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A Study on Precision Agriculture and Its Technologies

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ABSTRACT

Precision agriculture or satellite farming or site specific crop management is a farming management concept based on observing, measuring and responding to inter and intra-field variability in crops. Based on the analysis of the development of agricultural mechanization, the trend of agricultural service system reform, agricultural environment protection and the development of information technology, it is possible to realize the precision agriculture. The goal is to ensure profitability, sustainability and protection of the environment. The approach is also known as satellite agriculture, as-needed farming and site-specific crop management.

Keywords: Precision Agriculture, Site Specific Crop Management, Global Positioning System

I. INTRODUCTION

Agriculture is the science, art and business of growing crops and raising animals for food, medicine, fiber, timber and various industrial products. In addition, it involves preparation, value adding and marketing of the resulting products to generate income.

Over the past few decades, as larger and faster farm machines have delivered the capability to manage ever-expanding farms, farmers have for the most part continued to treat large fields as uniform elements. Attitudes have been changing in the past several years, though, and a new method of farming called precision agriculture is rapidly emerging. Based on what are called "site-specific" methods, precision agriculture involves studying and managing variations within fields that can affect crop yield. It revolves around the idea that treating a large region as a uniform area is essentially wasteful and uses an excess of costly resources in the form of fertilizers, pesticides, and herbicides.

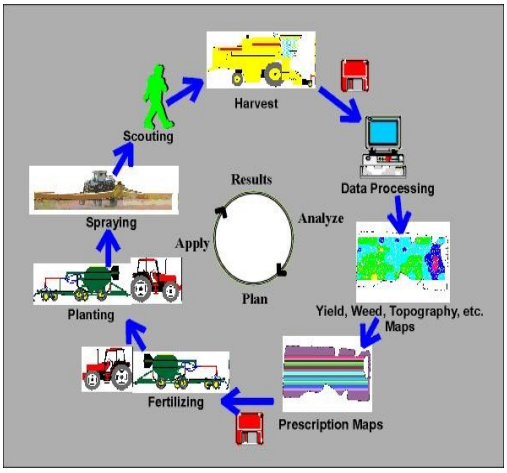

Figure 1. Precision in Agriculture cycle

Precision agriculture is a method of farm management that allows the farmer to produce more efficiently, thereby realizing gains through economical use of resources. An important effect of precision farming is the high environmental benefit from using chemical treatments only where and when they are necessary. This promotion of environmental stewardship is a key component of the new attitudes in agriculture.

II. METHODS AND MATERIAL

1. SITE-SPECIFIC

Site-specific is a term that refers to treating the smallest possible area as a single element. For

instance, rather than treating a whole field with herbicide because of a few isolated weed infestations, site-specific management calls for treatment of only those areas. A site is simply the smallest unit the farmer can manage with the tools available, whether that is a 100 square foot area or an individual plant. The treatment of each site is specific to the needs of each site, as determined by soil test data and crop scouting reports. The implementation of the GPS has enabled farmers to accurately map their fields and narrow down their site size to only a few meters area. With current computing capabilities, a field could be broken up into a grid of hundreds of separately manageable units. However, depending on field size and testing budget considerations, grid squares of an acre or two are common these days.

2. Global Positioning System

GPS-based applications in precision farming are being used for farm planning, field mapping, soil sampling, tractor guidance, crop scouting, variable rate applications, and yield mapping. GPS allows farmers to work during low visibility field conditions such as rain, dust, fog, and darkness. Precision agriculture is gaining in popularity largely due to the introduction of high technology tools into the agricultural community that are more accurate, cost effective, and user friendly. Many of the new innovations rely on the integration of on-board computers, data collection sensors, and GPS time and position reference systems. Through the use of GPS, geographic information systems (GIS), and remote sensing, information needed for improving land and water use can be collected. Farmers can achieve additional benefits by combining better utilization of fertilizers and other soil amendments, determining the economic threshold for treating pest and weed infestations, and protecting the natural resources for future use.

