



Strategic approaches of precision farming technology for improvement of fruit production

*Abhay Bisen¹, Vinamarta Jain¹, Joginder Singh²

¹S. K. S. College of Agriculture and Research Station, Rajnandgaon, IGKV, Chhattisgarh, India

²Department of Horticulture, J. V. College, Baraut, UP, India

*Corresponding email: abhay_horti@yahoo.co.in

ARTICLE INFO	ABSTRACT
<p>Original Research Article Received on November 14, 2024 Revised on November 17, 2024 Accepted on December 02, 2024 Published on December 12, 2024</p> <p>Article Authors Abhay Bisen, Vinamarta Jain, Joginder Singh</p> <p>Corresponding Author Email abhay_horti@yahoo.co.in</p>	<p>Precision farming is one of the most scientific and modern approaches to sustainable agriculture that has gained momentum towards the end of 20th century. Precision farming involves the application of technologies and principles to manage spatial and temporal variability associated with all aspects of horticultural production for improving crop performance and environment quality. Precision farming calls for an efficient management of resources through location specific hi-tech interventions. Hi-tech horticulture encompasses a variety of interventions such as micro irrigation, fertigation, protected/greenhouse cultivation, soil and leaf nutrient based fertilizer management, mulching for in-situ moisture conservation, micro propagation, biology for germplasm, genetically-modified crops, use of biofertilizers, vermiculture, high density planting, hi-tech mechanization, green food, soil less culture, biological control etc. Utilization of these interventions orchestrated together having the aim of achieving higher output in given time period leads to precision farming, which is largely knowledge driven.</p>
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Indian horticulture sector makes a very significant contribution to the Indian economy by contributing about 33% to the agriculture gross value added. Apart from ensuring nutritional security to the nation, it also provides alternate rural employment opportunities, diversification in farm activities, and enhanced income to farmers. From 25 MT (1950-51) to 353.19 MT (2023-24), a major boost in the production of horticultural crops has been observed over the years. India being the 2nd largest producer of fruits in the world, shares about 10.5% of global fruit production. India is producing about 112.73 million MT fruit crops over 7.04 million hectare area with a productivity of 15.10

tonnes per hectare (as per the second advance estimates). Fruits are rich sources of antioxidants and considered as 'protective foods' and play an important role in our diet. India ranks first in the production of mango, banana, guava, papaya, pomegranate, sapota and aonla in the world. Precision farming would involve the measurement and understanding of variability over time and space. Moreover, the system would use the information generated through surveys to manage this variability by matching inputs to conditions within fields using site-specific inputs. Thus, precision farming is technology enabled, information based, and decision focused.

The enabling technologies of precision farming can be grouped into five major categories such as computer, global position system (GPS), geographic information system (GIS), sensors and application control. Some of the enabling technologies were developed specifically for agriculture and their origin date back more than 20 years. Availability of contiguous blocks of mono crops and equipments needed for the survey, recording and analysis on real time basis has made the precision farming technologies a reality in developed countries, where farm holdings are large, heavily equipment dependent. Precision farming in the Indian context is still in its infancy stage.

A vast amount of data on various aspects is available (Mondal *et al.*, 2011). However, application of precision farming as a package in the farmer's fields has received little attention. This is primarily due to lack of awareness about the potential for increasing productivity and improving the quality of produce with minimum use of inputs. Secondly, there has been no serious attempt in the past to promote this technology by any agency. The infrastructure available in terms of remote sensing and GIS are yet to be used effectively in promoting precision farming. Therefore, there is an urgent need to develop a package based on knowledge of soil environment and crop needs to enhance the efficiency of inputs to get higher output in given time frame. Some of the other terminologies used for precision farming are precision agriculture (PA), site specific farming (SSF), site-specific management (SSM), farming-by-the-foot, variable-rate technology (VRT) etc. The main objective of adopting precision farming in India is to improve agricultural production, quality of environment and economic status of the farmers.

