IRRIGATED PRECISION FARMING

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INTRODUCTION

Precision farming (PF) or site specific management is currently being promoted by several sectors of agribusiness . Farmers are using combines with GPS and grain yield monitors to generate maps of yield variability within fields. Many fertilizer dealers offer variable application of fertilizers and chemicals using specialized equipment. The concept of precision farming is to apply the right amount of inputs at the right time on the right area. Precision farming is not just the use of high-tech equipment, but the acquisition and wise use of information obtained from that technology. The long term thrust of our research effort is to evaluate the impacts of PF on water quality and the economic feasibility of PF under irrigated conditions. The objectives are to quantify the causes of yield variability and the economic feasibility and environmental benefits of precision farming.

Sampling strategies and analysis techniques are needed for integration into a decision support system that determines the appropriate scale for implementing variable rate technology. A multidisciplinary team including soil fertility specialists, crop specialists, weed scientists, entomologists, plant pathologists, systems engineers, remote sensing specialists, GIS specialists, irrigation engineers, agricultural economists and statisticians is working together to systematically gain a better understanding of precision farming. The specific objective of this paper is to evaluate the factors affecting yield variability under the existing farm management and the potential for use of site specific management. Two cooperating farmers are managing their own corn production using high levels of inputs to obtain maximum yields and providing us with the yield data from two center pivot irrigated fields.

DATA COLLECTION

Aerial photographs obtained for the two center pivots from the USDA Farm Service Agency for the years of 1992-1995 and the USDA-NRCS soils maps were used to select fields that exhibited significant variability. Topography maps with 1 ft contour interval were made with the assistance of the NRCS. Scientists from each discipline sampled their respective parameters at 250 x 250 ft grid.

Soils data

The soils were sampled for fertility at randomly selected sites within each of the grid cells in April 1997 and March 1998. The surface 8 in was analyzed for NO_3-N, NH_4-N, P, K, Zn, pH, organic matter and texture. Subsoil samples for 1-2, 2-3 and 3-4 ft increments were analyzed for NO_3-N and NH_4-N. Cropping Systems and Water Quality Research Unit, ARS, Columbia, MO used a Geonics Limited EM38[1] conductivity sensor to generate an electromagnetic conductivity map in the spring of 1997 for both fields. Electrical conductivity data were collected in the spring of 1998 using the Veris soil mapping system.

Weed data

The weed seedling population was sampled after postemergence management to estimate the weed population that competed with the crop. Seedlings were identified and counted by species in quadrats of a 6 in band over 5 ft of crop row. Seedlings were sampled at the center of each grid cell and at a randomly selected site between adjacent center points within a row. Major species were pigweed (*Amaranthus retroflexus* L.), nightshade (*Solanum* sarrachoides Sendtner), lambsquarter (Chenopodium album L.), and field sandbur (*Chenchrus incertus* M.A. Curtis). Since weed species differ in the ability to compete with maize, the total competitive load was calculated for each quadrat. Total competitive load is a weighted sum of weed density with the density of a species weighted by an index of the relative competitiveness of that species:

$$TCL = \overset{n}{\underset{i=1}{3}} CI_i \ D_i$$

where n is the number of species, D_i is the density of species i, and CI_i is the index of relative competitiveness of species i; $0 < CI_i > 1$.

Insect data

Adult activity of locally important pest insects was measured. Pheromone traps were monitored weekly during the flight periods of European corn borer, *Ostrinia nubilalis* (Hübner), and western bean cutworm, *Richia albicosta* (Smith). Western corn rootworm, *Diabrotica virgifera virgifera* LeConte, adults were also monitored with traps containing the attractant 4-methoxycinnamaldehyde. One trap was located in each grid cell and more intense sampling was done at least one quarter of each field. A total of 375 trap locations were employed over the two study fields.

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[1] Mention of trademark, proprietary product , or vendor does not constitute a guarantee or warranty of the product by the USDA and does not imply its approval to the exclusion of the other products or vendors that may also be suitable.

Climatic and Irrigation Data

A weather station was located adjacent to each field to measure solar radiation, temperature, vapor pressure, wind run and precipitation. The data were used to calculate daily evapotranspiration (ET) for soil water budgeting purposes. Six recording raingages were place around the periphery and one at the center of each field to assess spatial variability of rainfall. Records of the irrigation timing and amount of water applied were maintained throughout the irrigation season.

Since it is unfeasible to physically collect irrigation depths across the fields for all irrigations, computed depths from a simulation model that had been verified by field catch can data were used to map total water application. The average, maximum, minimum and standard deviation of seasonal water applied in each grid cell were calculated. The water budget was calculated at each grid point to determine locations of excess and deficit irrigation throughout the season. The average seasonal water application for each grid cell varied from 22 - 39 in and 17 - 53 in for Field 1 and 2, respectively.

Yield Data

The cooperators harvested both fields with combines equipped with yield monitors and GPS units. A base GPS unit was installed in the area which broadcast differential signals to increase the accuracy of spatial resolution. Yield data were processed and mapped with Farmers' Software Harvest Mapping System on a Map Info platform. The average maize yields were 173 and 207 bu/ac for fields 1 and 2, respectively.

RESULTS

The best predictors of yield for field 1 were average conductivity, ammonium, organic matter, phosphorous, and the standard deviation of the irrigation. The best predictors of yield for field 2 were average shallow conductivity, ammonium, and minimum irrigation for the season.

The water terms for each of the models have the most significance in explaining the yield variability. The lower yields were on the outer periphery of the field where the lower applications and larger variations of water occurred. The majority of the fields were overirrigated and water was probably not limiting the yield. The ammonium and phosphorous resulted in a negative correlation with yield which indicates that they are not limiting. The EM soil electromagnetic conductivity is positively correlated with yield while the Veris soil electrical conductivity is negatively correlated. The actual soil effect that is measured by EM or Veris has not been determined. We need to further study the factors influencing the conductivity measurement. The organic matter in field 1 was positively correlated with yield.

The soil nitrogen variables were based upon preseason soil tests and not on the total available for plant growth. The total N applied during the season was 320 and 285 lb/ac for field 1 and 2, respectively. Of this total 180 and 130 lb/ac were applied by fertigation with the center pivot sprinkler system. Since approximately one half of the total N was applied with the water, the water uniformity would significantly influence the N availability. The variability of water would result in the same variability in N and contribute to the correlation with yield. The 1998 season has focused on measuring and quantifying this variation. However, this will be highly correlated with the water applied.

The current management has applied inputs at such high levels that it readily follows that the models will not provide the necessary input to site specific management of fertilizers or pest control chemicals. The challenge is to encourage users to experiment with reduced inputs and increase their risk. The reduction in inputs and their costs must not reduce gross production output or net return for the enterprise.

CONCLUSION

The potential benefit of increased site specific inputs of fertility and pest management chemicals is small where the farmers' management tolerance for risk is low and inputs are high to obtain maximum yields. The potential of site specific management is in reducing the cost of inputs, but could increase the risk. The environmental benefits are an important part of management that is minimally factored into many farmer decisions and will likely be increasingly important in the future. However, there benefits have not quantified.

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