PRECISION FARMING

Harshavardana N R ,Sujan D ,Abhisheka M V

College of Agriculture, Hassan; UAS(B)

“Agriculture is the backbone of the Indian Economy”- said Mahatma Gandhi five decades ago. Even today, as we entered in to the new millennium, the situation is still the same, *i.e.*, agriculture is the mainstay of the villages. Not only the economy, but also every one of us looks up to agriculture for our sustenance too. Agricultural production system is an outcome of a complex interaction of seed, soil, water and agro-chemicals.

The global availability of arable land is decreasing and will further decline from currently 0.24 ha per capita to 0.17 ha in 2020. A similar trend is expected in India. The per capita land availability will decline from currently 0.14 ha to 0.10 ha in 2025. Moreover, "The quality of land (in India) likely to remain available for agriculture due to severe competition from urbanization, industrialization and civic needs, will be poor", Therefore, judicious management of all the inputs is essential for the sustainability of such a complex system. The focus on enhancing the productivity during the Green revolution coupled with total disregard of proper management of inputs and without considering the ecological impacts, has resulted into environmental degradation. The only alternative left to enhance productivity in a sustainable manner from the limited natural resources at the disposal, without any adverse consequences, is by maximizing the resource input use efficiency. It is also certain that even in developing countries, availability of labour for agricultural activities is going to be in short supply in future. The time has now arrived to exploit all the modern tools available by bringing information technology and agricultural science together for improved economic and environmentally sustainable crop production.

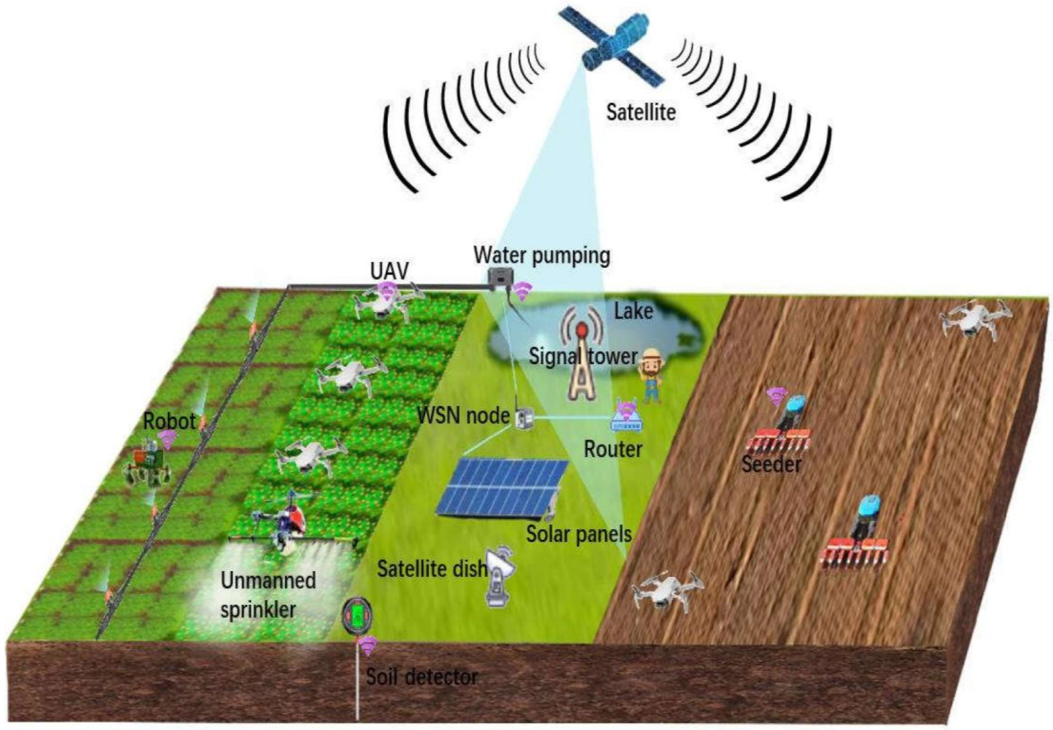
Modern technology in agriculture is the second key to success. Technology is rapidly evolving and the farmer must keep up with the changes that may be of benefit in his or her operation Sensors are available or under development that can monitor soil properties, crop condition, harvesting, or post harvest processing and give instant results or feedback which can be used to adjust or control the operation

Precision farming has been the buzzword of agricultural research around the globe in recent times. It is based on the philosophy of heterogeneity within homogeneity and requires precise information on the degree of variability for within field management, precision agriculture merges the new technologies of the information age with a mature agricultural industry. It is an integrated crop management system that attempts to match the kind and amount of inputs with the actual crop needs for small areas within a farm field. This goal is not new, but new technologies now available allow the concept of precision agriculture to be realized in a practical production setting.

