Ecofarming
e-Magazine for Agriculture and Allied Sciences
http://www.ecofarming.rdagriculture.in
e-ISSN: 2583-0791

PRECISION FARMING IN FRUIT CROPS

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Received: January, 2026; Accepted: May, 2026; Published: July, 2026

Abstract

Precision farming in fruit crops represents a transformative approach to horticultural production by integrating advanced technologies to optimize resource use, enhance productivity, and improve fruit quality. Modern fruit orchards face varied challenges, including climate variability, heterogeneous soil conditions, pest and disease pressures, and the rising demand for sustainable production. Precision farming addresses these challenges through site specific management, enabling growers to monitor and respond to the crops requirements with high accuracy technologies such as Global Positioning System (GPS), Geographic Information Systems (GIS), Remote sensing, drones-based monitoring systems allow real time collection and analysis of spatial and temporal data. These tools facilitate informed decision making related to irrigation scheduling, nutrient application, canopy management, pest and disease monitoring and yield prediction. Variable Rate Technology (VRT) further enhances efficiency by adjusting input application based on the specific needs of different orchard zones. The adoption of precision farming contributes to reduced input costs, conservation of natural resources, improved orchard sustainability, and higher economic returns. Overall precision farming in fruit crops offers a data driven sustainable pathway to increase productivity while minimizing environmental impacts.

Keywords: Precision farming, GIS, GPS, VRT, remote sensing, yield prediction.

Introduction

Precision farming is a technology and information-based agricultural management approach to detect, analyze and control inter and intra-field variations in crops with the help of a decision support system where precise use of inputs optimizes returns while preserving resources unlike traditional cultivation practices and thus leading to maximum sustainability, profitability, and environmental safety. Professor Pierre C. Robert, widely recognized as the pioneer of precision farming, has defined precision agriculture as a concept that goes beyond simply adopting new technologies; it signifies a revolution in information supported by new technologies, resulting in a more sophisticated and precise system for managing agriculture. During this period, the rate of adoption did not reach expectations till the first 10 to 15 years due to the two major factors responsible for rejection and identified the willingness and ability to adopt. He emphasized that the willingness relies on the accessibility of information technology, faith in the information, and trust that this information works as a foundation of favorable outcomes. The momentum of the implementation of precision agricultural approaches was gone down in the mid-to-late 1990s due to economic feasibility or cost-effectiveness earned by precision farming. By the early 2000s, the precision farming community had acknowledged the importance of three key factors for the successful implementation of precision farming: the ability to effectively handle farming challenges, its

user-friendly nature, and its profitability for farmers. Despite being classified as a developing nation, the current situation in India is really grim. With more than 75% of total farm assets in the country are less than approximately 4.8 acres. Fruit plants mostly rely on seasonal rainfall for their nourishment. Additionally, the use of irrigation, which accounts for nearly 50% of the water supply, leads to reduced productivity levels. The position is highly precarious, with about 60% of the population involved in agricultural pursuits and associated endeavors. Agricultural practices have become exceedingly laborious, leading to the majority of farmers' offspring pursuing alternative means of earning a living due to inadequate machinery, insufficient profitability, and strenuous physical work, among other factors. Moreover, farmers find it more practicable to sell their fields to builders, industries, and malls than farming. All of which would eventually lead to the dwindling of farmlands that can feed the billions plus of our country. The technologies used in precision farming are continuously improving and altering, and the effects of these technologies are evident in the overall productivity, efficiency, and ecological impact of farming operations that are involved in the production of fruit.

Need for Precision Farming in Fruit Crops

The worldwide fruit production system presently has significant obstacles that will expand evidently in near future but, present technologies and knowledge with appropriate motivation and investment can lead to achieve a lot. The 1960s 'Green revolution' improved the country's food production significantly, from six million to 72 million tons in 1947 to the second position in the world. Increased inputs such as pesticides, irrigation, fertilizer, high-yielding cultivars, crop density, and mechanization were blamed for this development.

