NEW ERA AGRICULTURE MAGAZINE

Precision agriculture: A Modern approach to smart agriculture

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Introduction:

Precision agriculture is defined as the application of principles and technologies to manage spatial and temporal variability associated with all aspects of agricultural production for the purpose of improving crop performance and environmental quality. Precision agriculture aims at optimizing profitability and protecting environment through efficient use of inputs based on temporal and spatial variability of soils and crops. Both sensors based and satellite image-based technologies have been developed and are being promoted in developed world. Economic analyses of adoption of precision farming have indicated marginal profitability to already existing best management practices and higher productivity level. Wide gap between potential and actual yield levels in developing world necessitates promotion of PF to achieve the intended benefits.

Concepts of precision farming

Precision farming basically depends on measurement and understanding of variability. Main components of precision farming system must address the variability.

Precision farming is a farm management concept based on modern information technologies. Components of precision farming include:

- Remote sensing
- Geographical information system (GIS)
- Global positioning system (GPS)
- Soil testing
- Yield monitors
- Variable rate technology (VRT)

Precision agriculture is a phrase that captures the imagination of many concerned with the production of food, feed and fiber. The concept of precision agriculture offers the promise of increasing productivity while decreasing production cost and minimizing environmental impacts. Precision agriculture conjures up images of farmer overcoming with the elements with computerized machinery that is precisely controlled via satellites and local sensors and using planning software that accurately predicts the crop development. This image has been called the future of agriculture.

In Indian contest, precision farming may be defined as an accurate application of agricultural inputs for crop

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growth, considering relevant factors such as soil, weather and crop management practices. It is actually information and technology-based farming system where inputs are managed and distributed on a site-specific basis for long-term benefits.

Precision farming system within a field is also referred to as site-specific crop management. Precision farming is concept of using the new technologies and collected field information. Precision farming provides farmers with a tool to apply fertilizer according to the need of a particular sub field and no longer based on the average of the field. The savings made with this variable application can be fairly large. Precision farming technology can be viable alternative to improve profitability and productivity.

Tools and techniques

Global positioning system (GPS): The GPS is a navigation system based on network of satellites that helps users to record positional information (latitude, longitude and elevation) with an accuracy of between 100 and 0.01 m. GPS allows farmers to locate exact position of the field features, such as soil type, pest occurrences, weed infestation, water holes, boundaries and obstructions. There is an automatic controlling system, with light or sound guiding panel (DPGS), antenna and receiver. GPS satellites broadcast signals that allow GPS receivers to calculate their position.

The GPS provides the same precise guidance for field operations. The system allows farmers to reliably identify field locations so that inputs can be applied to an individual field, based on performance criteria and previous input applications. Specific advantages on GPS in farm operation include:

1. Farm machines are guided along a track, hundreds of meters long, making only centimeter scale deviations.
2. Rows are not forgotten and overlaps are not made.
3. Number if rows can be counted during work.
4. Tools and equipments can be operated in the same way from year to year.
5. It is possible to work at night or in dirt with precision.
6. The system is not affected by wind.
7. An additional recorder can store field information to be used in making a map.

Sensor technologies: Various technologies: electromagnetic, conductivity, photo-electricity, ultrasound are used to measure humidity, vegetation, temperature, vapour, air etc. Remote sensing data are used to distinguish crop species, locate stress conditions, discover pests and weeds and monitor drought, soil and plant conditions. Sensors enable collection of immense quantities of data without laboratory analysis.

The specific uses of sensor technologies in farm operations are as follows:

1. **Sense soil characteristics:** Texture, structure, physical character, humidity, nutrient level and presence of clay.
2. Sense colours to understand conditions relating to: Plant population, water shortage and plant nutrients.
3. Monitor yield: Crop yield and crop humidity.
4. Variable rate system: To monitor the migration of fertilizers and discover weed invasion.

Geographic Information System (GIS):

This system comprises of hardware, software, and procedures designed to support the compilation, storage, retrieval, and analysis of feature attributes and location data to produce maps. GIS links information in one place so that it can be extrapolated when needed. Computerized GIS maps are different than conventional maps and contain various layers of information's (yield, soil survey map, rainfall, crops, soil nutrient levels and pests). GIS helps to convert digital information to a form that can be recognized and used. Digital images are analyzed to produce a digital information map of the land use and vegetation cover. Once analyzed, this information is used to understand the relationships between the various elements affecting a crop on a specific site. To sum up, the GIS technologies support people working in agriculture by providing:

1. Greater analytical support for precision farming.
2. Better understanding of risk factors.
3. Higher revenue generation and cost recovery.
4. Greater efficiency through task automation.
5. More accurate support for decision making.
6. Greater insights to policy making.
7. Easier reporting for government applications and regulatory compliance.
8. Better resource management.