Precision farming is generally defined as an information and technology based farm management system to identify, analyze and manage variability within fields for optimum profitability, sustainability and protection of the land resource. In this mode of farming, new information technologies can be used to make better decisions about many aspects of crop production. Precision farming involves looking at the increased efficiencies that can be realized by understanding and dealing with the natural variability found within a field. The goal is not to obtain the same yield everywhere, but rather to manage and distribute inputs on a site specific basis to maximize long term cost/benefit. Applying the same inputs across the entire field may no longer be the best choice. Precision farming is helping many farmers worldwide to maximize the effectiveness of crop inputs Precision farming distinguishes itself from traditional agriculture by its level of management wherein instead of managing whole fields as a single unit, management is customized for small areas within fields. This increased level of management emphasizes the need for sound agronomic practices. Before shifting to precision agriculture management, it is essential to have a good farm management system in place. Precision agriculture is a systems approach to farming. To be viable, both economic and environmental benefits must be considered, as well as the practical questions of field-level management and technologies needed. The issues related to precision agriculture include perceived benefits and also barriers to widespread adoption of precision agriculture management.
However, the conventional definition of precision farming is suitable when the land holdings are large and enough variability exists between the fields. In India, the average land holdings are very small even with large and progressive farmers. It is necessary to define revised definition of Precision farming in the context of Indian farming while retaining the basic concept of Precision farming. The more suitable definition for Precision Farming in the context of Indian farming scenario could be precise application of agricultural inputs based on soil, weather and crop requirement to maximize sustainable productivity, quality and profitability. Today because of increasing input casts and decreasing commodity prices, the farmers are looking for new ways to increase efficiency and cut costs. Precision farming technology would be a viable alternate to improve profitability and productivity.

Need for Precision agriculture

The potential of precision farming for economical and environmental benefits could be visualized through reduced use of water, fertility, herbicides and pesticides besides the farm equipments. Instead of managing an entire field based upon sore 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 (Goovaerts, 2000). Farmers usually are aware that their fields have variable yields across the landscape. These variations can be traced to management practices, soil properties and for environmental characteristics. Soil characteristics that affect yields include texture, structure, moisture, organic matter, nutrient status and landscape position. Environmental characteristics include weather, weeds, insects and diseases. In some fields, within-field variability can be substantial. In one field, the best crop growth was observed near waterways and level areas of the field. Side slopes where erosion depleted topsoil showed moisture stress and reduced plant stands. In another far in Missouri, it was observed that the variation in yield levels for com and soybean was typically 2 to 1. Seeing this magnitude of variation prompts most farmers to ask how the problem that is causing the low yields can be fixed. There is no economically feasible method of "fixing" the depleted topsoil areas in this field, so the management challenge is to optimally manage the areas within the field that have different production capacities. This does not necessarily mean having the same yield level in all areas of the field. A farmer's mental information database about how to treat different are as in a field required years of observation and implementation through trial-and error. Today, that level of knowledge of field conditions is difficult to maintain because of the larger farm sizes and changes in are as farmed due to annual shifts in leasing arrangements. 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. Technologies for Precision farming in order to collect and utilize information effectively, it is important for anyone considering precision farming to be familiar with the modern technological tools available. The vast array of tools include hardware, software and the best management practices. These are described briefly in the following paragraphs.



