MARUMEGH

Kisaan E- Patrika

Available online at www.marumegh.com

 ISSN: 2456-2904

POTENTIALS AND PROSPECTS OF PRECISION FARMING IN INDIAN AGRICULTURE

Vinod Kumar Yadav[1], M. R. Yadav[2], Rakesh Kumar[2], , Brijesh Yadav[3] and Anil Kumar Verma[3]

[1] Rajasthan College of Agriculture, Udaipur-313001

[2] ICAR-National Dairy Research Institute, Karnal-132001

[3]ICAR-Indian Agricultural Research Institute, New Delhi-11012

Introduction

India is a developing nation but one of the most important agricultural country of South East Asia which blessed with diverse agro-ecological conditions. Agricultural and allied sector contributes around 17.9 % to national Gross Domestic Product. Small land holdings along with low to medium productivity and unjudicious use of natural resources as well as other crop inputs are main feature of Indian agriculture. Beside these Indian agriculture has also been facing severe problems, such as reduction in crop productivity, increase in inputs price, shortage of electricity, water crises, environmental deterioration, land degradation in terms of accelerate soil and water erosion. Furthermore, low amounts of subsidies available on agricultural inputs, unpredictable prices of various food items, lack of information and skills for various new agricultural technologies and sound agricultural policies, and scarcity of irrigation in dry areas are some important issues which pessimistically affect Indian agricultural and farming community of the country. The conventional soil and crop management systems are mainly based on principles of the use of generalised recommendations for all the farm inputs across the whole field. This practice leads to inefficient use of inputs but also increased the production cost and environmental related concerns (Corwin *et al.*, 2003).

Precision farming is information and technology based farm input management system which aims at the use of technologies and principles to identify, analyse and manage spatial and temporal variability associated with all aspects of agricultural production. The use of precision farming practices enhanced farm profitability, sustainability, protecting land resources and maintain or improvement in the environment quality. This production system has great potential to solve all the above associated problems of agricultural production systems.

Precision Farming

Precision farming is newly introduced concept in the agricultural which includes several information based technologies for enhancing precision to asses farm variability and input application to increased farm profit and reducing environmental risks (Zhang *et al.*, 2002). The ideology behind application of these precision farming based management systems is that all the production inputs should be applied only as needed and where needed according to spatial and temporal variability of the field to achieve the most economic crop production. Precision farming envisioned at increasing agricultural output with minimum

production cost on the one hand and minimizing the environmental issues associated with crop production system to achieve the goal of sustainability (Whelan, 2007).

Precision farming is generally defined as 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 benefit (McBratney *et al.,* 2003). The biggest benefit of precision farming is that it gives producers the ability to manage their farm on a production zone basis rather than a whole field basis. This shift allows farmers to save time and money and helps them offset the rising cost of chemicals, nutrients, fuel and fertilizer.

Present Status and Scope of Precision Farming in India

Precision farming is still a new concept to Indian agriculture. Among all the technologies available the laser land leveling is only precision technology that has been used in India successfully from a few years especially in rice-wheat cropping system of north-western part of country. Laser land leveling is a practice of topographic modification, grading and smoothing land to an even level with little or no slope from its average elevation by using a GPS loaded scraper. This practice improves irrigation use efficiencies of the farm through the reduction in water losses and increases the uniformity of water application with less chance of over and under irrigation. In traditional practices of irrigation about 30-50% of total applied water is lost due to various conveyance losses of irrigation system. Apart from this, Country has also trying to made significant advances through the use of precision technologies such as micro-irrigation and protected cultivation during the last two decades. This is attributed to the support of government policies, which is encouraging farmers to adopt precision technologies. It is also true that adoption of precision farming in the entire country is not possible as every farmer will not be ready to accept these sophisticated technologies, but there are some relatively developed areas, which can act as incubators for adoption of these technologies for emerging.

Precision farming is also feasible in small landholding where the contiguous fields with the same management can be considered a large field and map-based precision agricultural applications have a great scope. For instance, rice-wheat cropping system in the IGP of India where rice and wheat are grown in rotation is the choice for precision technologies. Attractive site-specific decisions can be implemented in this region, such as soil characterization, non-destructive monitoring of crop stresses, crop nitrogen monitoring, weed infestation and determining crop biomass using precision tools like Remote sensing, GPS, GIS etc. Similarly, the progressive farmers of the country, with the help of government institutions and private agencies, can adopt some components of precision applications on a limited scale for demonstration to other farmers and stakeholders as the technology shows potential to increase yield and profit.

