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Precision Farming in Fruit Crops: A Modern Approach

*Preetika Verma[1], Shivali Chauhan[1] and Antima Sharma[2]
[1]Department of Fruit Science, Dr Yashwant Singh Parmar University of Horticulture & Forestry, Nauni, Solan, 173230 (H.P.), India
[2]Punjab Agricultural University, Ludhiana, Punjab, India
*Corresponding Author's email: preetika7007@gmail.com

Precision farming leverages modern technology to optimize agricultural inputs, enhancing fruit crop productivity while minimizing environmental impact. This article introduces the core components of precision farming, explores its varied applications in horticulture, and provides real-world examples of its success in fruit crops. Ultimately, farmers are encouraged to adopt these technologies cooperatively to overcome the challenges of fragmented landholdings and secure a profitable future.

Introduction

India is the second-largest producer of fruits globally, yet traditional farming methods often treat entire fields as homogeneous areas, applying uniform inputs regardless of local variations. Precision farming revolutionizes this by managing spatial and temporal variability using Information, Computers, and Technology (ICT). It ensures that the exact right amount of treatment is given at the right time and in the right location within a field. By breaking farm fields into smaller "management zones," farmers can address specific variability, thereby maximizing the use of minimal land units, conserving resources, and reducing environmental pollution.

Techniques of Precision Farming

To successfully implement site-specific crop management, precision farming relies on several key technological tools:

Global Positioning System (GPS) GPS is a satellite-based radio-navigation system that provides extremely accurate, 3-dimensional location information. It enables farmers to reliably identify field locations, map soil and crop variability, and guide machinery for precise input application even in low-visibility conditions like fog or darkness.

Geographical Information System (GIS) GIS is a computer program designed to capture, store, update, and analyze all geographically referenced information. It helps correlate physical factors—such as soil pH, nutrient levels, and climatic conditions—with spatial-based crop yields to develop predictive models.

Remote Sensing (RS) Remote sensing acquires information about crops without physical contact by measuring reflected or emitted electromagnetic energy. Sensors can detect near-infrared (NIR) light, which is highly effective for vegetation surveys, helping to identify nutrient deficiencies, assess crop conditions, and forecast yields.

Variable Rate Technologies (VRT) VRT comprises automated machine systems that adjust the application rate of inputs—such as liquid fertilizers, pesticides, and irrigation water—on the go. Based on sensor data or pre-loaded application maps, VRT ensures that chemicals are distributed precisely according to the specific needs of each field zone.

Yield Monitors Installed on harvesting equipment, yield monitors record crop yield data at regular intervals alongside GPS positional data. This data is used to produce yield maps, which help decision-makers estimate nutrient depletion and plan fertilizer applications for the next season.

Applications of Precision Farming

These technologies translate into actionable management practices in the orchard:

Precise Space Utilization Precision farming encourages High-Density Planting (HDP) and Meadow Orcharding. By manipulating tree size through dwarfing rootstocks, pruning, and training, farmers can accommodate an exponentially higher number of plants per hectare, vastly increasing production per unit area.

Precise Water and Nutrient Management Drip and sprinkler irrigation systems apply regulated water directly to the root zone, saving 50% to 70% of water compared to traditional methods. When combined with "fertigation"—the incorporation of fertilizers within the irrigation water—farmers achieve highly precise nutrient delivery, boosting fertilizer use efficiency to 80-90%. Further refinement is achieved through the Diagnosis and Recommendation Integrated System (DRIS) and Site-Specific Nutrient Management (SSNM), which calculate the exact nutritional demands of the crop based on plant tissue and soil composition.

Precision Plant Protection With the rise of invasive pests, precision agriculture employs electronic traps and wireless sensor networks. These systems provide real-time environmental data to predict pest outbreaks or fungal infections, allowing for targeted chemical application rather than preventative, blanket spraying.

Examples in Fruit Crops

The real-world implementation of these techniques has shown remarkable results across various fruit crops:

- **Apple:** In an experiment involving 7-year-old apple plantations, the use of drip fertigation and mulching saved 20% on fertilizers and 40% on water. More importantly, this precise application resulted in a 33% higher fruit yield compared to conventional surface fertilization practices.
- **Banana:** Studies on drip-irrigated bananas demonstrated that applying 100% of the recommended dose of water-soluble fertilizers via drip fertigation at 7-day intervals significantly enhanced growth, fruit quality, and overall yield compared to standard nitrogen fertigation.
- **Guava:** Utilizing an ultra-high-density meadow orchard system, researchers found that specific plant spacing (such as 2.0 x 1.0 m) optimized light interception and accommodated 5,000 plants per hectare, leading to superior fruit weight and total soluble solids (TSS) without compromising individual plant health.
- **The CHAMAN Project:** On a macro level, the Indian government utilizes the CHAMAN project to assess horticulture using geo-informatics. Satellites and UAVs are deployed to map suitable growing areas for crops like mango, citrus, banana, and kiwi across multiple states, guiding strategic agricultural expansion.

Conclusion

For the farming community, precision farming represents a vital shift from resource-heavy traditional agriculture to smart, sustainable cultivation. While the high cost of technology and the fragmentation of land holdings in India present genuine challenges, the basic principles of site-specific management can still be adopted. Farmers are encouraged to form cooperatives to access advanced tools like GIS and Remote Sensing. By embracing micro-irrigation, targeted fertigation, and high-density planting, growers can drastically lower input costs, conserve vital natural resources, and significantly increase their profitability.

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