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Precision Agriculture

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Precision agriculture (PA) is an approach to farm management that uses information technology (IT) to ensure that crops and soil receive exactly what they need for optimum health and productivity. The goal of PA is to ensure profitability, sustainability and protection of the environment. PA is also known as satellite agriculture, as-needed farming and site-specific crop management (SSCM).

Precision agriculture relies upon specialized equipment, software and IT services. The approach includes 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, labour costs and equipment availability. Predictive analytics software uses the data to provide farmers with guidance about crop rotation, optimal planting times, harvesting times and soil management.

Sensors in fields measure the moisture content and temperature of the soil and surrounding air. Satellites and robotic drones provide farmers with real-time images of individual plants. Information from those images can be processed and integrated with sensor and other data to yield guidance for immediate and future decisions, such as precisely what fields to water and when or where to plant a particular crop.

In the past, precision agriculture was limited to larger operations which could support the IT infrastructure and other technology resources required to fully implement and benefit from the benefits of precision agriculture. Today, however, Mobile apps, smart sensors, drones and cloud computing makes precision agriculture possible for farming cooperatives and even small family farms.

Agriculture production systems have benefited from incorporation of technological advances primarily developed for other industries. The industrial age brought mechanization and synthesized fertilizers to agriculture. The technology age offered genetic engineering and automation. The information age brings the potential for integrating the technological advances into precision agriculture (PA).

Equipment, methods, and technology supporting precision agriculture

Auto-steer: A GPS guidance system that steers agricultural equipment with centimetre accuracy. This level of accuracy requires real time kinematic (RTK) correction of GPS signals. Auto-steer is an add-on component for equipment. It includes both the GPS system to receive and process the signals, software and hardware to allow the input of control maps and the mechanical equipment to actually steer the tractor. Some new tractors are available "auto-steer ready."

Light bar guidance systems: A GPS guidance system mounted in the cab of agricultural equipment that provides direction to the driver by means of a horizontal display of lights a series of lights enables the operator to align the tractor with the next set of rows requiring treatment to prevent overapplication of nutrients or pesticides. Newer models can provide some auto-steer functions. Light bars are less accurate than RTK auto-steer systems and are generally used for spreading or spraying applications. Light bar technology is relatively inexpensive and can quickly have an environmental payoff.

Differential GPS: A generic term for the process to improve the positional accuracy of satellite broadcast GPS signals. Differential GPS (DGPS) requires that a GPS receiver be set up on a precisely known location. This GPS receiver is the base or reference station. The base station receiver calculates its position based on satellite signals and compares this location to the known location. The difference is applied to the GPS data recorded by the second GPS receiver, which is known as the roving receiver.

Commercial differential GPS: Commercially available DGPS signals. These signals are available from several companies that provide a wide-area DGPS service using satellite broadcast techniques. Data from many widely spaced reference stations are used to achieve sub-meter positioning. The signal is proprietary and users are charged a fee.

Nationwide differential GPS: A system operated by the U.S. Coast Guard using 37 ground stations that provide GPS signal corrections to provide better position accuracy. Nationwide differential GPS (NDGPS) service is provided for the coastal continental United States, the Great Lakes, Puerto Rico, portions of Alaska and Hawaii, and a greater part of the Mississippi River Basin. NDGPS provides accurate dynamic navigation information with 1-meter accuracy (accuracy deteriorates as the distance to the ground station increases). There is no charge for this service.

Wide area augmentation system: A system of satellites and ground stations that provide GPS signal corrections to provide better position accuracy. A WAAS-capable receiver can give a position accuracy of better than 3 meters 95 percent of the time. WAAS is operated by the Federal Aviation Administration. This signal is available without charge.

Real time kinematic: A process to produce very accurate locations from GPS signals. RTK is currently the most accurate and most expensive commercially available GPS system. RTK systems use a single base station receiver and one or more mobile units. The base station can be a temporary base station set up by farmers for their own use or permanent station set up to broadcast a signal for general-purpose use.

The building blocks of a precision agriculture

The starting point for developing a precision agriculture plan may be different depending upon the results a farmer is trying to achieve. However, in general, to be successful with precision agriculture from both an economic perspective and environmental perspective, a farmer should have the following basic components:

- background data
- a recordkeeping system
- analysis and decision-making process
- specialized implementation equipment
- evaluation and revision

A recordkeeping system is very important for successful implementation of precision agriculture. Precision agriculture can produce large amounts of data. If the farmer does not have a way to organize and process the data, it will become overwhelming and meaningless. Commercial software packages can help with this task by producing maps that allow the farmer to see differences within fields.

Steps for the environmental focus of precision agriculture

1. Identify a resource concern for which precision agriculture techniques can have a positive impact. Identify the precision agriculture techniques that can be used to address the resource concern. Determine which techniques have the most positive effect on the resource concern and can be used by farmers.

2. Identify background data that is needed to address the resource concern. Consider the difficulty of collecting the data and whether the farmer can collect the data independently or if a consultant is needed. Determine if specialized equipment is needed and available to collect the data. Consider the use and value of data, records, or other information the farmer collects for other purposes.
3. Determine if the farmer has an appropriate method to keep track of geospatial data. The farmer needs to develop or acquire a recordkeeping system or hire a consultant to organize data so that it can be analyzed.
4. Develop a plan for how precision agriculture will be used to address the resource concern. Analysis of the background data is required. A consultant might be needed to analyze the data and develop a farm-specific plan to address the resource concern using precision agriculture.
5. Determine the type and availability of specialized equipment required to implement the plan. This might include an auto-steer tractor, a light bar guidance system, variable rate application equipment, a yield monitor, or other equipment.
6. Evaluate and revise the plan after each cropping season.

The benefits of precision agriculture

The primary benefits from precision agriculture, both economic and environmental, result from reduced or targeted placement of crop inputs such as nutrients, pesticides and water. There are many other benefits.

1. Precise nutrient applications
2. Grid soil sampling—over time, as more information is learned about a field, grid sampling can evolve into sampling of similar zones to reduce the number of samples taken.
3. Yield monitoring—knowing how much different areas of a field actually yield provides perhaps the most important clue about potential and appropriate application rates.
4. Detailed soils information—knowing the properties of the soils in a field provides important information about yield potential and environmental sensitivity.
5. Remote sensing—new technologies will use aerial photography to identify in-season nutrient deficiencies and other problems causing crop stress and reduced yield.
6. Environmentally sensitive areas—georeferenced the location of waterways, streams, ditches, wetlands, high leach potential soils, and tile inlets can help protect these areas from over application of nutrients.
7. Precise pesticide applications can provide both environmental and economic benefits. One of the quickest and least expensive environmental payoffs for pesticide applications is the use of light bar guidance systems.
8. Remote sensing—new technology promises to identify in-season insect damage from aerial photography.
9. Detailed soils information—knowing the properties of the soils in a field will provide important information about yield potential and environmental sensitivity. County soils maps, while helpful, generally do not provide the necessary level of detail.
10. Variable rate irrigation is an emerging technology that is being used in conjunction with canter pivot irrigation systems.