The Need for Precision Farming The ‘Green revolution’ has made our country self-sufficient in food production**.** As a result of green revolution and intensive use of available

natural resources in last five decades the total food production has increased more than three times, while the productivity in the same period has increased more than twice. This successful story has been possible due to intensive use of agricultural inputs such as use of chemical fertilizers; expand area under assured irrigation, higher use of agrochemicals, development of high yielding crop varieties, horizontal diversification of agriculture leads to higher cropping intensity and improvement in farm mechanization. However, recent years have witnessed a significant slowdown in the yield growth rate and sustainability is at risk due to second-generation problems such as emerging multi nutrient deficiency, receding water table, reduction in total factor productivity, yield stagnation of major crops, environmental pollutions, soil sickness and emerging new pest as well as diseases resulted mounting pressure on natural resources. Even after the spectacular growth in the agriculture production system, the achievable productivity levels of most of the crops in our country is remain far below than world average. We have not achieved even the lowest level of potential productivity of world's high yielding varieties. There is an urgently needs to incorporate precision agricultural technologies in Indian agriculture to conserve natural resources as well as to sustain crop productivity.

Basic Steps in Precision Farming

The Precision farming has the potential and wisdom in utilising natural resources efficiently and protecting natural environment. There are three basic steps to implement precision farming (Adamchuk *et al.,* 2011).

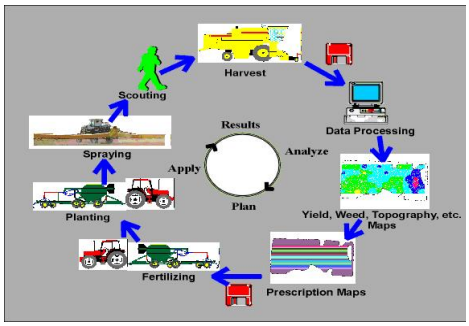
1). Assessing variability

Assessing variability is the most critical step and serves as core characteristic to any Precision farming system. In any farming system the factors and the processes that control the overall crop performance in terms of yield and productivity vary not only in space but also in time. Accounting the variability associated with these factors as well as processes and determining when and where various combinations and interrelationship are responsible for the spatial and temporal variation in crop output is the real challenge for performing precision farming under various farming systems. The most critical and challenging part in precision farming lies in assessing to spatial variability of the crop field. For efficient and effective management of available production inputs we need enough knowledge about both the spatial as well as temporal variability statistics of the given farm. But this is not always true and common to all the variability that dictate crop yield. Some variables are more associated with space rather with time, hence proper knowledge about these variations and their correct assessment are critical in precision farming.

2). Managing variability

Management of field variability through site specific allocation of available crop production inputs is second step in precision farming. Once variation correctively and adequately assessed, farmers must match all the agronomic inputs to known conditions employing management recommendations. These are allocated by employing site specific management strategy using accurate control precision equipment. For site-specific variability management system, we can use global position system, so that the site specificity is pronounced and management of variability will be easy. The potential about improved precision in soil fertility management combined with increased precision in application make

precise soil fertility management as attractive, but largely unproven alternative to average field management which largely depends on blanket recommendations of farm inputs. For successful implementation, the concept of precision soil fertility management requires that the variability exists within-field is accurately identified and reliably interpreted, that variability influences crop yield, crop quality and environment. Therefore, by doing this all the agriculture inputs can be applied accurately at the right time, right place in a right amount. The degree of the farming system, however, increases as the temporal component of spatial variability increases.



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3). Evaluation For effective evaluation of any precision technology relies on three important issues which are evaluation with regards to economics, environment and technology transfer. The most critical fact regarding the analysis of profitability of precision farming is that the value comes from the application of the data of performance of the given system which are collected from the field and not from the use of the technology. Precision farming systems has been tested for potential improvements in environmental quality by reducing green house gases on the one hand and lowering the agriculture input on the other, which often cited as a reason for using precision farming . Reduced agro-chemical use to pest control, higher nutrient use efficiencies of applied nutrients, increased efficiency of managed inputs and increased production are frequently cited as potential benefits to the environment. Enabling technologies can make precision farming feasible, agronomic principles and decision rules can make it applicable and enhanced production efficiency or other forms of value can make it profitable.

Components of Precision Farming

Information or Database

Soil: Soil texture, structure, physical condition, moisture and nutrients etc.

Crop: Plant population; crop tissue nutrient status, crop stresses, infestation of pest and diseases (species and intensity) and crop yield etc.

Climate: Temperature, humidity, rainfall, solar radiation, wind velocity, etc. are important databases that need to be developed to realize the potential of precision farming.

Technologies needed

Remote sensing

It is the process of collecting information about any object from the distance without making any physical contact with it. Remote sensing is critical to precision farming and provides a large range of fundamental information either on the basis of spectral reflectance or thermal remittance properties of soils and crops to their various agronomic and physical characteristics at a wide scales that may range from small patches within a field to large region of the country. Remote sensing tools are serve as an attractive mean for employing site-specific decisions under diverse agro-ecological conditions and crop environment, especially related to characterization of soil variability, monitoring of plant growth in non-

destructive manner and identification of various environmental stresses which might be limit crop output.

Global positioning system (GPS)

Simply, GPS is a navigation system based on a wide network of satellites that enable users to record the exact location of various data points of crops and soil attributes with respect to latitude, longitude and elevation with high accuracy. GPS enable the farmers to locate the exact position of various field features, such as occurrence of insect-pest infestation, soil type, water regimes and boundaries as well as obstructions present in the field. Besides these GPS system also help in allocation of precious crop inputs as per the need of an individual field, based on crop performance criteria and amount of previously applied input (Mondal and Basu, 2009).