Variable rate technologies (VRT):

Variable rate technologies are automatic and may be applied to numerous farming operations. The VRT systems set the rate of delivery of farm inputs depending on soil type noted on a soil map. Information extrapolated from the GIS can control processes, such as seeding, fertilizer and pesticide application and herbicide selection and application, at a variable (appropriate) rate in the right place at right time. It is the most widely used technology in precision agriculture.

Steps of precision farming

The basic steps in precision farming are, assessing the variability, managing the variability and evaluating the variability. The available technologies enable us in understanding the variability and by giving site-specific agronomic recommendations we can manage the variability that makes precision agriculture viable. And finally, and evaluation must be an integral part of any precision farming system. The detailed steps involved in each process are depicted.

1. Assessing the variability:

Assessing variability is the critical first step in precision farming. Since one cannot manage what one does not know. Factors and the processes that regulate or control crop performance in terms of yield vary in space and time. Quantifying the variability of these factors and processes and determining when and where different combinations are responsible for the spatial and temporal variation in crop yield is the challenge for precision agriculture. Techniques for assessing spatial variability are readily available and have been applied extensively in precision agriculture. The major part of precision agriculture lies in assessing spatial variability. Techniques for assessing temporal variability also exist but the simultaneous reporting of a spatial and temporal variation is rare.

2. Managing the variability:

Once the variation is adequately assessed, farmers must match agronomic inputs to known conditions employing management recommendations. Those are site-specific and use accurate applications control equipment. We can use the technology most effectively, In site-specific variability management. We can use a GPS instrument so that the site-specificity is pronounced and management will be easy and economical. While taking the soil/plant samples, we have to note the sample site coordinates and further, we can use the same for management. This results in the effective use of inputs and avoids any wastage and this is what we are looking for. The potential for improved precision in soil fertility management combined with increased precision in application control makes precise soil fertility management an attractive, but largely unproven alternative to uniform field management.

3. Evaluating the variability:

There are three important issues regarding precision agriculture evaluation. a) Economics b) Environment and c) Technology transfer

a) Economics: The most important fact regarding the analysis of the profitability of precision agriculture is that the value comes from the application of the data and not from the use of the technology.

b) Environment: Potential improvements in environmental quality are often cited as a reason for using precision agriculture. Reduced agrochemical use, higher nutrient use efficiencies, increased efficiency of managed inputs and increased production of soils from degradation are frequently cited as potential benefits to the environment. Enabling technologies can make precision agriculture feasible, agronomic principles and decision rules can make it applicable and enhanced production efficiency or other forms of value can make it profitable.

c) Technology transfer: The term technology transfer could imply that precision agriculture occurs when individuals or firms simply acquire and use the enabling technologies.

Precision farming concerns for Indian Agriculture

Framers in developed countries typically own large farms and crop production systems are highly mechanized in most cases. Large farms can comprise several fields in differing conditions. Even within a relatively small field, the degree of pest infestation, disease infection and weed competition may differ from one area to another.

In conventional agriculture, although a soil map of a region may exist, farmers still tend to practice the same crop management throughout their fields, crop varieties, land preparation, fertilizer, pesticides and herbicides are uniformly applied in spite of variation. Optimum growth and development are thus not achieved. Further, there is an ineffective use of input and labour.

Practical problems in Indian Agriculture:

Precision agriculture has been mostly confined to developed countries. Limitations for its implementation in developing countries like India are:

1. Small land holdings.
2. Heterogeneity of cropping systems and market imperfections.
3. Complexities of tools and techniques requiring new skills.
4. Lack of technical expertise knowledge and technology.
5. Infrastructure and technical constraints including market imperfections.
6. High cost.

Conclusion

precision agriculture represents a paradigm shift in modern farming practices, aiming to optimize productivity, profitability, and environmental sustainability through the judicious application of technology and data-driven decision-making. By harnessing tools such as remote sensing, GPS, GIS, soil testing, and variable rate technologies, precision farming enables farmers to tailor agronomic practices to specific site conditions, thereby maximizing resource efficiency and minimizing environmental impact.

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