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Precision Farming; their tools and techniques

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Definitions

The word 'precision' means exactness or accuracy Precision agriculture is a management strategy that gathers, processes and analyses temporal, spatial and individual data and combines it withother information to support management decisions according to estimated variability for improved resource use efficiency, productivity, quality, profitability and sustainability of agricultural production (International Society of Precision Agriculture). Precision farming is a tool of several technologies which act together for efficient utilization of resources. In precision agriculture inputs are utilised in precise amounts to get increased average yields, compared to traditional cultivation techniques.

Precision farming or precision agriculture is a modern management strategy that employs the details of site-specific nutrient management, remote sensing, global information system, global positioning system, variable rate application to precise manage the production input. Precision farming or precision agriculture is about doing the right thing, in the right place, in the right way, at the right time through the right procedures. Managing crop production inputs such as water, seed, fertilizer etc to increase yield, quality, profit, reduce waste and becomes eco-friendly. Precision farming intends to match agricultural inputs and practices as per crop and agro-climatic conditions to improve the accuracy of their applications.

Need of Precision Farming

The conventional farming systems has led to extensive usage of agricultural inputs like machinery, pesticides, water, and other inputs resulting in negative environmental impacts such as pollution of the environment by emission of greenhouse gases. Research suggests educational and economic challenges as the two most important in the application of precision agriculture. Among the variables that contribute to educational challenges, lack of local experts, funds, knowledgeable research and extension personnel have more of an impact compared to others. PA and initial costs have more of an impact on the economic challenges compared to the other issues. Rather than this PF increase agriculture productivity with prevents soil degradation. PF reduce the use of the chemical application in crop production and efficient use of water resources. It is also helpful in the dissemination of modern farm practices to improve quality, quantity and reduced cost of production, developing favourable attitudes and changing the socio-economic status of farmers more cost-efficient farming

A farmer's expense sheet is often the thing of doom and dread. Precision farming aims to reduce a farmer's expenditure by minimising the need for things like fertiliser, pesticide and herbicide. Over a growing season, growers are seeing significant reductions in the amount of money they are spending on all of the above where technology is using the components sparingly and only where needed. As an alternative to blanket spraying, this has seen massive savings and allows farmers to better budget and keeps costs to a minimum.

Objectives

- Promotion of new venture in the 'Agriculture and its allied sector' bringing together various component of agriculture to exploit the variability
- Reduction in cost of cultivation due to site-specific crop management practices
- Increase in production efficiency of inputs due to site-specific management of inputs
- Reduction in soil and environmental pollution
- Reduction in the application of nutrients especially nitrogen fertilizer thus reducing nitrate in underground water and nitrous oxide to the atmosphere
- Reduction in chemicals does through variable rate application technology
- Reduction in the application of irrigation water thus reducing of nutrient along with deep percolations
- Reducing erosion, runoff and sedimentation of water bodies

Concept of precision farming

The main concept of precision farming is that reducing health hazards and safety for soil, environment and human health by implication of several technologies and machinery. Precision farming depends on the identification, evaluation and management of variability.

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Component/tools or techniques of precision farming/geo-informatics

In the past, it was difficult for researchers to correlate production techniques and crop yields with resources variability. Precision farming in the form of farming location-specific practices is adopted playing due to consideration of spatial variability of land to maximize crop production and minimize the cost of inputs with the least damage tothe environment, soil, water and human health. The major components of precision farming are; Geographical information system (GIS), Geographical positioning system (GPS), Remote sensing, Variable rate technology, NDVI, Nutrient expert system, SSNM, Bio-intensive farming, Real-time nitrogen management, DRIS approach, Soil testing and yield monitoring.

1. Geographical information system (GIS):

The use of GIS was started in 1960. GIS is a computerized mapping system to acquire, store, analyse and display information thatis specially referenced to the earth. It is software that imports, exports and processes spatially and temporally geographically distributed data. GIS system provides a way to overlay different layers of data, these data used for land use, irrigation management, the study of the crop, soil and environment etc. this system comprises hardware, software and procedures designed to support the compilation, storage, retrieval and analysis of feature attributes and location data to produce the map.

