Precision Farming in New Mexico: Enhancing the Economic Health of Agriculture

Cooperative Extension Service
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What is in this Guide

AGRICULTURE'S ROLE IN NEW MEXICO'S ECONOMY

Agriculture's contribution to New Mexico's heritage and economic health is well known. New Mexico's favorable climate has stimulated a large measure of agricultural diversity from traditional staples to green chile, wine making, and cultivation of blue corn, allowing us to lead the way in many specialty markets. By statistics compiled through 1995, New Mexico leads the nation in production of chile, Valencia peanuts, summer potatoes, and non-storage onions. In the last 10 years, demand for blue corn increased acreage from less than 100 acres to 2,500 acres, grown mostly in Quay, Curry, and San Juan counties. New Mexico is the nation's third largest producer of pecans.

The 1991 cash receipts from farm marketings in New Mexico totaled $1.5 billion, up 1.2 percent from cash receipts in 1990. Of these, crops valued at $486 million represented 34.0 percent of cash receipts; livestock and livestock products accounted for the balance. Major farm production includes cattle, sheep and wool, dairies and dairy products, alfalfa and other hays, wheat, sorghum, 1517 cotton, chile, pecans, lettuce, corn, and onions. Miscellaneous specialty crops include barley, blue corn, green beans, oats for grain and hay, pumpkins, and wine grapes. Agriculture is and will continue to be a growth area of our state's economy.

AN INVESTMENT IN THE FUTURE

As with all businesses, advanced technical approaches that contribute to greater efficiency and higher production give their users the competitive edge over those who continue down more traditional paths. As the costs of doing agribusiness increase and compliance with environmental practices becomes more closely monitored, farmers and ranchers are turning to management tools that optimize yields and profits, as well as minimize environmental impacts.

One barrier to reaching these goals is that conventional farming practices treat entire fields as a homogeneous unit, although farm fields are often large and variable in productive potential. This practice will change in the future, as technology allows producers to measure information such as crop yield, soil organic matter, soil pH, and water use efficiency at specific sites within a field. Site-specific information allows producers to make management decisions about discrete areas of the field. This farming method is called *precision farming*, *prescription farming*, or *site-specific crop management*.

Researchers have suggested that precision farming could create a revolution in agriculture on the same scale as that of hybrid corn (the last revolution, which began only about 20 years ago). The availability of low-cost computing power and improved understanding of crop growth will allow site-specific crop management. Farmers will be able to manage a field as a collection of small units that can each be optimally managed, based on the inherent productivity of each unit.

Precision farming utilizes three technologies: Global Positioning Systems (GPS), Geographic Information Systems (GIS), and Variable Rate Technology (VRT). GPS provides navigation that can position a tractor within a few feet anywhere in a field. GIS computer systems capture, manage, and analyze spatial data relating crop productivity and field inputs. VRT provides "on-the-fly" estimation of field inputs. Working in concert, GIS, GPS, and VRT provide information that allows producers to apply inputs, such as fertilizers and insecticides, precisely where they are needed. In addition to potential productivity gains and cost savings, this emerging technology enables thorough study and regulation of ecosystem impacts from agricultural practices.

The techniques of precision farming can complement sustainable land management. The goal of sustainable development is to avoid negative changes in natural resources and increase the quality of life of producers. Precise, detailed information on discrete sites within a field can lead to, for example, more efficient (reduced) use of inputs such as fertilizers and insecticides and more efficient water use. Therefore, precision farming can be used to provide good stewardship of the land for future generations, preserve the land's potential for multiple uses, and evaluate both off- and on-site effects of agricultural practices.

ESTABLISHING PRECISION FARMING EDUCATION AND OUTREACH IN NEW MEXICO

Partners in Precision Farming Education

Precision farming in New Mexico is in its infancy. Fortunately, technical resources and expertise related to this subject currently exist within NMSU's Cooperative Extension Service (Extension) and Agricultural Experiment Station, as well as the University of New Mexico's New Mexico Engineering Research Institute (NMERI). NMERI has recently been designated a National Center for Resource Innovations (NCRI) future site, the seventh NCRI representative in the country. NCRI's mission is to communicate GIS and related technologies, such as precision farming, to public decision makers and natural resources managers.

