menthol are exported, others meet home requirement. India is the leading producer in the world market even replacing china and US due to low price. At present there is a need for increasing area

Problems

- The cost of raw materials used for this industry is increasing day by day
- Plant cultivation largely depends on climatic conditions and yield vary year after year
- Price fluctuation is rampant
- The use of synthetic substitutes for natural products are also increasing

Future thrust

At present, Cis – 3 hexanol is fractionated from DMO and exported at a high price. Its production started in 1994-95 and this pushed price of DMO from Rs.50 to 90 in that year itself. There is scope for producing L-limonene, 3–octonol, pure menthone and isomenthone. Similarly, L-menthol, neo-menthol, isomenthone can be converted into high value menthol and esters of menthol, like methyl isovalerate, menthol lactate, methyl salicylate which fetches better price in trade. All this can sustain a high level of cultivation and support export trade. The market demand for pure L-menthol, iso-menthone, L-limonene, neo-menthol and pinene is high.

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