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Precision Agriculture a Promising Technology in Agriculture: A Review

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Abstract

This paper discusses about the development of precision agriculture technology in India with their existing constraints and opportunities. India is an agricultural country has quite wide agricultural land and most of the people in this country are working in this sector. A Precision Agriculture is a farm management strategy with a goal of multi-year crop growth stability. Precision agriculture employs the techniques to improve the production and its quality. Precision farming becomes more and more an accepted way of crop production in India and helps to achieve a sustainable environmentally friendly agriculture. The benefit and effectiveness of using precision farming techniques is highly dependent on the capabilities of the utilized technology. Thus, the emerging techniques of Precision Agriculture are used. Farmers should be encouraged by fostering their knowledge, technology, networking, and information access in order to prepare them as modern agricultural actors in the 21st century. It is being suggested by most of the authors to adopt the remote sensing network for Precision Agriculture.

Keywords*: Precision agriculture; precision farming; remote sensing; sustainable*

1. INTRODUCTION

India's 55% population depends on agriculture for its livelihood and this percentage may keep decrease in upcoming future because of less productivity, continuously decreasing farm field size, various crops diseases, unpredictable natural disasters etc. Non-availability of skilled labour, increase in labour wages makes conditions worse. Keeping in mind the ICAR vision 2020 - "To harness science to ensure comprehensive and sustained physical, economic and ecological access to food and livelihood security to all Indians, through assessment, refinement, generation and adoption of appropriate technologies." Currently, India is moving towards precise agriculture. [1]. 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 the implementation of advanced information technologies. 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 [2]. Precision Farming Technology can cover a huge scale of farm land by the support of using satellite. Farm field considered is divided into many small meshes and the various data for each mesh such as soil fertility, moisture content, yield, and etc. are measured, collected and installed as the database in geographical information system (GIS). Global positioning system (GPS) is also used to identify the exact location of both machines and farm field for giving the suitable treatment and operation to meet the condition obtained as the database in geographical information system (GIS). As the various kinds of operation can be given based on the data obtained from the measurement, more precise control and necessary treatments such as fertilizer, herbicide and pesticide applications are applied timely to each area of mesh accurately with suitable amount. This farming method leads not only to the saving of material resources and energy in operation, but also to the control to jeopardize the environment 3[]. Precision farming requires some degree of competence in the use of software and hardware on the part of growers and/or crop consultants. Indeed, the success of precision farming largely depends on creation of management systems, which will involve some combination of computerized decision support systems and the wisdom of farmers. Growers will adopt information technologies only if they are reliable and easy to use, offer some competitive advantage and can be introduced into farming without too much difficulty or expense [4]. The main aim behind introducing this is increasing agricultural profit with minimum inputs, reducing wastage of fertilizers, herbicides &man power. In this method of farming, advanced and updated technologies such as GPS, stereo vision cameras, remote sensing are introduced to make it more precise and productive.

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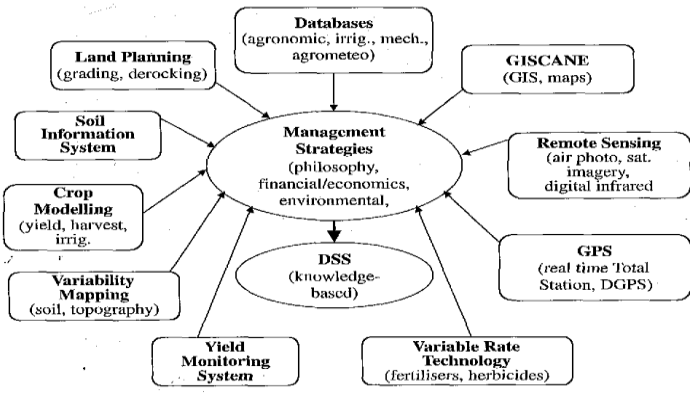

Fig.1 Components of Precision Agriculture

2. NEED FOR PRECISION AGRICULTURE IN INDIA

India is by large an agricultural economy. And it falls within top 10 ranks in the total production of most crops, however, India's productivity ranking is very poor and is not even in the top 50 in many crops. A report by the Australian department of agriculture's research centre, Abares, indicates that the demand for agri-foods in India will surge by 136% by 2050. With such a gigantic quantum of food grain to be produced, can existing agricultural techniques meet the requirement? Realizing the inadequacy of existing farming management techniques, farmers are now getting inclined towards techniques which are more advanced as well as cost-efficient Precision Agriculture (PA) is one technique to directly influence crop productivity and farmers' income. It is the practice of customizing the crop inputs applied on a farm to smaller patches within the farm land depending on the agronomic characteristics and resource needs of that particular patch of land at that particular time [5]. Although the Indian government designed and implemented various schemes for making agriculture more sustainable, more productive and climate-resilient and remunerative by introducing a golden fusion of information technology and space technology (satellite). This technology mainly focused on soil and conservation measures, efficient water resource management, efficiently predicting upcoming disasters. Still as compare to developed nations India's agriculture production is still low.

