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Precision farming: A new vista for Indian horticulture

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Agriculture is the backbone of our country and economy, which acounts for almost 30 per cent of GDP and employs 70 per cent of the population. Agricultural technology available in the 1940s could not have been able to meet the demand of food for today's population, in spite of the green revolution. To meet the forthcoming demand and challenge we have to divert towards new technologies, for revolutionizing our agricultural productivity.

In the post-green revolution period agricultural production has become stagnant, and horizontal expansion of cultivable lands became limited due to burgeoning population and industrialization. As the availability of land has decreased, application fertilizers and pesticides became necessary to increase production. In this situation, it is essential to develop eco-friendly technologies for maintaining crop productivity. Since long, it has been recognized that crops and soils are not uniform within a given field. The farmers have always responded to such variability to take actions, but such actions are inappropriate and less frequent. Over the last decade, technical methods have been developed to utilize modern electronics to respond to field variability. Such methods are known as spatially variable crop production, Geographic Positioning System (GPS)-based agriculture, site-specific and Precision Farming (PF). Non–stop supply of pollutant free huge food production for the ever-increasing population as well as the challenges of free and globalised market creates the scope of introduction and adoption of modern technologies in agriculture. Precision farming is such a new emerging, highly promising technology, spreading rapidly mainly in the developed countries and has gained momentum in 21st century.

Present status of Indian Horticulture : Horticultural development had not been a priority in India until recent years. It was in the post-1993 period that a focused attention was given to horticulture development through an enhancement of plan allocation and knowledge-based technology. Despite of this decade being called a "golden revolution" in horticultural production, the productivity of horticultural crops has increased only marginally from 7.5 tons per hectare in 1991-92 to 12.3 tons per hectare in 2013-14 (NBH, 2013-14). The Indian horticulture sector is facing severe constrains such as low crop productivity, limited irrigation facilities and underdeveloped infrastructure support like cold storages, markets, roads, transportation facilities, etc. There are heavy post-harvest and handling losses, resulting in low productivity per unit area and high cost of production. However, on the other hand, India's long growing-season, diverse soil and climatic conditions comprising several agro-ecological regions provide ample opportunity to grow a variety of horticulture crops. Thus, efforts are needed in the direction to capitalize on our strengths and remove constrains to meet the goal of moving towards a formidable horticultural growth in India. Horticulture contributes nearly 28 per cent of GDP in agriculture and 54 per cent of export share in agriculture Thus, in a holistic way; horticulture can be promoted as a means of agro-diversification for the second Green Revolution, providing the much needed impetus to the growth of agricultural sector through increase in trade, income and employment.

Precision farming (PF) : PF is a management philosophy or approach to the farm and is not a definable prescriptive system. It identifies the critical factors where yield is limited by controllable factors, and determines intrinsic spatial variability the variations occurring in crop or soil properties within a field are noted, mapped and then management actions are taken as a consequence of continued assessment of the spatial variability within that field. Development of geomatics technology in the later part of the 20th century has aided in the adoption of site-specific management systems using remote sensing (RS), GPS and Geographical Information system (GIS). This approach is called PF or site specific management. It is a refinement of good whole field management, where management decisions are adjusted to suit variations in resource conditions. Precision Farming requires special tools and resources to recognize the inherent spatial variability associated with soil characteristics, crop growth and to prescribe the most appropriate management strategy on a site-specific basis. It involves the application of technologies and principles to manage spatial and temporal variability associated with all the aspects of agricultural production for improving crop performance and environmental qualities. In short it means adding the right amount of treatment at the right time and the right location within a field. Philosophy behind the precision farming is that production inputs (seed, fertilizer, chemicals, etc.) should be applied as needed and where needed for the economic production.