Component and Facilitator of Precision Farming Computer and Internet

The computers and Internet are the most important components in enabling the precision farming possible as they are the main source of information, processing and gathering.

Global Positioning System (GPS)

The most common use of GPS in agriculture is for yield mapping and variable rate fertilizer/pesticide applicator.

The GPS are important to find out the exact location in the field to assess the spatial variability and site-specific application of inputs. The GPS operating in differential mode are capable of providing location accuracy of 1m.

Geographical Information System (GIS)

The GIS is an organized collection of computer hardware, software, geographical data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information. It is rightly called as the brain of precision farming. It can help in agriculture in two ways. One is in linking and integrating GIS data (soil, crop, weather field history) with simulation models. Other is to support the engineering component for designing implements and GPS guided machineries (variable rate applicator) for precision agriculture.

Remote Sensing

Remote sensing holds great promise for precision farming because of its potential for monitoring spatial variability over time at high resolution. Remote sensing imagery for precision farming can be obtained either through satellite-based sensors or CIR video digital cameras on board small aircraft.

Steps in Precision Farming

The basic steps contributing to the concept of precision farming are assessing, managing and evaluation of variability. Assessing variability is the critical first step in precision farming since it is clear that one cannot manage what one does not know. The spatial variability in the field can be mapped by different means like surveying, interpolation of point samples, using high resolution aerial and satellite data and modeling to estimate spatial patterns (Nabi *et al.*, 2017).

Assessing Variability

Assessing variability is the critical first step in precision farming since it is clear that one cannot manage what one does not know. The spatial variability in the field can be mapped by different means like surveying, interpolation of point samples, using high resolution aerial and satellite data and modeling to estimate spatial patterns.

Managing Variability

Once variation is adequately assessed farmers must match agronomic inputs to known conditions using management recommendations that are site-specific and use accurate control equipment. The success of implementation of precision farming depends on how precisely, soil fertility, pest infestation, crop management with respect to biotic and abiotic variables and water are managed in the field and also how accurately the corrective actions are taken as per the variability noticed in the field.

Evaluation of Precision Farming

There are three important evaluation issues namely, economic viability, maintenance of environment and feasibility of technology transfer of precision agriculture. The economic evaluation focus on whether the documented agronomic benefits translate into value through market mechanisms. Environment evaluation focuses on whether precision farming can improve soil, water and general ecological sustainability of our agricultural systems (Gemtos *et al.*, 2016). Final and the foremost important issue is whether this technology of site-specific farming will work on individual farms and how far this technology can be transferred to other farmers.

Potential of Precision Farming in India

Although precision farming is a proven technology in many advanced countries of the world but its scope in India are limited. The constraints, which limit the scope for site-specific farming in India, are:

- Small size of land holdings
- Socio-economic status of Indian farmers
- Lack of success stories or cost-benefits studied on precision farming
- Knowledge and technological gap v. Heterogeneity of cropping system in India
- Lack of market perfections vii. Lack of local technical expertise
- Lack of data availability in terms of quality and cost.

However, many horticultural crops in India, which are high profit making, offer wide scope for precision farming.

Land and Nutrient Management in Precision Farming

The natural resources of the world are dwindling and the human population is increasing, along with increase in environmental pollution especially water, land and air. This is more in developing countries like India. Thus, with the increase in population there will be more requirements of food and fibre, but our land and water resources are diminishing. Hence precision farming is the urgent need of the day. The factors that contribute to higher growth and yield are crop variety, methods and amount of water, method of fertilizer application, agro-chemicals for pest management, effect of rootstock, root wetting, high density planting, environmental consideration and automated irrigation (Pérez-Ruiz *et al.*, 2012).