Concerns about trade liberalization in agricultural sector, narrow opportunities in non-farming areas, climatic disparity, stagnating farm incomes, diminishing and degrading natural resources, and declining and fragmented land holdings have become paramount to growth and development of agriculture. Hence, the recently evolved technique is regarded as one of the most viable strategies to boost agricultural output in the future. Precision agriculture gives the key to automate and simplify the gathering and analysis of information by

- Doing appropriate things in the right location at the right time
- Higher productivity
- Raising the efficiency of inputs
- Using minimal land unit

The diversity in yield and quality of the food throughout the fields may be connected to management practices, soil and environmental features and adjustments can be made by obtaining and analyzing the information by means of Precision farming.

Significance of Precision Farming in Fruits Crops

- Precision farming increases crop yield.
- It gives information to help with decision-making in management.
- It helps to lower the cost of fertilizer and plant protection chemicals by applying them effectively.
- Precision farming has the ability to produce at peak efficiency with consistent and superior quality.
- More precise farm records can be kept.
- It can decrease the cultivation costs and help raise the input production efficiency.
- The reduction of chemical doses through VRT can be obtained.
- It helps in reduction of irrigation water application, which lessens nutrient leaching and deep percolation.
- Precision farming decrease runoff, erosion, and sedimentation of water bodies; and the reduction of environmental pollution.

Tools and Equipment of Precision Farming

Technologies used in precision farming include a range of implements, software and hardware. These are:

Global Positioning System (GPS): GPS offers uninterrupted positioning information consisting latitude, longitude and elevation in real time by a network of satellites in motion with an accuracy of between 100 and 0.01m. It provides the precise location information at any time such as soil type, pest incidence, weed occurrence, water holes, boundaries, obstructions and crop measurements. There is a programmed controlling system consisting of a panel guided by light or sound (DGPS), an antenna and a receiver that estimates the position by the signals broadcasted by the GPS satellites. The reliable identification of the field location allows the users to apply the inputs such as fertilizers, herbicides, irrigation water, pesticides and seeds to a certain field determined by performance standards and prior input applications. GPS receivers equipped with automated yield monitoring devices are commonly utilized for accurately collecting yield data. GPS are extensively utilized in agriculture for various purposes. These include mapping yields (using GPS in combination with a yield monitoring device), implementing variable rate planting (using GPS in conjunction with a variable rate planting system), applying variable rates of fertilizer (using GPS with a variable rate controller), creating field maps for record-keeping and insurance purposes (using GPS with mapping software), and performing parallel wrapping (using GPS with a navigation device). Researchers and cooperative farmers are using GPS receivers with barcode readers to locate the high-risk fruits in the orchards and thus it allows them to determine the location of the bin of fruits harvested from the orchard. This helps in tracking the fruit with quality problems eventually leading to the tree that is producing the damaged fruit.

Geographic information systems (GIS): It is an arrangement of hardware and software components that produce maps by using the feature attributes and location data. An agricultural Geographic Information System (GIS) plays a crucial role in storing several layers of information, including data on yields, yield maps, soil survey maps, data from remote sensing, reports of crop scouting, and the status of soil nutrients.

Two types of data set are recorded by a GIS: (a) geographically referenced data (such as field boundaries, roads, and sample sites) and (b) attribute data that define the spatial data (such as soil drainage class and type). The spatial data is often recorded in raster (grid cell) or vector (arc-node) formats and is linked to a geographic coordinate system. In order to integrate findings and plan for distinct management zones within fields, the data provided by the GIS are used as an input into a number of decision support system models. The variation in particular biological or environmental characteristics that influence agricultural activities, such as tillage, planting, fertilization, and managing weeds, pests, and diseases, is taken into consideration in the management plan. A critical source of feedback for assessing and modifying the management strategy for the following crop cycle is yield monitoring. A simple rule-of-thumb dictating, for instance, that lime should be added if the soil pH drops below a certain level might serve as the decision support system. In order to project the results of different weather situations and management decisions, more sophisticated decision support systems incorporate many data sources with crop simulation models.

E.g. GIS for rice fields is an interactive, easy to use system that serves to manage the paddy fields more effectively and economically.