Fundamentally, PF acknowledges the conditions for agricultural production as determined by soil, weather and prior management across space and over time. Considering this inherent variability, management decisions should be specific to time and place, rather than rigidly scheduled and uniform. Site-specific management to spatial variability of farm is developed to maximize crop production and to minimize environmental pollution and degradation, leading to sustainable development. Site-specific management recognizes the variability within a field and is about doing the right thing, in the right way, at the right place and time. It involves assessing and reacting to field variability by tailoring management actions, such as fertilization levels, seeding rates and variety selection, to match changing field conditions.

Technologies for precision farming: Technologies used in PF cover three aspects such as data collection, analysis or processing of recorded information and recommendations based on available information. Technologies required are as follows:

Yield mapping: Mapping of yield and correlation of that map with the spatial and temporal variability of different agronomic parameters helps in development of next season crop management strategy.

Remote sensing: Remote sensing is a tool for collection, processing and analysis of data to exact information from earth surface without coming in to physical contact with it. It holds great promise for precision agriculture because it is potential for monitoring spatial variability over time at high resolution.

Geographic information system (GIS): It is a computer base management system used for computation, storage, analysis and display of spatial data in the form of a map. The GIS is the key to extracting value from information on variability. It helps in agriculture in two ways: One is in linking and integrating GIS data (soil, crop, weather, field history etc.) with simulation models. Another is to support the engineering component for designing implement and GPS guided machines.

Global positioning system (GPS) : GPS are important to find out the exact location in the field to assess the spatial variability and site specific application of inputs.

Variable rate technology (VRT): VRT consists of farm field equipment with the ability to precisely control the rate of application of crop inputs that can be varied in their application, commonly include fertilizer, weed control, insect control, plant population and irrigation. In agriculture it is used to optimize the input or maximize the crop yield from a given quantum of unit.

Yield monitering: Yield monitor are crop yield measuring devices installed in harvesting equipment. The yield data from the monitor is recorded and stored at regular interval along with positional data revised from the GIS unit. GIS software takes the yield data and produce yield map.

Importance of precision farming :

– Improve crop yield.

– Provide information to make better management decisions.

– Reduce chemical and fertilizer costs through more efficient application.

– Provide more accurate farm records.

– Increase profit margin.

– Reduce pollution.

Processing precision farming data: To date, most analysis has been visual interpretations of yield maps. But recently, data visualization is being extended through map analysis at three levels: cognitive, analysis and synthesis. The foundation of precision farming occurs at several levels:

– Cognitive

– Analysis

– Synthesis

Technical issues: The precision farming process can be viewed as four steps:

– Data logging,

– Point sampling,

– Data analysis and

– Spatial modeling.

Application of precision farming :

– Water management

- Surface covered cultivation
- Controlled environment structure
- Organic farming
- Precise space utilization
- Micro propagation / tissue culture
- IPM/INM

Water management: In precision farming mainly we consider drip irrigation, sprinkler irrigation and fertigation.

Drip irrigation: It is described as a regulated or slow application of irrigation water through emitters at frequent interval near the root zone plant over a long period of time.

- It saves water by 50-70%.
- Reduces labour and energy cost.
- Weed infestation is almost negligible.

Sprinkler irrigation: In this system, water is sprayed into the air and allow to fall on the ground surface somewhat resembling to rainfall. The spray is developed by the flow of water pressure through small nozzles.

Fertigation: It includes both water and fertilizers which are delivered to the crop through drip irrigation. Fertigation provide essential element directly to the active root zone, thus minimizing the loss of expensive nutrients, which ultimately helps in improving productivity and quality of farm product.

Surface covered cultivation :

Mulching: It is used to reduce or increase the temperature, suppress weed growth and conserve soil moisture.

Soil solarization: It is a method of healing the soil by covering it with transparent polythene sheets during hot periods to control soil born diseases.

Controlled environmental condition: It includes green house, polyhouse, tunnels etc. This are a framed structure covered with a transpirant or translucent material which provide protection to crop and create environment for growing crop out of season.

Organic farming: Organic farming is a system of agriculture that uses natural and biodegradable input while deliberately avoiding the use of synthetic fertilizer. It mainly includes the use of vermicompost, manures, biofertilizers, animal husbandry, Greenleaf manures, biological management and crop rotation.

