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Precision Farming: The Future of Indian Agriculture

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SUMMARY

Precision Farming or Precision Agriculture is generally defined as information and technology based farm management system to identify, analyse and manage spatial and temporal variability within fields for optimum productivity and profitability, sustainability and protection of the land resource by minimizing the production costs. It is a system, doing the right thing, in the right place, in the right way, at the right time. Managing crop production inputs such as water, seed, fertilizer etc to increase yield, quality, profit, reduce waste and becomes eco-friendly. The intent of precision farming is to match agricultural inputs and practices as per crop and agro-climatic conditions to improve the accuracy of their applications. Increasing environmental consciousness of the general public is necessitating us to modify agricultural management practices for sustainable conservation of natural resources such as water, air and soil quality, while staying economically profitable. The use of inputs (i.e. chemical fertilizers and pesticides) based on the right quantity, at the right time, and in the right place. This type of management is commonly known as "Site-Specific Management". The productivity gain in global food supply have increasingly relied on expansion of irrigation schemes over recent decades, with more than a third of the world's food now requiring irrigation for production. All-together, market-based global competition in agricultural products is challenging economic viability of the traditional agricultural systems, and requires the development of new and dynamic production systems.

INTRODUCTION

Precision farming is an approach where inputs are utilized in precise amounts to get increased average yields compared to traditional cultivation techniques. Hence it is a comprehensive system designed to optimize production by using a key elements of information, technology, and management, so as to increase production efficiency, improve product quality, improve the efficiency of crop chemical use, conserve energy and protect environment (Shibusawa, 2000). Thus, precision farming is an appealing concept and its principles quite naturally lead to the expectation that farming inputs can be used more effectively, with subsequent improvements in profits and environmentally less burdensome production. The precision farming developments of today can provide the technology for the environment friendly agriculture of tomorrow. Especially in the case of small farmers in developing countries, precision farming holds the promise of substantial yield improvement with minimal external input use.

Why Precision farming:

- To enhance productivity in agriculture.
- Prevents soil degradation in cultivable land.
- Reduction of chemical use in crop production
- Efficient use of water resources
- Dissemination of modern farm practices to improve quality, quantity & reduced cost of production in agricultural crops.

Advantages-

- Agronomical perspective- Use agronomical practices by looking at specific requirements of crop.
- Technical perspective- Allows efficient time management.
- Environmental perspective- Eco-friendly practices in crop.
- Economical perspective- Increases crop yield, quality and reduces cost of production by efficient use of farm inputs, labour, water etc.

Over the last fifteen years, many new technologies have been developed for, or adapted to, agricultural use. Examples of these include: low-cost positioning systems, such as the Global Positioning System, proximal biomass and Leaf Area Index (LAI) sensors mounted on-board agricultural machinery, geophysical sensors to measure soil properties and low-cost, reliable devices to store and exchange/share the information. Combined, these new technologies produce a large amount of affordable high resolution information and have lead to the development of fine-scale or site-specific agricultural management that is often termed Precision Agriculture.

Need of Precision Farming

The global food system faces formidable challenges today that will increase markedly over the next 40 years. Much can be achieved immediately with current technologies and knowledge, given sufficient will and investment. But coping with future challenges will require more radical changes to the food system and investment in research to provide new solutions to novel problems. The decline in the total productivity, diminishing and degrading natural resources, stagnating farm incomes, lack of Eco regional approach, declining and fragmented land holdings, trade liberalization on agriculture, limited employment opportunities in non-farm sector, and global climatic variation have become major concerns in agricultural growth and development. Therefore, the use of newly emerged technology adoption is seen as one key to increase agriculture productivity in the future. Instead of managing an entire field based upon some hypothetical average condition, which may not exist anywhere in the field, a precision farming approach recognizes site-specific differences within fields and adjusts management actions accordingly. The technology gaining popularity in many fruit crops viz., grapes, banana, citrus, mango, and also in vegetables. In grapes precision farming applied to optimize vineyard performance, maximizing grape yield and quality while minimizing environmental impacts and risk (Proffitt *et al.*, 2006; Urretavizcaya *et al.*, 2017). Several authors have studied precision viticulture in different countries (Bramley *et al.*, 2000; Bramley and Lamb, 2003; Bramley and Hamilton, 2004). Farmers usually are aware that their fields have variable yields across the landscape. These variations can be traced to management practices, soil properties and/or environmental characteristics. The level of knowledge of field conditions is difficult to maintain because of the large sizes and changes due to annual shifts in leasing arrangements in the farm area. So the entire farm area has to be divided into small farm units of 50 cents or less. Precision agriculture offers the potential to automate and simplify the collection and analysis of information. It allows management decisions to be made and quickly implemented on small areas within larger fields.