Approaches and Strategies for Precision Farming in Mango

Mango is the important crop of India, accounting for about 39.16 per cent of total area under fruits and more than 23.09 per cent of total production in the country. India ranks first in the world for mango production and area under cultivation but with very low productivity as compared to Israel, Mexico and South Africa. In spite of large area under mango, per capita availability of mango is insufficient in India. Therefore, there is a need and great scope of boosting mango production for fresh consumption and processing into various products, both for domestic as well as export markets. Adoption of proper strategies, for overall increase in mango productivity is the present-day need to sustain commercial viability of the orchards.

Strategies for Higher Production Selection of Suitable Variety

In India, more than thousand mango varieties are being grown in different parts of the country. Most of the Indian commercial cultivars are characteristically specific to geographical adaptation and their performance is satisfactory in a particular region. Therefore, selection of varieties for mango cultivation should be based on their suitability for a particular region. Selection of cultivars, for specific purpose, is one of the important factors.

A regular bearing and high yielding clone have to be recommended for commercial plantation.

Multiplication of Genuine Planting Material

Establishment of healthy mother tree block with desirable characteristics of varieties is one of the important factors deciding the fate of the production efficiency in mango orchard. Therefore, high yielding clones of various commercial varieties should be selected for developing mother blocks. Adoption of suitable propagation technique standardized for respective region for making healthy planting material on a large scale for expanding area under mango cultivation is of importance. Use of salt tolerant rootstock, 13-1 should be tried in problem soils of India.

Water-Use Efficiency

Several factors, which determine the response of irrigation like soil type, season, region, stage of tree growth and varieties should be taken into account while making irrigation schedules. For judicious water use, drip irrigation is being used in mango growing.

Balanced Nutrition

Studies on leaf sampling techniques has shown that a sample of 6-7 months old. 30-40 normal and healthy leaves from middle of the shoot, representing almost all elevations on the crown from all directions reveals the correct nutrient status of the tree. Critical limits of N, P, K, Ca, Mg, S, Fe, Mn, Zn, and Cu have to be worked out. Optimum levels of leaf N have to be worked out for maximizing the production. Beneficial effect on growth, flowering, fruiting and fruit quality can be achieved with foliar sprays. Application of organic manure in addition to balanced nutrient is important in the maintenance of soil fertility, which play vital role in tree growth and productivity. Soil testing, as the sole basis for making fertilizer recommendations, has limited applicability with mango due to its large root distribution, perennial habit, rootstock effect and differential fruiting, soil and leaf analysis should, therefore, be complementary for determining the optimum dose of nutrients (Bongiovanni *et al.*, 2004).

Manipulation of Vegetative Growth and Flowering

The habit of growth, flowering and fruiting of mango cultivars should be thoroughly understood to safeguard the adversaries of cultivation. The seasonal cyclic changes of growth in shoot, root, flower, fruit and their development differ between cultivar and location. Environmental stimuli are dominant factors on yield potential of a mango cultivar. Tree canopy size of mango depends upon the variety, climate, edaphic conditions and cultural practices. Mango tree requires new vegetative growth in order to produce fruits each year. Temperature of 24-30°C is considered as optimum for proper growth. A cessation of vegetative growth is required to induce transformation from vegetative to reproductive phase. Therefore, canopy management and reproductive manipulation practices vary according to cultivars and climatic conditions. In tropics, with the understanding of flowering behavior along with advances in technology it is possible to manipulate the time of flowering and indirectly productivity and net returns.

High-Density Planting and Tree Canopy Management

Poor yields experienced in Indian mango industry are partly due to wide tree spacing of conventional orchards with spacing ranging from 10 to 12 m between trees in rows and between rows. Canopies of these trees often take more than 10 years to fill the allocated space in the orchard row. This problem can be resolved with higher density plantings. Tree canopy management, especially size control, has become a priority for reducing production cost and increasing fruit yield and quality.

Alternate Bearing Management

Alternate bearing is a common phenomenon in majority of commercial mango cultivars, which is mostly because of existing antagonism between vegetative and reproductive phases. To manage these problem efforts can be made to regulate vegetative growth and flowering.