Remote sensing: With the use of data sensors that may be easily carried in the hand, installed on an airplane, or based on satellites, remote sensing technology allows a user to simultaneously collect a wide variety of information from a remote location. A tool for assessing the health of the crop is provided by the sensor data. Overhead photos are frequently

used to identify elements of plant stress, such as those pertaining to moisture level, available nutrients, compaction, disease occurrence, and other issues with plant health. The unpredictability that impacts crop productivity within a given season can be identified using remote sensing, and timely management actions can increase profitability. The timing and extent of mid-season drainage, the amount and timing of nitrogenous fertilizer application, and harvesting period are just a few examples of the varied field conditions that make it challenging to identify the critical management factor, even though remote sensing technology gathers a lot of information. GIS, or geographic information systems, are ideal for these kinds of investigations. Geographic information systems (GIS) are widely used in agriculture, particularly in the areas of planning and monitoring the irrigation supply for rice cultivation, heavy metal regional distribution maps, groundwater recharge estimation and regionalization, and resource management. For instance, the ratio of leaves to trunk as well as the tree vigor can be seen in infrared images of hazelnut plantations.

Variable Rate Technology: In order to precisely regulate the application rate of different components in crop production, such as fertilization, weed and pest management, and irrigation, VRT integrates agricultural equipment. It is applied in agriculture to raise crop yields at a specific unit rate or to increase inputs. Automated variable rate technology (VRT) has numerous uses in agriculture. The controller computer, locator, and actuator are the major parts of a variable rate applicator. The computer that is mounted on a variable rate applicator loads the roadmap for application into it. The computer operates a product-delivery controller that utilizes a GPS receiver and the application map. This controller has the ability to modify the type or amount of product being supplied, guided by the information provided by the map (for example, in the case of combine harvesters having yield monitors). Here, the flow of grain is continuously measured and recorded by the yield monitors in the clean grain elevator of a combine harvester and they can provide the information necessary for producing yield maps when connected to a GPS receiver. Variable rate irrigation and fertilization can efficiently optimize the available resources and increase productivity. Canopy sprayers reportedly reduced 40% of the total pesticide consumption during the early season in grape orchard using infra-red sensors to observe the growth of canopy.

Strategies for Precision Farming in fruit crops

1. Selection of Suitable Variety
2. Water-use Efficiency
3. Balanced Nutrition
4. Manipulation of Vegetative Growth and Flowering
5. High-density Planting and Tree Canopy Management
6. Alternate Bearing Management
7. Rejuvenation of Unproductive Orchards
8. Managing disorders
9. Pest and disease management
10. Harvesting and post-harvest management
11. Packaging and transport

Successful Implementation in India

Tata Kisan Kendra (TKK): Tata Chemicals (TCL) launched the Tata Kisan Kendra as a way to utilize technology relevant to India's farming sector. Various technologies like soil and crop health analysis, recording of pest attacks and final outcome prediction using remote sensing system is brough to the farmers by Tata Chemicals through the Tata Kisan Kendra.

Summary of results

- Healthier harvests
- Greater yields
- Increased farmers income
- Financial assistance
- Natural disaster insurance
- Buyback options

Tamil Nadu Precision Farming Project: Government of Tamil Nadu gave Tamil Nadu Agricultural University, the mission of

developing precision farming in exchange for a cash subsidy for crop output and drip irrigation construction. Water consumption efficiency is higher with drip irrigation than with other methods because it delivers a precisely controlled distribution of water and nutrients, finely regulated at low pressure and controlled the intervals through pipelines straight into the rhizosphere of the plants.

Summary of results

- Lower need for water and fertilizer
- Lesser weed growth
- Optimal moisture management and soil aeration
- Enhanced productivity
- Water conservation
- Prevention of soil erosion

Challenges of Precision Farming in India

- 80% of farmers own fragmented land (less than two hectares of land);
- Poor financial situation of the farming community
- Highly diverse cropping sequences
- Inadequate software for general Indian farmers' Precision agriculture
- Uncertainty over the availability of high-quality seed or planting materials for the intended variety and crop.

Conclusion

The establishment of fruits orchard is a long-term venture and requires proper planning such as location and site selection, soil testing for the suitability, selection of crops, laying out, planting density, cultural operations, nutrient and water management, and plant protection measures to ensure less disease and pest infestation for maximum quality production. Precision farming has already been adopted by many progressive entrepreneurs as it is a perfect tool for most of these operations with more accuracy and efficiency. There are a lot more scopes for improvement in the precision farming techniques for sustainable orchard management and development.