Technology

Global positioning system (GPS): GPS is a navigation system based on a 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 the exact position of field information, such as soil type, pest occurrence, weed invasion, water holes, boundaries and obstructions. There is an automatic controlling system, with light or sound guiding panel (DGPS), antenna and receiver. GPS satellites broadcast signals that allow GPS receivers to calculate their position. The system allows farmers to reliably identify field locations so that inputs (seeds, fertilizers, pesticides, herbicides and irrigation water) can be applied to an individual field, based on performance criteria and previous input applications (Das *et al.*, 2018).

Sensor Technologies: Various technologies such as electromagnetic, conductivity, photo electricity and ultra sound are used to measure humidity, vegetation, temperature, texture, structure, physical character, humidity, nutrient level, vapour, air etc. Remote sensing data are used to distinguish crop species, locate stress conditions, identify pests and weeds, and monitor drought, soil and plant conditions. Sensors enable the collection of immense quantities of data without laboratory analysis. This type of information is cost effective and can be very useful for site-specific crop management programs (Plant, 2001). It is a useful technology for precision agriculture as it can give data for parameters of the field relatively easily.

Geographic information system (GIS): This system comprises 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 from conventional maps and contain various layers of information (e.g. yield, soil survey maps, rainfall, crops, soil nutrient levels and pests). GIS is a kind of computerized map, but its real role is using statistics and spatial methods to analyse characters and geography. A farming GIS database can provide information on filed topography, soil types, surface drainage, subsurface drainage, soil testing, irrigation, chemical application rates and crop yield. Once analysed, this information is used to understand the relationships between the various elements affecting a crop on a specific site. In addition to data storage and display, the GIS can be used to evaluate present and alternative management by combining and manipulating data layers to produce an analysis of management scenarios.

Grid soil sampling and variable-rate fertilizer (VRT) application: Variable-rate technologies (VRT) are automatic and may be applied to numerous farming operations. VRT systems set the rate of delivery of farm inputs depending on the soil type noted in a soil map. Information extrapolated from the GIS can control processes, such as seeding, fertilizer and pesticide application, herbicide selection and application at a variable rate in the right place at the right time. VRT is perhaps the most widely used PFS technology in the United States. Variable fertilizer applications in vineyard could help minimizing variability in vine growth as well as fruit quality (Sethuramasamyraja *et al*., 2010).Grid soil sampling uses the same principles of soil sampling but increases the intensity of sampling. Soil samples collected in a systematic grid also have location information that allows the data to be mapped. The goal of grid soil sampling is a map of nutrient needs, called an application map. Samples may be collected for more than one area of a field which fall in to the same range of yield, soil colour, etc. and thus the same zone. Grid soil samples are analysed in the laboratory, and an interpretation of crop nutrient needs is made for each soil sample. Then the fertilizer application map is plotted using the entire set of soil samples. The application map is loaded into a computer mounted on a variable-rate fertilizer spreader. The computer uses the application map and a GPS receiver to direct a product-delivery controller that changes the amount and/or kind of fertilizer product, according to the application map.

Crop Management: Satellite data provide farmers a better understanding of the variation in soil conditions and topography that influence crop performance within the field. Farmers can, therefore, precisely manage production factors, such as seeds, fertilizers, pesticides, herbicides and water control, to increase yield and efficiency.