Global Positioning System (GPS) receivers:

Global Positioning System satellites broadcast signals that allow GPS receivers to compute their location. This information is provided in real time, meaning that continuous position information is provided while in motion. Having precise location information at any time allows soil and crop measurements to be mapped. GPS receivers, either carried to the field or mounted on implements allow users to return to specific locations to sample or treat those areas Uncorrected GPS signals have an accuracy of about 300 feet. To be useful in agriculture, the uncorrected GPS signals must be compared to a land-based or satellite-based signal that provides a position correction called a differential correction. The corrected position accuracy is typically 63-10 feet. When purchasing a GPS receiver, the type of differential correction and its coverage relative to use area should be considered.

Yield monitoring and mapping:

In highly mechanized systems, gain yield monitors continuously measure and record the flow of grain in the clean grain elevator of a combine when linked with a GPS receiver, yield monitors can provide data necessary for yield mops.

Yield measurements are essential for making sound management decisions. However, soil, landscape and other environmental factors should also be weighed when interpreting a yield map. Used properly, yield information provides important feedback in determining the effects of managed inputs such as fertilizer amendments, seed pesticides and cultural practices including tillage and irrigation. Since yield measurements from a single year may be heavily influenced by weather, it is always advisable to examine yield data of several years including data from extreme weather years that helps in pinpointing whether the observed yields are due to management or climate induced

Grid soil sampling and variable rate fertilizer (VRT) application:

Under normal conditions, the recommended soil sampling procedure is to take samples from portions of fields (that are not more than 20 acres in area Soil cores taken from random locations in the sampling area are combined and sent to a laboratory to be tested. Crop advisors make fertilizer application recommendations from the soil test information for the 20-acre area.
Grid sail sampling uses the same principles of sail sampling but increases the intensity of sampling. For example, a 20-acre sampling area would have 10 samples using a 2-acxe grid sampling system (samples are spaced 300 feet from each other) compared to one sample in the traditional recommendations. 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 to generate a map of nutrient requirement, called an application map. Grid soil samples are analyzed 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 sail 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.

Remote sensing:

Remote sensing is collection of data from a distance. Data sensors can simply be hand held devices, mounted on aircraft or satellite based Remotely-sensed data provide a tool for evaluating crop health Plant stress related to moisture, nutrients, compaction, crop diseases and other plant health concerns are often easily detected in overhead images. Electronic cameras can also record near infrared images that are highly correlated with healthy plant tissue. New image sensors with high spectral resolution are increasing the information collected from satellites. Remote sensing can reveal in-season variability that affects crop yield, and can be timely enough to make management decisions that improve profitability for the current crop. Remotely-sensed images can help determine the location and extent of crop stress. Analysis of such images used in tandem with scouting can help determine the cause of certain components of crop stress. The images can then be used to develop and implement a spot treatment plan that optimizes the use of agricultural chemicals.

Crop scouting:

In-season observations of crop conditions may include: Weed patches (weed type and intensity); Insect or fungal infestation (species and intensity; Crop tissue nutrient status, Flooded and eroded areas using a GPS receiver on an all terrain vehicle or in a backpack, a location can be associated with observations, making it easier to return to the same location for treatment. These observations also can be helpful later when explaining variations in yield maps.

Geographic information systems (GIS):

Geographic information systems (GIS) are computer hardware and software that use feature attributes and location data to produce maps. An important function of an agricultural GIS is to store layers of information, such as yields, soil survey maps, remotely sensed data, crop scouting reports and soil nutrient levels. Geographically referenced data can be displayed in the GIS, adding a visual perspective for interpretation. 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

Variable Rate Applicator

The variable rate applicator has three components

- Control computer
- Locator and
- Actuator

The control computer coordinates the field operation. It has a map of desired activity as a function of geographic location. It receives the equipment’s current location from the locator, which has a GPS in it, and decides what to do based upon the map in its memory or data storage. It then issues the command to the actuator, which does the input application. Variety of substance including granular and liquid fertilizer, pesticides, seed and irrigation water can be applied by VRT systems. The most widely used VRT machines are large scale chemical applicators that control up to 11 different materials at once. The VRT systems adjust the actual material flow rate and regulate the desired application rate of chemicals in the fields.