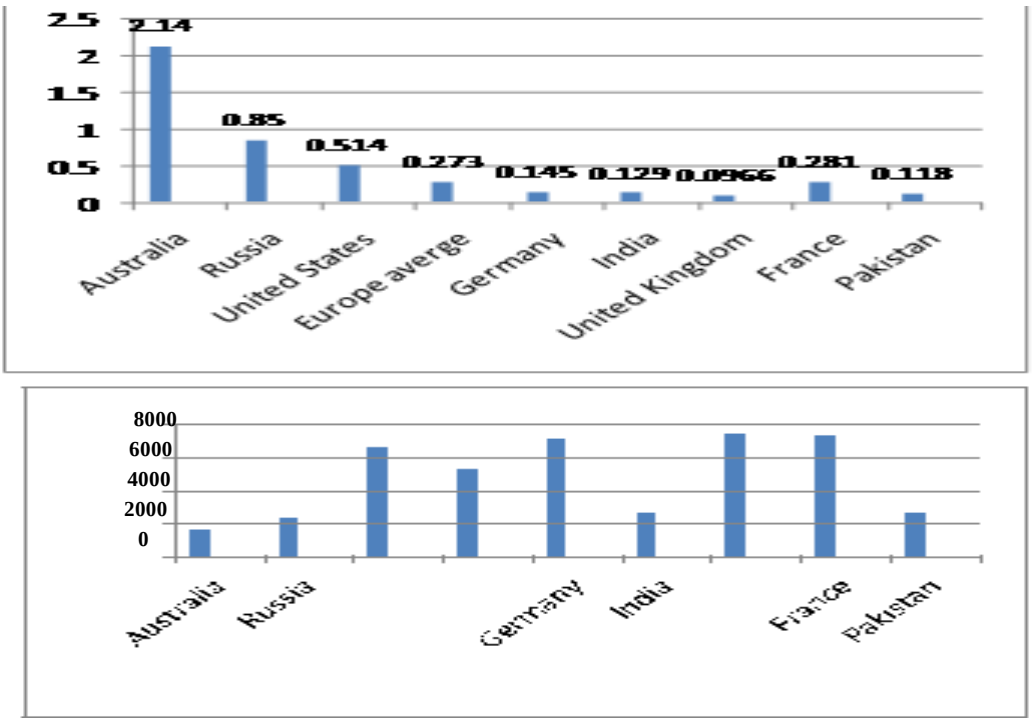

Fig. 2. Comparison between countries based on land distribution and production [6]

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The Bar graphs above show a comparison between various countries based on land distribution in terms of a hectare per capita and production in Kg per hectare. From the data above it is clear that developed countries lead production capability because of precision agriculture whereas India lagging because of conventional approach it made in agriculture. Hence India needs to move towards precision agriculture. PA as technology should be developed immediately in India in order to give more opportunities for more precise treatment toward every parts of land, so that it can increase the productivity level by increasing the product result, pressing the production cost and reducing the environmental effect. The implementation of this technology considers land, social, and cultural factors including its local wisdom, and also farming benefits but it is still concerned with the land conservation. Thus, the implementation of this technology is expected to be able to fulfil the balance of three integrated subject, which are [7]:

a. Sustainable economic development through the addition of food product value and the increase of food product output.
b. Social justice through the equality of rights and opportunities to access efficient technology in the food production system.
c. Environmental conservation especially natural resources conservation which means to conserve land by preserving its fertility.

