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Precision Agriculture: The Only Way Forward

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Introduction

Agricultural production system is an outcome of a complex interaction of seed, soil, water and agrochemicals. Therefore, judicious management of all the inputs is essential for the sustainability of such a complex system. Enhancing the productivity without proper management of inputs has resulted into environmental degradation. The problem can be solved only through maximizing the input use efficiency. Precision agriculture is referred as satellite farming, 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 instead of managing an entire field based on hypothetical value and adjusts management actions accordingly. In many developing countries the promotion of rapid adoption for precision agriculture concept is still required. Successful adoption of precision agriculture comprises three phases *viz.* exploration, analysis and execution. The success of precision agriculture depends on how well and how quickly the new technologies can be generated, adapted and up scaled. Ultimately, precision agriculture is 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. It includes describing and modeling the variation in soil-plant system and integrating agricultural practices to meet site specific requirements. It is a system approach to the agriculture farming efficiency for holistic development. The potential of precision agriculture for economical and environmental benefits could be visualized through efficient use of water, fertilizers, herbicides and pesticides besides the farm equipments.

Technologies for precision agriculture:

To collect the maximum benefits, modern technological tools including hardware, software and best management practices should be utilized effectively. These tools include the following technologies:

Global positioning system (GPS) receivers

The GPS receivers compute the location of samples with the help of signals broadcasted by GPS satellites. The GPS receivers carried to the field or mounted on

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implements allow to be returned to the specific locations of sample. Uncorrected GPS signals have an accuracy of about 300 feet. For application in agriculture, the uncorrected GPS signals must be compared to a land based or satellite based signal that provides a position correction. For using GPS receiver, type of differential correction and its coverage area should be considered.

Yield monitoring and mapping

Yield monitoring is an important base for making management decisions. Impact of soil, land, environmental factors and inputs like fertilizer, seed, pesticides, cultural and irrigation practices should be taken care for interpretation of yield map. Yield monitors linked with a GPS receiver can provide the necessary data for yield maps. Yield maps should be prepared using yield data of several years instead of single year to eliminate the weather effect.

Grid soil sampling and variable rate fertilizer (VRT) application

As per Soil Health Mission of Govt. of India, under normal conditions, one representative sample is collected from 2.5 and 10 ha area in irrigated and rainfed condition, respectively. Fertilizer recommendation is made on the basis of these respective soil test results. In grid sampling, principle of soil sampling remains same but number of samples collected is increased. The purpose of grid sampling is to generate an application map of nutrient requirement for each soil sample. This application map is loaded into a computer mounted on variable rate fertilizer spreader. The computer uses the application map and GPS receiver to direct a product delivery controller that changes the amount or kind of fertilizer according to the application map.

Remote sensing

Remote sensing is collection of data from some distance using data sensors mounted on aircraft or satellite. This data provides a tool for evaluating crop health, plant stress due to moisture, nutrients and diseases etc. Remotely sensed images help to determine the location and extent of crop stress. This technique can reveal in-season variability that effects crop yields and help to take timely management decisions that increases profitability.

Crop scouting

In season observations of crop conditions may include weed or insect infestation; nutrient stress; flooded and eroded areas. Using a GPS receiver on all-terrain vehicle or in a backpack, observations can be recorded along with location, making it easier to return to the

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same location for treatment. These observations can also be helpful for explaining the variations in yield maps.

Geographic information systems (GIS)

Geographic information systems are computer hardware and software that use feature attributes and location data to produce maps. An agricultural GIS is used to store information about yield, soil survey maps, remotely sensed data, crop scouting reports and soil nutrient levels etc. The GIS can also be used to evaluate present and alternative management by combining and manipulating data layers.