Geographical Information System (GIS)

Geographic information system is a technology for handling available data regarding to geographic features of the crop field. It is an organised assembly which consist of collection of geographic data by using computer hardware and software on the one hand and store, retrieve, analyze and display all form of geographically referenced information according to use on the other hand. GIS can display analyze information in the form of maps that allow not only better understanding of interactions among yield, soil fertility, inset-pest, weed flora and other factors and processes that control crop productivity but also provide an opportunity for decision making based on such spatial relationship. On the farm GIS database can helpful to the farmers by making available information regarding topography characteristic of the field, soil types, drainage characteristics including both surface as well as subsurface drainage, soil fertility evaluation, irrigation monitoring, agro-chemical application rates and crop output. The information collected through GPS can be used to understand the relationships between the various elements as well as processes that affecting a crop and their yield on a specific site.

Variable Rate Technology (VRT)

A soil fertility map with GIS is stored in a computer hardware mounted on a GPS guided tractor that senses the exact location of tractor within the field and sends signals to the computer system. The decision support system technology (DSS) enables farmers to decide the actual requirement of agrochemicals as well as other inputs of crop production according to their spatial as well as temporal variability. For the variable and precise application of other inputs under field condition farmers employ a range of variable rate technologies such as variable chemical sprayers, granular spreaders, tillage implements, irrigation systems and herbicide applicators**.** For this purpose the amount of information extrapolated from the GIS technology can control processes, such as seeding, chemical fertilizer and pesticide application, and selection of herbicide and their application, at a variable rate in the right place at the right time (Maleki *et al.*, 2007).

Yield Monitors

Yield Monitors are also a critical component of precision management system especially in crop production. Yield monitors are fitted to combine harvesters, which measure the crop yield and moisture content of grains in real-time and on the basis of these recorded data yield maps are produced. These yield maps give the indication of poor and productive

spots throughout the field and on the basis of these spots variable rate application of inputs are carried out**.** Yield monitors are easy to use and may be the point of entry to implement precision agricultural technologies for many farmers (Barnes *et al.,* 2003).

Computer and internet

Computer and internet play a prominent role in precision farming and act as a source of information gathering and processing tools. With the help computer one can made faster processing the data collected during precise management of crop fields. Internet, which is simply a network of computer, is most recent development among all these technologies and provides valuable information for effective and speedily analysis of gathered data.

Advantages of Precision Farming

Agronomical perspective: Precise application of inputs as per the crop requirements leads to increases crop yield and quality. Further the use of agronomical practices like selection of suitable crop varieties, the application of optimum quantity of nutrients, pesticides and herbicides, and appropriate irrigation management to meet the demand of crops for optimum growth and development attributed to higher crop yield, especially in areas where traditionally practised crop management practices were adopted.

Technical perspective: Precision farming allows efficient time management through acquire accurate information, which is processed and analysed in decision making for land preparation, seeding, fertilizer, pesticide and herbicide application, irrigation and drainage, and post-production activities. Farmers can also accumulate knowledge about their farms and production systems to achieve better management.

Environmental perspective: The timely application of agrochemicals at accurate rates avoids excessive residue in soils and water and thus reduces environmental footprints.

Economical perspective: Application of precision farming can reduces cost of production by efficient use of farm inputs, labour, water etc.

Challenges, Issues and Implications of Precision Farming

India is an agrarian country, yet the agricultural sector is not achieved potential level of production. Challenges towards the adoption of precision agricultural technologies in Indian agriculture are as follows:

- Introducing various precision agricultural based technologies requires improved modern tools; such as computers, remote sensing, yield monitors etc. Currently, there is in large scale no such facilities is available in our country and therefore, introduction of these technologies is still awaited.
- In India, 85% of farmers are small and marginal and adoption of these technologies may not provide comparable benefits, due initial high cost incurred in establish and operating these precision technologies.
- India represents a diverse range of agro climatic conditions where heterogeneity of cropping systems is also a challenge in the adoption of precision farming over large scale.
- The lack of legislation and policies from the government towards using these technologies is a big hurdle.
- Precision farming requires organisations and agencies in public as well private sector that provide consultancy services to farmers to use precision technologies. Unfortunately in

India, there are no such agencies are available that can provide consultancy services to farmers.

- Precision farming yet a new story to Indian farmer's needs large scale demonstration through farmer participatory approach.
- Infrastructural and Institutional constraints including market imperfection is also an important hurdle in adoption of these techniques.

Conclusion

There is an urgent need to incorporate precision agricultural technologies in Indian agriculture. It is suggested that despite small landholding and low income levels, precision technologies has potential to make a significant difference in the livelihoods of farmers which account a large share of national population. There is a good scope of many precision technologies to be implemented in the country but for this farmers and government authorities should look forward to adopt these technologies and tools to increase the efficiency of available scare resources and reducing the inputs costs. Before a widespread implementation of precision technologies in the country, their location specific effectiveness and feasibility needs to be realised on experimental farms for possible applications.

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