Precise space itilisation :

High density planting: HDP is a system of planting more number of plant than optimum through manipulation of tree size. It accommodates 500-100000 plants/hac. Following methods are applied to control the size of plants in HDP:

- Genetically dwarf scion cultivars
- Dwarfing rootstock and interstock
- Training and pruning
- Use of growth retardants

Meadow orcharding: It is also known as ultra high density planting system. It accommodates 20000-100000 plants/ha. It is literally called as grass land. In order to maintain tree form, severe top pruning is practiced similar to mowing of grassland.

Micro propagation: Micro propagation refers to the production of plant from very small plant parts, tissues or cells, grown aseptically in a test tube or containers under controlled environment.

Integrated pest management (IPM): Weeds, insects and disease are an ever-present and costly management problem to crop production because significant infestations reduce crop yield and quality and, if severe can limit crop production options. Now a days people are more concern about health risk related to food safety and others, therefore agricultural practices reduce pesticide application, which result into more insect population. The potential direct economic benefit of precision pest management is the reduction in chemical/ non chemical pest management costs, crop damage or both due to more efficacious of efficient application of pest control measures. A pest management practices which involves a mixture of practices such as use of resistant varieties, managing the natural predators of pest, cultural practices and judicious application of pesticides to control the pests.

Other aspect of precision farming:

Precision soil moisture management: Soil moisture forms one of the most important factors of crop production. Irrigation scheduling suing VRT combines knowledge of spatially variable soil water holding capacity, spatial and temporal variability of applied water, system delivery specification and weather-driven crop evaporation (ET) calculation. On the hand conventional systems, a single value of crop is typically used for entire field for use in irrigation scheduling software.

Precision soil fertility management: Since soil supply and plant demand vary in space and time and nutrient losses through leaching, erosion, and runoff also vary temporally and spatially indicates that significant opportunities may exist for precision management of soil fertility. The potential for improved precision in soil fertility management combined with increased precision in application control make precision soil fertility management an attractive, but largely unproven, alternative to uniform field management.

Management of phosphorus and potassium: Precision management of P and K was an early focus of precision farming because there was an established basis for fertilizer recommendations in soil testing that could theoretically be applied at any scale. Spatial variability in P and K was already known and was not difficult to measure within agricultural fields. The concept of VRT was very initiative and easy to understand and implement. The temporal component of the spatial variability of P and K is low, making it easy to soil test at a convenient time and requiring only periodic validation.

Management of nitrogen: The precision management of N is applicable to situation in which the factors that control total N in soils and N availability to plants vary spatially. Both N deficiency and excess N availability create problems for production agriculture. Most fertility concern is focused on deficiencies in N availability to plants because they reduce yield and / or quality of crop. Excess nitrate –N in soil can lead to N losses to the environment that reduce water quality and can reduce yield and / or quality for some crops. Leaching, runoff and denitrification are processes that result in loss of N from the soil plant system creating the potential for N deficiency in crops and degradation of water and air quality. Thus, where soils or landscapes consistently regulate water availability, precision N management would have potential.

Precision weed management: The application of precision farming to weed management in potentially beneficial to agriculture because (a) it offers an opportunity to reduce chemical / non chemical inputs into crop production through site-specific weed control and the use of precise application techniques and (b) the acquisition of spatial and temporal information on weed occurrence and distribution made possible with precision agriculture technologies. A common approach to precision weed management is site specific weed control achieved by (a) applying herbicide only where weeds are present of above economic threshold level, termed intermittent herbicide application or patch spraying, (b) varying herbicide application (type, formulation, rate) according to soil physical and chemical properties or weed characteristics (species, growth stage, and density), or (c) some combination of the two approaches. For prevention or pre- emergence weed control, site specific application requires prior knowledge of historical weed distribution since no weed are visible at the time of application. This knowledge can obtain by mapping weed.