Rejuvenation of Unproductive Orchards

One of the reasons for the low productivity is due to large number of old mango orchards in the age group of 30-62 and above, has either gone unproductive or showing marked decline in productivity. This is attributed to overcrowded and intermingling of large branches and meager foliage, allowing poor light availability to growing shoots within the canopy. This renders them uneconomical. Severe pruning can rejuvenate these trees.

Managing Disorders

This involves the management of various disorders like spongy tissue, malformation, black tip and leaf scorch

Pest and Disease Management

Efficient management of insect pests and diseases is important because they affect essentially every phase of growth and development. It is necessary to adopt IPM for important pest management. Monthly integrated pest and disease management schedule can be maintained and followed.

Harvesting and Post-Harvest Management

An improved method of harvesting has to be adopted. Alternative packaging containers such as corrugated cardboard package can be used. Precise management of post harvest handling has to be followed.

Precision Farming of Banana

Banana is one of the few crops in India, where hi-tech and precision farming techniques have been successfully practiced with full advantage. Introduction of improved variety suitable for processing and export, micro propagation, crop geometry, drip irrigation, fertigation, mulching, green manuring, recycling of banana waste, organic farming, proper hygiene of banana plantation through integrated disease and pests management, processing to puree transfer technology, training, participative demonstration etc., are some of the aspects responsible for the increased productivity.

Precision Farming of Guava

Guava is considered to be one of the exquisite, nutritionally valuable and remunerative crops. Guava fruits are used for both, fresh eating and processing. The precision technologies for improved production include selection of varieties, multiplication of genuine planting material and establishment of guava orchard. Under establishment the factors like planting techniques, training and pruning, high density planting, rejuvenation of old plantation, growth and development, crop regulation, weed control, irrigation, inter cultivation, nutrition, fertilization and judicious management of deficiencies, pest and diseases and harvesting are taken into account. Meadow orcharding also known as ultra high density planting system, of guava was developed first time in India at Central Institute for Subtropical Horticulture, Lucknow, Uttar Pradesh. It is very dense planting system that will produce a full field cover canopy within one year. Trees attain a maximum height of 2.2m. It accommodates 5000 plants per hectare in case of guava, however, in apple about 10000-100000 plants per hectare can be accommodated. In order to maintain tree canopy, severe pruning is done like mowing of grassland. Meadow orcharding is generally being practiced in guava at a spacing of 2m × 1m.

Precision Farming of Papaya

Papaya is widely grown in tropics and India is the largest producer in the world. The precision technologies for improved production include selection of varieties, propagation and nursery production, planting season, spacing, sex expression and thinning, irrigation management, intercrop, plant protection and harvesting.

Precision Farming of Aonla

Aonla or Indian gooseberry is indigenous to Indian subcontinent. The precision technologies for improved production include selection of varieties, multiplication of genuine planting material, planting techniques, training and pruning, Manuring and fertilizer application, efficient water management, mulching, pest and disease management, harvesting and post harvest management.

Conclusion

The concept of precision farming in India is still in its infancy. The major reasons are high cost of technology and high level of fragmentation of farm holdings. However, Indian farmers can have better yield and profit than the conventional method by following the basic principles of precision farming. Over last few decades, the progress in science and technology has led a negative impact on the society and ecosystem by depleting the biological resources. In near future, horticulture will face challenges to provide adequate nutrition for people. There is a need to increase the productivity of horticultural crops in a sustainable way. In upcoming years, the precision horticultural practices may help the farmers to harvest the fruits of frontier technology without deteriorating the quality of land and produce. A package should be developed for fruit crops such as mango, banana, sapota, strawberry, citrus, papaya, litchi, apple, plum, pear, peach, apricot, pomegranate etc., depending upon the knowledge on climate, soil environment and crop needs to enhance the efficiency of inputs given in time frame. Agriculture sector is expected to achieve a vertical growth with the introduction and adoption of modern precise technologies.

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