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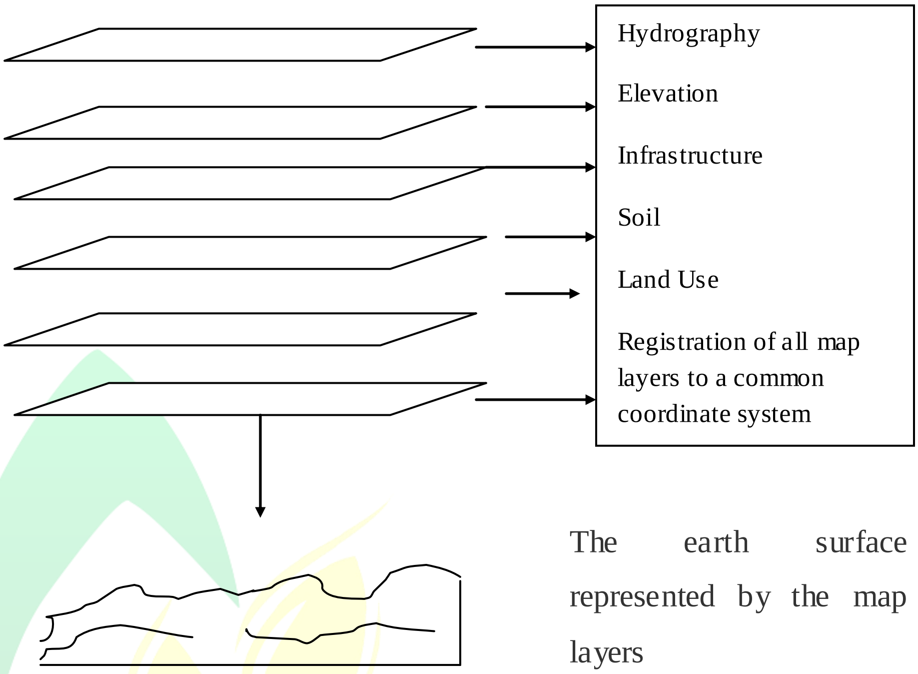

Fig. Overlay analysis of different layers by GIS (Modern Concept of Agronomy, ISA New Delhi)

Computerized GIS maps are differentfrom conventional maps and it's containing various layers of information. GIS can use any information that includes location. The location can be expressed in many different ways, such as latitude and longitude, address, or ZIP code.

Many different types of information can be compared and contrasted using GIS. The system can include data about people, such as population, income, or education level. It can include information about the landscape, such as the location of streams, different kinds of vegetation, and different kinds of soil. It can include information about the sites of factories, farms, and schools, or storm drains, roads, and electric power lines. If, for example, a rare plant is observed in three different places, GIS analysis might show that the plants are all on north-facing slopes that are above an elevation of 1,000 feet and that get more than ten inches of rain per year. GIS maps can then display all locations in the area that have similar conditions, so researchers know where to look for more of the rare plants.

2. Geographical positioning system (GPS)

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The Global Positioning System (GPS) is a navigation system it utilizes a network of 24 satellites in outer space that helps to user to record positional information's (latitude, longitude and altitude) by using satellites. GPS It has a 95% probability that the given position on the earth will be within 10-15 meters of the actual position. GPS allows precise mapping of the farms and together with appropriate software informs the farmer about the status of his crop and which part of the farm requires what input such as water or fertilizer and/or pesticides etc.

3. Remote sensing (RS)

Remote sensing is the science of obtaining information about objects or areas from a distance, typically from aircraft or satellites. In another word, RS means to collect the information of an object without its physical contact. A remote sensor is used to collect the information. Remote Sensors are general categories of aerial or satellite sensors. They can indicate variations in the colours of the field that corresponds to changes in soil type, crop development, field boundaries, roads, water, etc. Arial and satellite imagery can be processed to provide vegetative indices, which reflect the health of the plant.

4. Variable Rate Technology (VRT)

Variable-rate technology (VRT) allows fertilizer, chemicals, lime, gypsum, irrigation water and other farm inputs to be applied at different rates across a field. Variable-rate application (VRA) can range from the simple control of flow rate to the more complex management of rate, chemical mix and application pattern. VRA can match changes in crop yield potential with specific input rates resulting in a more efficient system and minimizing potential environmental impacts. VRT can be used to deal with spatial variability between management zones. There are two types of VRT: 1. Map-based control: a map of application rates is produced for the field before the operation. 2. Real-time control: decisions about what rates to apply in different locations are made using information gathered during the operation. This requires sensors to detect necessary information on' on-the-go and is usually designed for a specific job such as herbicide application. The variable rate applicator has three components. These include control computer, locator and actuator. The application map is loaded into a computer mounted on a variable-rate applicator.