Soil and Plant Sensors: Sensor technology is an important component of precision agriculture technology and their use has been widely reported to provide information on soil properties and plant fertility/water status. A comprehensive list of current sensors as well as desirable features for new sensors to be developed in the future. One of the most popular ways to characterize soil variability is surveying the field with soil apparent electrical conductivity (ECa) sensors that collect information continuously when pulled over the field surface. Because ECa is sensitive to changes in soil texture and salinity, these sensors provide an excellent baseline to implement site-specific management.

Aircraft: Aircraft allow ground monitoring with wide flight range and high payload in terms of weight and dimensions, thus providing the ability to manage a large number of sensors. The aircraft bypasses some limitations of the satellite application by programming the image time acquisition and providing higher ground resolution, depending on the flying altitude. However, the reduced flexibility of the time acquisition, due to the rigid schedule of flight planning and high operational costs, makes it economically viable only on areas of more than 10 ha. An example is the Sky Arrow 650 TC/P68, an aircraft built entirely in carbon and Kevlar, equipped with a 100 HP

Rotax engine, with a flight range of about 6 hours. It is a flexible aircraft, which can take off from and land on airports and airfields with a runway length of only 500 m.

Rate Controllers: Rate controllers are devices designed to control the delivery rate of chemical inputs such as fertilizers and pesticides, either liquid or granular. These rate controllers monitor the speed of the tractor/sprayer traveling across the field, as well as the flow rate and pressure (if liquid) of the material, making delivery adjustments in real-time to apply a target rate. Rate controllers have been available for some time and are frequently used as stand-alone systems.

Precision irrigation in pressurized systems: Recent developments are being released for commercial use in sprinkler irrigation by controlling the irrigation machines motion with GPS based controllers. In addition to motion control, wireless communication and sensor technologies are being developed to monitor soil and ambient conditions, along with operation parameters of the irrigation machines (i.e. flow and pressure) to achieve higher water application efficiency and utilization by the crop. These technologies show remarkable potential but further development is needed before they become commercially available.

Software: Applying precision agriculture technologies will frequently require the use of software to carry out diverse tasks such as display-controller interfacing, information layers mapping, pre and post processing data analysis and interpretation, farm accounting of inputs per field, and many others. The most common are software to generate maps (e.g. yield, soil); software to filtering collected data; software to generate variable rate applications maps (e.g. for fertilizer, lime, chemicals); software to overlay different maps; and software to provide advanced geostatistical features.

Yield Monitor: Yield monitors are a combination of several components. They typically include several different sensors and other components, including a data storage device, user interface (display and key pad), and a task computer located in the combine cab, which controls the integration and interaction of these components. The sensors measure the mass or the volume of grain flow (grain flow sensors), separator speed, ground speed, grain. In the case of grains, yield is continuously recorded by measuring the force of the grain flow as it impacts a sensible plate in the clean grain elevator of the combine. A recent development of a mass flow sensor works on the principle of transmitting beams of microwave energy and measuring the portion of that energy that bounces back after hitting the stream of seeds flowing through the chutes. In all yield monitors, GPS receivers are used to record the location of yield data and create yield maps. Other yield monitoring systems include devices used in forage crops to keep track of weight, moisture, and other information on a per-bale basis.

Precision farming is still only a concept in many developing countries and strategic support from the public and private sectors is essential to promote its rapid adoption. Successful adoption, however, comprises at least three phases including exploration, analysis and execution. Precision agriculture can address both economic and environmental issues that surround production agriculture today. Questions remain about cost-effectiveness and the most effective ways to use the technological tools we now have, but the concept of “doing the right thing in the right place at the right time” has a strong intuitive appeal. In the light of today’s urgent need, there should be an allout effort to use new technological inputs to make the ‘Green Revolution’ as an ‘Evergreen Revolution’. Ultimately, the success of precision agriculture depends largely on how well and how quickly the knowledge needed to guide the new technologies can be found.

CONCLUSION

Precision farming provides a new solution using a systems approach for today's agricultural issues such as the need to balance productivity with environmental concerns. It is based on advanced information technology.

It includes describing and modelling variation in soils and plant species, and integrating agricultural practices to meet site-specific requirements. It aims at increased economic returns, as well as at reducing the energy input and the environmental impact of agriculture.

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