Therefore, it has been proposed that a cooperative effort to educate New Mexico producers about precision farming techniques be advanced through NMERI's NCRI site. Cooperating partners, which will be assembled through NCRI and Extension, are in unique positions to move quickly into this rapidly emerging agri-management arena. A good initial partnership between NMERI and Extension already has begun. It is the desire of both participating agencies that roles and responsibilities be clarified and formalized through a memorandum of understanding.

Future partners may include the New Mexico Department of Agriculture (NMDA), National Resource Conservation Service (NRCS), Soil and Water Conservation Society, Environmental Protection Agency (EPA), non-profit organizations, environmentalists, agribusiness associations, and key politicians. Department of Energy satellite resources also should be investigated as a contributing resource.

Through cooperative interactions between people with differing priorities and viewpoints, we will enlarge our own knowledge and create many win/win solutions to agricultural problems in New Mexico. For example, consumers will have more accurate information on their food products and related environmental issues, assuring them that their food will be safe and economical. Precision farming techniques should help us all become better guardians of our nation's natural resources.

What to Teach?

A precision farming education project should focus on producer profitability, crop diversification, and environmental protection. A logical approach to developing this information would include conducting a case study in New Mexico to address setup and optimization issues prior to conducting a formal outreach program.

Precision farming educators should be prepared to answer both basic and advanced questions that will inevitably be asked by New Mexico food and fiber producers. New Mexico-specific information on soils mapping, crop growth cycles, localized precipitation and weather, and irrigation practices must be built into any yield and financial advantage optimization schemes. Educators also should provide an assessment of the economic incentives and the specific technologies required to enter the precision farming arena, such as GIS mapping, Real Time Differential Correction Services, and VRT.

A Framework of Information

Precision farming can provide a framework of information with which farmers can make management and production decisions. In the near future, precision farming will be used to answer questions pertaining to:

- **Ground preparation**—tillage depth and type; residue management and organic matter; compaction reduction.
- **Fertilizers**—nitrogen, phosphorous, potassium, and other nutrients; pH additives; application methods.
- **Harvest**—dates and moisture; quality.
- **Post-harvest soil preparation**—residue management; tillage.
- **Seed**—planting date and rotation; population and planting depth; cultivar selection.
- **Diseases, insects, and weeds**—weed management using infrared sensors; best fungicides and insecticides; optimal rates and methods of application.

In addition to farm management, precision farming techniques can contribute to research—research that can provide the foundation for more valid small-plot and on-farm variety trials; determine relationships between crop growth and yield failures; and estimate optimal plot and block configurations for field experiments. Data gathered in precision farming systems also can help researchers identify areas with high pollution potentials; estimate loading rates of different pollutants; and assess surface water movement of agricultural chemicals.

Therefore, precision farming encompasses all areas of crop production, helping farmers lower their cost per unit of production.

Understanding the Data

Although precision farming has great potential to improve profitability and sustainability in crop production, this technology is very new and, consequently, it has a number of weaknesses. For example, mapping the yield of each site may be the most important component of precision farming, however, evaluation of yield sensors, as well as the interpretation and management of data is quite limited.

One objective is to understand the data obtained from a precision farming system given the variability on a specific farm and within an agriclimatic zone. Our long-range goal is to assist farmers in the practical and cost-effective use of precision farming so they can maximize their profits and make good crop production and management decisions. Methods to help farmers will include:

- Offering information seminars designed to help New Mexico's farmers use precision farming technology correctly and cost effectively.
- Processing the enormous amounts of data generated from this technology, resulting in user-friendly summaries that will help farmers manage their crop production.
- Providing the technical expertise to integrate the various components of precision farming (i.e., GPS, soil sampling, remote sensing, variable rate fertilizer applications, on-the-fly yield monitoring, crop stress management, and field mapping) for each farmer's specific application.

SCIENCE FICTION OR A MODERN TECHNIQUE?

Precision farming technology is available now and is being implemented on an increasing number of farms throughout the United States. Environmental concerns will be integrated with economic impacts of each decision while considering the within-field variabilities of the soil and climatic fluctuations. Eventually, each field within a farm will become an on-site research center where management decisions will be carefully analyzed and implemented.