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Requirements of VRA systems:

- Prescription maps to provide site- or zone-specific input rates.
- Global Navigation Satellite System (GNSS) such as GPS to help the applicator interpret the prescription map.
- Variable-rate capable machinery (sprayer, spreader, etc.).
- A controller that uses application maps to vary the rate of input.

5. Normalised difference vegetation index (NDVI)

NDVI value given by Green Seeker. It provides a crude estimate of vegetation health and means of monitoring the change in vegetation over time

$$NDVI = \frac{NIR - PAR}{NIR + PAR}$$

Where: NIR is near-infrared radiation and PAR is photosynthetically active radiation. NDVI value range = +1 to -1 (+1 for dark green vegetation area and -1 for vegetation less area)

6. **Nutrient expert system**

It is computer-based decision tool provide balance nutrition recommendation for rice, wheat and maize for an individual farmer in presence and absence of soil testing data. This tool also estimates attainable yield for farmers based on growing conditions. This tool was developed by 'International Plant Nutrition Institute'. It is used for all macronutrients. It helps in reducing the wastage of nutrients. It also generates location-specific nutrient management

7. Site-specific nutrient management (SSNM)

SSNM approach is based on feeding crops with nutrients when needed. SSNM replies on 5R's *i.e.* Right dose, time, place, method and source. The processes of SSNM are**;** Establishment of an attainable yield target. Effective utilization of indigenous nutrient resources Apply fertilizer to fill the deficit between crop need and indigenous supply

8. **Bio-intensive farming**

It is an organic agricultural system. It focused on maximum yield from a minimum area of land while simultaneously maintaining and improving the fertility of the soil. It aims

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is producing maximum biomass per unit area. The concept and practices of bio-intensive farming introduce by Alan Chadwick in the USA. Components of bio-intensive farming are: Raised bed, BBF, FIRB, intensive planting, intercropping, companion planting and whole system energy

9. Real-time nitrogen management

It means synchronization between crop N_2 demand and supply for improving nitrogen use efficiency and crop yield**.** Techniques (Instrumentation) used for real-time N_2 management; 1. Chlorophyll (SPAD) meter, 2 Leaf colour chart (For rice crop)**,** 3Through green seeker (It is given NDVI value)

10. DRIS approach

This technique is useful for nutrient analysis in the plant. The full form of DRIS is Diagnosis and recommendation integrated system. It was given by Beaufils, 1973. This technique considered nutrient concentration ratio in the plant rather than individual element concentration

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,an 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. We need both spatial and temporal statistics. We can observe the variability in the yield of a crop in space but we cannot predict the reasons for the variability. It needs the observations at crop growth and development over the growing season, which is nothing but the temporal variation. Hence, we need both space and time statistics to apply precision farming techniques. But this is not common to all the variability/factors that dictate crop yield. Some variables are more produced in space rather with time, making them more conducive to current forms of precision management.

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. For successful implementation, the concept of precision soil fertility management requires that within-field variability exists and is accurately identified and reliably interpreted, that variability influences crop yield, crop quality and the environment. Therefore, inputs can be applied accurately. The higher the spatial dependence of a manageable soil property, the higher the potential for precision management and the greater its potential value. The degree of difficulty, however, increases as the temporal component of spatial variability increases. Applying this hypothesis to soil fertility would support that Phosphorus and Potassium fertility are very conducive to precision management because temporal variability is low. For

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N, the temporal component of variability can be larger than its spatial component, making precision N management much more difficult in some cases.

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. While precision agriculture does involve the application of enabling technologies and agronomic principles to manage spatial and temporal variability, the key term is managing. Much of the attention in what is called technology transfer has focused on how to communicate with the farmer. These issues associated with the managerial capability of the operator, the spatial distribution of infrastructure and the compatibility of technology to individual farms will change radically as precision agriculture continues to develop.

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