Precision insect management: Precision insect management has potential because distribution of insect population are spatially variable, in part because insect are mobile during at least part of their life cycle and in part during the relative non-mobile stages insects cluster in response to environmental and behavioral responses. Therefore, precision insect management has the potential to reduce insecticide application and improve the efficacy of both prevention insect management strategies.

Constraints :

- Small farm size,
- lack of success stories,
- Lack of local technical expertise,
- Knowledge and technical gap,
- High cost of obtaining site specific data.

Precision farming in India : Green revolution has not only increased productivity, but it has also several negative ecological consequences such The green as depletion of lands, decline in soil fertility, soil salinization, soil erosion, deterioration of environment, health hazards, poor sustainability of agricultural lands and degradation of biodiversity. Indiscriminate use of pesticides, irrigation and imbalanced fertilization has threatened sustainability. According to CGIAR, 'Sustainable agriculture is the successful management of resources to satisfy the changing human needs, while maintaining or enhancing the quality of environmental and conserving natural resources'.

Nehru said, 'everything can wait but not the agriculture'. Therefore, agricultural research seeks the generation of new technologies to reorient the current and future needs and constraints. The new technology should be highly productive, cost-effective and ecologically sustainable. In the present context, maintenance of ecological balances through precise and site-specific management is most desirable. Planners have long recognized that an accurate and timely crop production forecasting system is essential for strengthening the food security. The concept of PF maybe appropriate to solve these problems, though it looks unsuitable to Indian conditions; but it is not impossible to adopt. Due to urgent need for increasing productivity of horticulture crops for meeting the domestic and export demand. The National Agriculture Policy stipulate the deployment of available tools including precision farming. The initiative for promoting the precision farming concepts in India commenced only recently in the year 2001 by way of re-designating 17 Plasticulture Development Centers (PDC) into Precision Farming Development Centers (PFDC).

Depending upon the location of PDFCs they have been assigned different crops to work on precision farming models. Besides, the Government of India is contemplating to launch a new scheme on hi-tech Horticulture & Precision Farming during the Tenth plan.

Scope of precision farming : Any technological development does not provide a total solution for the user until and unless it is commercialized for extensive use as a service mode. The interest in PF and its introduction has resulted in a gap between the technological capabilities and scientific understanding of the relationship between the input supplies and output products. Development of PF has been largely market-driven, but its future growth needs collaboration between private and public sectors. Precision farming technology has been deployed predominantly for agricultural crops like corn, soyabean, rice, cotton, peanut, sugar beet and sugarcane. Among horticultural crops this technology has been applied for crops like potato, banana and oil palm. The tools available commercially for the potato growers are yield monitoring and VRT fertilizer application, yield monitoring, VRT insects and pest control can be applied to horticultural crops.

Conclusion : During the last century, numerous changes have taken place in the major components of agriculture, both in the positive as well as in negative direction. Over last few decades, the impact of science and technology on society and ecosystem has intensified the deterioration of the ecosystem, leading to depletion of biological resources. In future, agriculture will face formidable challenges to provide adequate nutrition for people. Therefore, how to increase agricultural productivity, as the developing countries have the lowest productivity for most of the food crops. It is obvious that unless the latest tools of science and technology are applied for sustainable and equitable distribution of natural resources of our country, poverty and hunger will persist. The new technology may be able to harness several newer possibilities in managing the farm sector precisely. In the light of today's urgent need, there should be an all out effort to use new technological inputs for the development of our society, as well as to make the 'Green Revolution' an 'Evergreen Revolution'.

– In coming years, precision horticulture may help the Indian farmer to harvest the fruits of frontier technology without compromising the quality of land and produce.

– In the overall perspective, with the introduction and adoption of modern technologies, agriculture sector is expected to achieve a vertical growth.

Future thrust :

– Formation of farmers co-operatives since many of the precision agriculture tools are costly (GIS, GPS, RS etc.).

– Creating awareness amongst farmer about consequences of applying imbalanced doses of farm inputs like irrigation, fertilizers, insecticides and pesticides.

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