Precision farming objectives

- Increased production efficiency
- Improved product quality
- More efficient chemical use
- Energy conservation
- Soil and ground water protection

Applications of precision farming

i) **Yield monitoring**: They provide a crop yield by time or distance (e.g. every second or every few metres).

ii) **Yield mapping:** GPS receivers coupled with yield monitors provide spatial coordinates for the yield monitor data. This can be made into yield maps of each field.

iii) **Variable rate fertilizer:** Variable rate controllers are available for granular, liquid and gaseous fertilizer materials. Variable rates can either be manually controlled by the driver or automatically controlled by an on board computer with an electronic prescription map.

iv) **Weed mapping**: A farmer can map weeds while combining, seeding, spraying or field scouting by using a keypad or buttons hooked up to a GPS receiver and data logger. These occurrences can then be mapped out on a computer and compared to yield maps, fertilizer maps and spray maps.

v) **Variable spraying**: By knowing weed locations from weed mapping spot 15 control can be implemented. Controllers are available to electronically turn booms on and off, and alter the amount (and blend) of herbicide applied.

vi) **Topography and boundaries:** Using high precision DGPS a very accurate topographic map can be made of any field. Field boundaries, roads, yards, tree stands and wetlands can all be accurately mapped to aid in farm planning.

vii) **Salinity mapping**: GPS can be coupled to a salinity meter sled which is towed behind an ATV (or pickup) across fields affected by salinity. Salinity mapping is valuable in interpreting yield maps and weed maps as well as tracking the change in salinity over time.

viii) **Guidance systems**: Guidance systems using high precision DGPS that can accurately points out the position of a moving vehicle within a foot or less.

ix) **Records and analyses**: Precision farming may produce an explosion in the amount of records available for farm management. Electronic sensors can collect a lot of data in a short period of time Electronic controllers can also be designed to provide signals that are recorded electronically. A lot of new data is generated every year (yields, weeds, etc). This means a large database is needed with the capability to archive, and retrieve, data for future analyses.

Steps to be taken for implementing PF in India

In the present existent situation, the potential of precision agriculture in India is limited by the lack of appropriate measurement and analysis techniques for agronomically important factors (National Research Council, 1997). The following methodology could be adopted in order to operationalise precision farming in the country.

1. Creation of multidisciplinary teams involving agricultural scientists in various fields, engineers, manufacturers and economists to study the overall scope of precision agriculture.
2. Formation of farmer’s co-operatives since many of the precision agriculture tools are costly (GIS, GPS, RS, etc.).
3. Government legislation restraining farmers using indiscriminate farm inputs and thereby causing ecological/environmental imbalance would induce the farmer to go for alternative approach.
4. Pilot study should be conducted on farmer’s field to show the results of precision agriculture implementation.
5. Creating awareness amongst farmers about consequences of applying imbalanced doses of farm inputs like irrigation, fertilizers, insecticides and pesticides.

Realizing the potential of space technology in precision farming, the Department of Space, Government of India has initiated eight pilot studies in well-managed agricultural farms of the ICRISAT, the Indian Council of Agricultural Research and the Agricultural Universities, as well as in farmers' fields. The pilot studies aim at delineating homogeneous zones with respect to soil fertility and crop yield, estimation of potential yield, yield gap analysis, monitoring seasonally-variable soil and crop conditions using optical and microwave sensor data, and matching the farm inputs to bridge the gap between potential and actual yield through Spatial Decision Support Systems (SDSS)

Prospects of Precision Farming in Indian Agricultural Situation Precision farming, Though in many cases a proven technology, is still mostly restricted to developed (American and European) countries. The reasons for limited implementation of PF in developing countries like India are following:

a. Small land holdings
b. Cost/benefit aspect of PF system
c. Heterogeneity of cropping systems
d. Lack of local technical expertise (India spends only 0.3% of its agricultural gross domestic Product in Research and Development)
e. Knowledge and technological gap

Conclusions

Precision agriculture gives farmers the ability to use crop inputs more effectively including fertilizers, pesticides, tillage and irrigation water. More effective use of inputs means greater crop yield and 'or quality, without polluting the environment. However, it has proven difficult to determine the cost benefits of precision agriculture management. At present, many of the technologies used are in their infancy, and pricing of equipment and services is hard to pin down. This can make our current economic statements about a particular technology dated.

Precision agriculture can address both economic and emvironmental 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. 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. The approach required to be adopted by the policy makers to promote precision farming at farm level.

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