3. CONVENTIONAL AND PRECISION AGRICULTURE

Conventional agriculture vs Precision Agriculture

Conventional Agriculture	Precision Agriculture
Choose a good location	
Manually	Using drones and GPS
Soil Preparation	
Adding chemicals based on previous experience	Using sensors like temperature sensor, Humidity Sensor, Volatile matter sensor etc.
Field preparation (Ploughing and planking)	
Using tractors and bullocks	Agricultural robot for automatic ploughing
Seeding and planting	
Manually using hand tools	Precision drills, Broadcast seeders, Seed drills, Air seeders
Watering	
Drip Irrigation	Drip Irrigation using Internet of Things
Fertilizer and Pesticide application	
Hand spray and manually	UAVs and UGVs, Sprayers, GPS, Smartphone Applications, and Remote sensing
Weed removal	
Using hand tools	Blue River Technology and Naio Technologies Weeding Robot Oz
Harvesting	
Manual picking	Robotic pick and place arm, Mechanical harvesting, limb shaker, canopy shaker, Abscission Chemical

4. PRESENT SCENARIO OF PRECISION AGRICULTURE IN INDIA

Precision Agriculture is a management concept of farming idea which is based monitoring, measuring and responding to identify, analyse and manage spatial and temporal variability within inter and intra-field for optimum production and profitability, sustainability and preservation of agricultural land resource optimizing production costs. [8]. Though a proven concept, it is mostly restricted to some of the developed countries such as Europe and America and except for a few, very less literature is available in Indian context. The research for precision farming has already started in India, in many research institutes. Indian Space Application Centre (ISRO), Ahmedabad has begun research in the Central Potato Research Station farm at Jalandhar, Punjab to analyse the role of remote sensing in mapping the variations of output with respect to space and time. M S Swaminathan research Foundation, Chennai, in a joint effort with NABARD, has adopted a small village in Dindigul region of Tamil Nadu for variable rate input application. Indian Agricultural Research Organization has attracted made up a long-term plan to do precision farming research in the institute ‘s farm. Project Directorate for Cropping Systems Research (PDCSR), Modipuram and Meerut (UP) in alliance with Central Institute of Agricultural

Engineering (CIAE), Bhopal likewise initiated variable rate input application in various cropping systems. [9] Considering all these efforts and research in precision farming in India, next couple of years may help the Indian farmers to leverage the data analytics in field of agriculture without compromising the quality of land.

5. TECHNOLOGIES FOR PRECISION AGRICULTURE

A. Global Positioning System (GPS)

GPS provides continuous position information in real time, 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. GPS receiver with electronic yield monitors generally used to collect yield data across the land in precise way. Global positioning systems (GPS) are widely available in the agricultural community. Farm uses include: mapping yields (GPS + combine yield monitor), variable rate planting (GPS + variable rate planting system), variable rate lime and fertilizer application (GPS + variable rate controller), field mapping for records and insurance purposes (GPS + mapping software), and parallel swathing (GPS + navigation tool) [10].

B. Geographic Information System (GIS)

GIS 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, understand the relationships between the various elements affecting a crop on a specific site [11]. 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.

C. Remote Sensing

Remotely sensed data, obtained either by aircraft or satellite, containing electromagnetic emittance and reflectance data of crop can provide information useful for soil condition, plant growth, weed infestation etc. This type of information is cost effective and can be very useful for site-specific crop management programs [12]. It is a useful technology for precision agriculture as it can give data for parameters of the field relatively easily. In general, we see the reflected sun light that is formed by the ultraviolet wave lengths, the visible light (Red, Green and Blue) and the infrared. The green plants are absorbing the red and blue wave lengths and reflect the green and the infrared. Measuring the reflected wavelengths with multi spectral cameras we can measure the vigour of the plants or any problem like disease, nutrient deficiency or water logging etc. We can correlate soil colour to the organic matter, moisture etc. Light reflectance (sun or some artificial light source) has been used in precision agriculture in the form of vegetation indices. For this kind of study, geographic information systems (GIS) are highly suitable. They have evolved largely by innovations created in one application of GIS being shared and built upon in subsequent applications [13]. GIS have become highly important tools for natural resource research and management [14]. GIS has been popularly applied in agriculture, such as groundwater recharge estimation and regionalization [15], regional distribution maps for heavy metals [16], scheduling and monitoring of irrigation delivery for rice irrigation systems [17].

D. 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.

E. Variable Rate Applicator

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. The computer uses the application map and a GPS receiver to direct a product-delivery controller that changes the amount and/or kind of product, according to the application map, e.g. Combine harvesters with yield monitors. Here 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 maps.

F. 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.

G. 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 [18]. 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 yield maps and fertilizer companies provide software to generate variable rate applications maps. Some of the packages are very complicated for farmers to use and they are fairly expensive, while some others are considerably simpler and cheaper with fewer options. The packages are more user-friendly still problems related to data transfer between farmers, and between farmer, co-op and consultant. To overlay maps, mainly soil and yield maps, is also a difficult task so far.

