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Precision Agriculture and Associated Technologies

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Introduction

Precision agriculture is considered as one of the top ten innovations and is crucial for modern agriculture (Crookston 2006). Pierre Robert is regarded as the father of Precision Agriculture (Robert, 1982) and his Ph.D. work was also on “Evaluation of Some Remote Sensing Techniques for Soil and Crop Management”. Precision agriculture has been referred with several terminologies such as satellite farming, site-specific crop management (SSCM) or precision farming. It generally means doing right thing or right practice at right place and right time with right intensity.

But the proper definition for precision agriculture adopted by the International Society of Precision Agriculture is:

“Precision Agriculture is a management strategy that gathers, processes and analyzes temporal, spatial and individual data and combines it with other information to support management decisions according to estimated variability for improved resource use efficiency, productivity, quality, profitability and sustainability of agricultural production.”

The concept of precision agriculture is integration of crop management system with the help of advance technologies in order to balance the agro-chemical input with the actual crop requirement in smaller areas of field. This approach minimizes waste, increases crop yield and is environmentally friendly. This modern concept is widely accepted and is proved to be successful, well mechanized at industrial or commercial farming scale (Swinton and Lowenberg-DeBoer, 2001) especially for certain valuable cash-crops which demands for higher agrochemical inputs and are marketed with huge variability in context of quality.

Step-wise process of Precision Agriculture

1. identifying yield-limiting factors at certain time and place
2. mapping these elements throughout the desired region

3. designing a variable-rate management approach that takes into account the spatial variability of these factors
4. evaluating the economic and environmental advantages of using variable-rate management systems

Benefits of Precision Agriculture

- **Cost reduction:** It helps reduce costs by optimizing the use of inputs such as water, fertilizer, and pesticides.
- **Increased productivity:** By using precision agriculture techniques, farmers can better understand the variability of their fields and tailor their management practices accordingly. This can lead to higher yields and improved crop quality.
- **Environmental sustainability:** It allows farmers to minimize the use of inputs that can harm the environment, such as pesticides and fertilizers.
- **Efficient use of resources:** With precision agriculture, farmers can optimize the use of resources such as water and energy. This can help to conserve these resources for future generations.
- **Better decision-making:** Precision agriculture generates a wealth of data that farmers can use to make better decisions about their operations. By analyzing this data, farmers can identify trends and patterns that can inform their management practices and help them make more informed decisions.

Technologies for Precision Agriculture

Precision Agriculture incorporates several advanced techniques which are categorised on the basis of technological principle applied in it. Khanna (2001) divided such techniques into diagnostic techniques and application techniques. The major tools of precision agriculture based on such techniques are Global Positioning System (GPS), geographic information system (GIS), miniaturized computer components, mobile computing, remote sensors, automatic control, yield monitors, advanced information processing, *etc.* (Gibbons, 2000).

Global Positioning System (GPS)

GPS receivers are used to calculate location of global positioning system satellites using signals transmitted by them. The fact that this information is given in real time suggests that it is given continuously while in motion. It is possible to map measurements of soil and crops when one has access to precise location data any time. GPS receivers could be taken along to the field or installed on tools which makes possible to treat certain areas of the field by returning to sample at specific location. It also allows collection of soil sample from smaller areas of the field each year and thus monitor crop condition according to spatial variability of soil.

Geographical Information System (GIS)

Geographic information systems (GIS) are computer hardware and software which makes use of specific characteristic and location information to generate maps. GIS has potential to process huge data at higher speed and thus it is necessary for storage and handling of location specific data (Lee *et al.*, 1997). In precision agriculture, GIS thus play role in collection of layers of information, such as yields, soil survey maps, remotely sensed data, crop scouting reports, and soil nutrient levels. Spatial variability maps generated through these data are guide to the agricultural inputs, such as water, fertilizer, pesticide, etc., for appropriate management.

Remote Sensing

Remote sensing is collection of data from a distance through sensors placed on satellites or are aircraft mounted. The components of remote sensing system are categorized into three main categories such as ground base, spatial foundation and remote sensing data storage system (Yin *et al.*, 2019). These components provide carrier platform, remote sensor, control and positioning system, data transmission and data pre-processing systems. The data collected through remotely sensed system provides base for detecting crop health. Crop conditions affected by nutrients, diseases, moisture, *etc*. are easily detectable through overhead images. Remote sensing can identify in-season variability that influences agricultural output and help making decisions that will increase the profitability of the crop.

Variable Rate Technology (VRT)

Variable rate technology is defined as application of agricultural inputs precisely and variably depending on the current status and need of units of field. To create management zones within larger fields, analysis of one or more variable factor affecting crop yield is carried out. VRT (variable rate technology) and VRA (variable rate applications) make use of programmable machines that are attached with sprayers available to deliver the right amount of agro-inputs relying on actual field conditions such as growth stage and condition of crop and previously collected crop growth data.

Yield Monitoring and Mapping

The fully automated grain yield monitor system measures and records the grain flow in the clean-grain elevator of a combine. The information needed for yield maps can be obtained from yield monitors when connected to a GPS receiver. For appropriate management decisions, yield assessments are crucial. When used effectively, yield data offers significant insight for assessing the effects of inputs like seeds, herbicides, fertiliser and cultural practises like irrigation and tillage.

Conclusion

Precision agriculture is extensively beneficial for farmers as well as it is eco-friendly mode of agriculture. It is blessing for issues like food security when there is continuous rise in global population above which climate change also affects the agricultural production. The advanced technological base of precision agriculture guides farmer in decision-making and crop management with efficient application of agro-inputs and increased productivity. However, technological gaps could constraint the level of success in precision agriculture.

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