Site specific nutrient management (SSNM)

About 85% of Indian farmers belong to small and marginal category with farm holdings less than 2 ha. So, it is advised to go for balanced fertilization based on soil test report or Soil Health Card. Site-specific management fine-tune the crop management systems using 4R nutrient stewardship: the right source, rate, time and place of nutrient. Implementation of SSNM becomes easy by using the soil fertility status information. This concept is beneficial to accrual in soil fertility and its health because SSNM relies to feed the crop as and when required.

Customized fertilizer

Soils vary in their fertility status from location to location as well as individual farmers' management level. Thus, customized fertilizer application can provide larger economic returns with negligible higher investment and minimizing the unwanted impacts on the environment and human health. There are about 36 customized formulations approved by Fertilizer Control Order of India. Due to vast variety of crops grown in India, making customized fertilizer available at local level is a formidable task. But such smart fertilizers could circumvent the problems of over and under usage of agricultural inputs.

Soil nutrient management

Soil nutrient information of any field shows the existence of significant nutrient variability within the area. Use of GIS technologies can simplify and assist in dealing with soil variability. Advanced GIS soil sampling and soil nutrient management will lead to increased yields, reduced fertilizer costs and better management of the environmental impact of intensive agriculture practices. In a specific situation, it may not have a great impact on amounts of inputs but it has the potential to improve the efficiency, increase productivity and reduce adverse impacts on soil. As per today's need, it is not good to depend on soil sampling

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only for improved fertilizer inputs due to costs and technical challenges. It becomes necessary to combine a variety of techniques such as soil sampling, remote sensing, soil pH and EC together with expert knowledge in order to find correlations among them. If significant correlation is found among these factors, it would be possible to use less costly and time saving methods for improved and site specific soil nutrient management.

Nano technology applications

Nanotechnology provides more effective way of environment detection, sensing and bioremediation. This technology enhances agricultural productivity by following ways:

- Nanoporous zeolites for controlled and efficient release of water and nutrients/fertilizer etc.
- Nanocapsules for delivering herbicide, pesticides and agrochemicals
- Nanosensors for detecting aquatic toxins and pests
- Nanoscale biopolymers based nanoparticles may be used in disinfection and recycling of heavy metals
- Nano structured metals can be explored for decomposition of harmful organics
- Smart particles can be useful in environmental monitoring and purification processes
- Nanoparticles can be used as novel photocatalyst
- Waste water treatment

Robotics in agriculture

In developed countries farmers are suffering from lack of workforce. This problem can be solved using robotics and advanced sensing. Robots can assess the areas where other machine cannot reach. Some companies offer combined packages of robotic hardware and software analysis. Ground based robots can provide even more detailed monitoring because they can get closer to the crops. Other robots can also be used for weeding and fertilizer applications.

Precision livestock farming (PLF)

Precision farming is not confined to crop production only. Precision livestock farming approach focuses on monitoring of each of animals in a farm. Farmers can be familiar when number of animals is low, but with increased number, it becomes impossible manually. With automation, it is possible to develop a data for each animal about various attributes like pedigree, age, reproduction, growth, health, feed conversion, meat quality etc. and have it on

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an electronic ID tag. This would lead to high quality and safe food, efficient healthy and sustainable animal farming with low environmental footprints.

Precision agriculture involves the usage of crop inputs like fertilizers, pesticides, tillage and irrigation water etc. more effectively without polluting the environment. However, it has proven difficult to determine the cost benefits of precision agriculture management. The success of precision agriculture depends on how well and how quickly the knowledge needed can be generated and implemented on farmers' fields. To promote precision agriculture at farm level the following approaches should be adopted by the policy makers:

- Promote precision agriculture technology for specific progressive farmers who have sufficient risk bearing capacity because this technology may require huge investment
- Adopt water saving techniques
- Provide complete technical backup support to the farmers to develop pilots or models, which can be further scaled up
- Develop policy for efficient transfer of advanced technology to the farmers

Efficient use of inputs under precision agriculture could lead to enhance income, improve soil health, safeguarding of environment as well as saving of resources.