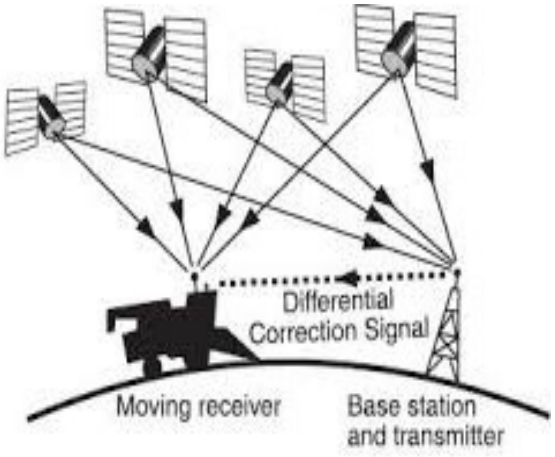

Figure 2 : Real-time differential GPS

We started using more digital technology in the last 10 years. We have gone to GPS (Global Positioning System) for a handful of different operations from cultivating to planting. By using GPS on the tractors, the entire process from levelling the field to planting the seed to irrigating the crop has been much more efficient than in the past. GPS is used in a lot of applications throughout most aspects of agriculture.

GPS equipment manufacturers have developed several tools to help farmers and agribusinesses become more productive and efficient in their precision farming activities. Today, many farmers use GPS-derived products to enhance operations in their farming businesses. Location information is collected by GPS receivers for mapping field boundaries, roads, irrigation systems, and problem areas in crops such as weeds or disease. The accuracy of GPS allows farmers to create farm maps with precise acreage for field areas, road locations and distances between points of interest. GPS allows farmers to accurately navigate to specific locations in the field, year after year, to collect soil samples or monitor crop conditions.

3. Steps in The Precision Agriculture

Precision agriculture is a cyclic process, of course, but a farmer can get started on site-specific farming at just about any time of the year. Generally, farmers need to perform annual planning, data collection, and analysing steps to complete the precision agriculture cycle.

- Before Planting - perform soil testing, then data analysis to determine spatial variations in soil

conditions that call for a variety of treatments or planting methods.

- In the Growing Season - begin by planting with variable seeding rates across the field, and use variable rate application (VRA) of fertilizers as determined by soil test data. Crop scouting is done to search for problems such as weeds, pests, or diseases. Findings determine whether further VRA of chemical treatments or other actions are warranted.
- During the Harvest - as the crop is harvested, a yield monitor in the combine logs geo-referenced yield data to be analysed and mapped across the field. Variable yield results across the field can help the farmer discover if his management methods have been successful, and determine how to proceed in the next season.

4. Methods in Modern Agriculture

Today's farmer depends on outside sources for some information, such as soil data. Testing laboratories can run soil assays for nitrogen, phosphorus, potassium, and other nutrients. There are various methods of sample point selection available to the farmer, and a sampling grid can be obtained from a GIS.

A. Planting

In precision agriculture, crops are planted at variable rates as determined from prior knowledge about field conditions and soil test data. Today's planting equipment can be programmed to deliver variable seeding rates; rate changes are determined and programmed by the farmer. What is planted is also of critical importance, and the explosion in development of genetically enhanced crops offers farmers an impressive advantage in choosing hardy, high-yield varieties.

B. Crop Scouting

As crops grow, observations must be carefully documented about any developing problems in the field. Although crop scouting is nothing new, today's crop scouts can enter their observations into a GIS, linked to the precise location of the problem via GPS data, and the information can be analysed by comparison to other data in the GIS. Among the modern crop scout's field tools are the GPS receiver and a laptop computer. With the advent of video mapping, any untrained person can record field conditions to be reviewed by experts later. Other methods of identifying problems in a field include aerial or satellite remote sensing. Presently these methods can be cost-prohibitive and have a high turnaround time.

C. Variable Rate Chemical Application

VRT (variable rate technology) and VRA (variable rate application) refers to the development of automated variable rate sprayers, which are an extremely important tool in precision agriculture. Where the practice of whole-field application of chemicals has been replaced by site-specific treatments, sprayers capable of variable rate applications are essential. These machines are programmed to deliver precisely the right amount of chemicals necessary across a field, after input from crop scouting and analyzing the variability of field conditions. This element in the precision agricultural system is greatly responsible for lowering cost of input and decreasing environmental impact, through the automated application of the least amount of chemicals necessary.