For example, farmers will be able to optimize input costs by detecting high- and low-production areas in their fields. With this information farmers will adapt fertilization rates, planting populations, and pesticides use to a field-specific needs, resulting in fewer chemicals being applied to our ecosystems. In addition, farmers will be able to determine the performance of agricultural products by accurately evaluating each product in side-by-side comparisons. Also, farmers will be able to maximize crop outputs by managing each field and the site-specific environmental stresses more effectively.

TERMINOLOGY

The following list provides definitions of common terms related to precision farming technologies.

Accuracy. Closeness of measurements to the true value.

Anywhere fix. An electronic receiver's ability to start position calculations without being given an approximate location and time.

Bandwidth. The range of frequencies in a signal.

C/A code. Acronym for course/acquisition, the standard GPS code. A sequence of 1023 pseudo-random, binary, biphase modulations on the GPS carrier at a chip rate of 1.023 MHz.

Carrier-aided tracking. A signal processing system that uses GPS carrier signal to achieve an exact lock on the pseudo-random code.

Channel. A channel of a GPS receiver consists of the circuitry necessary to tune the signal from a single GPS satellite.

DGPS. Differential global positioning satellites.

Clock bias. The difference between the clock's indicated time and true universal time.

Cycle slip. A discontinuity in the measured carrier beat phase resulting from a temporary loss-of-lock in the carrier tracking loop of a GPS receiver.

Differential correction. To achieve an accuracy acceptable in agricultural GPS applications (1 to 3 meters), a land-based differential unit is needed to correct errors in signal transmission and reception signals.

Dilution of precision. The multiplicative factor that modifies ranging error. It is caused solely by the geometry between the user and the set of satellites being used. Also known as DOP.

Doppler shift. The apparent change in the frequency of a signal caused by the relative motion of the transmitter and receiver.

Fast-multiplexing channel. A single channel that rapidly samples a number of satellite ranges. "Fast" means the switching time is sufficiently fast (2 to 5 milliseconds) to recover the data message.

GIS. Geographic information systems. System of computer hardware, software, and procedures designed to support the capture, management, and analysis of spatially referred data.

GPS. Global positioning satellites (or system).

Latitude. Distance on the earth's surface from the equator, measured in degrees of the meridian.

Longitude. Distance east or west on the earth's surface, measured by the angle created by the intersection of an adopted meridian with a standard meridian.

Ionospheric refraction. The change in the propagation speed of a signal as it passes through the ionosphere.

L-band. The group of radio frequencies extending from 390 MHz to 1550 MHz. The GPS carrier frequencies (1227.6 MHz and 1575.42 MHz) are in the L band.

Multipath error. Errors caused by the interference of a signal that has reached the receiver antenna by two or more different paths. Usually caused by one path being bounced or reflected.

Multi-channel receiver. A GPS receiver that can simultaneously track more than one satellite signal.

Multiplexing channel. A channel of a GPS receiver that can be sequenced through a number of satellite signals.

P-code. The "precise" or "protected" code. A very long sequence of pseudo-random, binary, biphase modulations on the GPS carrier at a chip rate of 10.23 MHz, which repeats about every 267 days. Each one-week segment of this code is unique to a single GPS satellite and is reset each week.

Precision. Measure of agreement among individual measurements.

Precise Positioning Service (PPS). The most accurate dynamic positioning possible with GPS, based on the dual frequency P-code.

Pseudolite. A ground-based differential GPS receiver that transmits a signal like that of an actual GPS satellite. The data portion of the signal contains the differential corrections that can be used by other receivers to correct for GPS errors.

Pseudo-random code. A signal with random-noise-like properties. It is a very complicated but repeated pattern of 1s and 0s.

Pseudorange. A distance measurement based on the correlation of a satellite transmitted code and the local receiver's reference code, that has not been corrected for errors in synchronization between the transmitter's clock and the receiver's clock.

SA. Selective availability.

Spread spectrum. A system in which the transmitted signal is spread over a frequency band much wider than the minimum band-width needed to transmit the information being sent. For GPS, this is done by modulating the carrier with a pseudo-random code.

Standard positioning service (SPS). The normal civilian positioning accuracy obtained by using the single-frequency C/A code.

Static positioning. Location determination when the receiver's antenna is presumed to be stationary in the earth. This allows the use of various averaging techniques that improve accuracy by factors of over 1000.

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