H. 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.

6. FUTURE STRATEGY FOR PRECISION AGRICULTURE

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. Data on crop yield, soil variables, weather and other characteristics are collected and mapped in the exploratory stage, which is important for increasing the awareness among farmers of long-term benefits. The approaches to data collection and mapping must, therefore, reflect local needs and resources. Future strategy for adoption of precision agriculture in India should consider the problem of land fragmentation, lack of highly sophisticated technical centres for precision agriculture, specific software for precision agriculture, poor economic condition of general Indian farmer etc. precision agriculture in small farms is that individual farms will be treated as if they were management zones within a field and that some centralized entity will provide information to the individual farmers on a co-operative basis[19]. The problem of high cost of positioning system for small fields can be solved by 'dead reckoning system'. The dead reckoning system, suitable for small regularly shaped fields, relies on infield markers, such as foam to maintain consistent application [20]. This approach provided farmers with a robust and credible method for making decisions about spatial management of their fields [21]. Nature of crop and weed vary from zone to zone, country to country. So, development of software and hardware for crop and weeds of India, site specific tillage technique, etc. should be started and these packages will be used for precision agriculture. not only suitable for developed countries but also for developing countries, if applied properly and has a wider impact in farm management through more efficient machinery management. Almost centuries Indian farmers follow a group of prescribed manuals or guideless during fertilizer application and spraying. The local Agri university or research agencies give farmers data on the dosage and mode of application which is common to all or any farms and farmers. The evolution of crop sensors goes to vary in this scenario. Sensors tomorrow are getting to provide site-specific information on the precise amount of nutrient required for a farm. This will save tons of fertilizers and also conserve valuable soil resources. Skyscrapers in agriculture will be the longer-term goals in increasing farm output per area. With draining soil fertility levels and increasing urbanization, land for farming tomorrow is going to be costlier than before. This means that food goes to be costlier and not affordable to folk. To avoid this example, the vertically farming technique using soil- less medium and using artificial lights are the longer-term solutions. This technique will reduce cost, produce more, protect crops from inclemency and ultimately produce food which is safe and healthier. Robotic Swarms think of numerous agribots loaded with sensors collecting real-time information in the fields. The data recorded and shared to the cloud, analysed and automatic reports are generated in terms of excess moisture, nutrient deficiency and many more insights of the farm. This idea is already in use in Israel farm to increase productivity. An international firm called FENDT is currently working on a project called MARS Mobile Agricultural Robot Swarms. It is research in the field of agricultural robotics funded by the European Union. Big data in farming in the form of Storing and analysing tons of data will help in making real-time decisions quickly and with greater accuracy and precision. Feedback on various plants such as their height colour and diseases and their life span will help to increase productivity in a particular farm or field or area. Using the above-mentioned technologies in Indian agriculture within affordable price will boost the Indian agricultural revenue. The above technologies are expected to be utilized on a large scale in India by farmers by 2022.

7. CONCLUSION

The interest in precision Agriculture and its introduction has resulted in a gap between the technological capabilities and scientific understanding of the relationship between the input supplies and output products. Agriculture, the dynamic system governed by several biotic and abiotic factors, needs to be sustained, as it is the major player in Indian economy. Though we are self-sufficient in food grain production, there are several Gray areas which need to be improved for achieving ever-green revolution. There is a need to transform low-yielding food production systems in to high yielding ones through the convergences of aggrotech (mainly production related), biotech (productivity related) with space technology (RS and GIS). Crop genetic manipulation-in the interests of growth efficiency; stress tolerance and food quality for human and animal nuüffon will require physical or chemical sensors to monitor microclimate and pest infestation, possibly augmented by indicator plants. These plants would be genetically tailored to signal Changes in their environment in ways that could be monitored in real-time (in other words, an extension of the speaking plant concept). They would provide inputs to management models. Improved growth efficiency could lead to more precise control of crop inputs, in association with detailed terrain mapping, linked to position sensing [22]. It is predicted that the coming decade will feature multidisciplina1Y research teams of scientists and engineers, working on new materials, biosensors, bioelectronics and micro-electro-mechanical systems [23]. Translation of remote sensing data, GIS techniques and precision farming database information in to implementable schemes at the field level and absorption of technology at the grass root level by the actual beneficiaries still remains a greater challenge. These technologies should infiltrate in to agricultural sector at micro level for greater and sustainable benefits.

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