5. Yield Monitors

The traditional method of monitoring yield by weighing harvested batches of crops is giving way to the precision agriculture method of instantaneous yield monitoring. The modern yield monitor utilizes sensors in the combine to continuously log grain flow rate during harvesting, and the combine's speed. This data, combined with the GPS location for each data point, allows the creation of a yield map within a GIS. The yield map is a visual tool farmer and crop consultants can compare to maps of soil test data, chemical application maps, and other information, resulting in a recommendation for the next year's site-specific management plan. When layered in a GIS with associated maps, a yield map displays evidence of relationships between crop yield and field condition variables.

III. RESULTS AND DISCUSSION

1. Precision Maps

Precision maps are an extremely useful tool in precision agriculture and are becoming more and more commonly

used in the agriculture industry. Precision maps assist farmers by showing them precise locations in the field and providing them specific information about that location.

Precision maps work by using a variety of different physical sensors along with GPS information to analyze variables such crop or soil moisture, crop yield, and more. The benefit of precision maps is a farmer can use this type of information to accurately locate areas of need, low crop yield or low moisture levels, and react accordingly. Precision maps can help to save farmers money by preventing overspray, if a farmer utilizes precision maps, he or she will be able to mitigate their spraying by only spraying pesticides, fertilizers or replanting seeds in areas of need; this helps to not only save the farmer money, but also aids the environment.

2. Types of Precision Maps

A. Soil Maps

Soil Maps can be collected in a variety of different ways, although geo-referenced soil maps are collected in different methods. One method is to divide the field into a grid pattern and sample each individual grid block, the more grid blocks and samples, the more accurate soil map you will have. Another method is to take samples of the field in zones that are designated by previous information such as yield maps, topography or other precision maps. In both of these examples, all of the soil samples are geo-referenced - which means that the location of the sample is recorded. This is so that specific samples can represent soil fertility levels in any particular zone of the field.

B. Yield Maps

A yield map is a map that focuses on crop yield - for example, how much more fruitful one area of the field is in comparison to another. This map is used as a visual tool and can help to show farmers relationships between crop yield and field condition variables. A yield map is best utilized when layered with many different types of maps so that it can accurately show farmers a variety of different information that is supported by other sources. Similar to soil maps and many other different types of precision maps, yield maps can be used alongside other technologies like variable rate technologies (VRT) to help aid farmers even more as they harvest, or spread seed, fertilizer or apply pesticides.

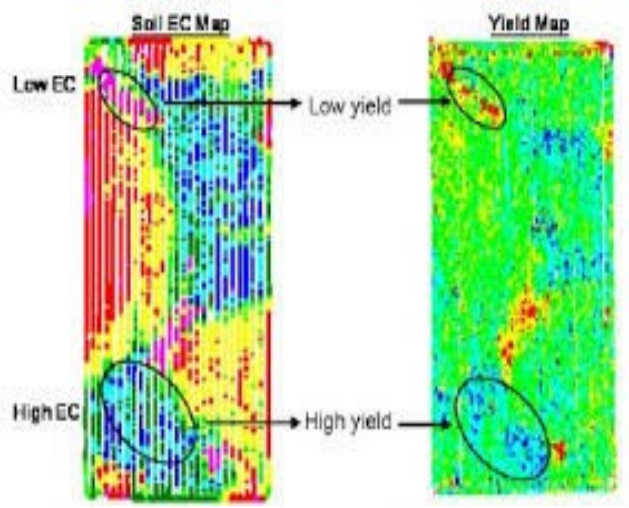

Figure 3. Soil and Yield Map

IV. CONCLUSION

Precision agriculture is an art and science of utilizing innovation, site-specific techniques for management of spatial and temporal variability using affordable technologies. It uses specialized equipment, software and services. Processes include accessing real-time data about the conditions of the crops, soil and ambient air, along with other relevant information such as hyper-local weather predictions and labour costs and availability.

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