SF-1176-4 (Revised)

Site-specific Farming 4

Field seeded with swath control.
Note small amount of overlap into end rows.
(Photo used by permission from John Deere)

Economics and the Environment

Dave Franzen, NDSU Extension Soil Specialist

It is clear that through future government policies, economics and the environmental effects of farming may become linked.

Site-specific farming has been described as doing the right thing at the right place at the right time. Site-specific farming systems can be as simple or complex as required by the grower. Economic returns to the grower from site-specific technologies depend on the tools used and the scale of the system. Global positioning system (GPS)-linked guidance tools and identity-preserved (IP) locations are whole-field scales. Use of yield monitors, zone soil sampling, variable-rate fertilizer or variable-rate seeding is within-field scale. In the past, economics and environmental effects have not been linked. However, what is clear is that through future government policies, economics and the environmental effects of farming may become linked.

NDSU Extension Service
North Dakota State University
Fargo, North Dakota 58108

MAY 2009

GPS-linked tractor/vehicle guidance

GPS-linked guidance systems claim to reduce fertilizer/pesticide overlap during application, increase the speed of operations, offer greater flexibility in labor quality, extend the workday and may aid in more optimum input placement (Griffin et al., 2008). In a case study of guidance systems, Griffen et al. found that a three-hour extended workday from a guided tractor resulted in an additional $1.63/acre return. The guidance systems also helped plant fields in the most efficient manner with minimal overlap, reducing planter time by 30 percent. This additional time could be used to finish planting earlier, which in corn has been shown to increase yield by a bushel/acre/day, or the extra time might be filled by being able to farm more acres. Overlap was estimated at 10 percent. With guidance systems, the overlap was reduced to 0.5 percent. Overlap is possible between passes (22 passes in a square 40-acre field with 10 percent overlap in 30-inch rows of about 0.5 acre overlapped per field) and also at each end of the field (1,320 feet with 6 feet of overlap at ends results in about a 0.36-acre overlap in a 40-acre field). Total overlap in a square field then typically is about 0.86 acre, or about 2 percent extra seed, fertilizer and pesticide required. Use of these systems to reduce overlap would result in input cost savings of $1.55/acre for soybeans, $2/acre for dry beans, $2.50/acre for wheat (Swenson and Haugen, 2009) and more than $4/acre for corn and sugar beets.

Environmentally, reduction in overlap has the benefit of reducing total fertilizer and pesticide load by about 2 percent in square fields and more in odd-shaped fields, fields with point-rows and fields with potholes or other internal features that require driving around. Individual sprayer shut-offs that are GPS-controlled are available to nearly eliminate overlap in odd-shaped areas while spraying pesticides or liquid fertilizers.

Swath control (Shockley et al., 2008) reduced input costs much more than guidance systems alone in irregular-boundary fields. Savings in fertilizer alone due to individual nozzle shut-offs ranged from $24 to $32/acre.

Identity preserved

The use of GPS and geographic information systems (GIS) is limited in mapping in the contracting and marketing of IP grains (Unity Seed, Casselton, N.D., personal communication, 2009). However, some fields have provided GPS locations. Because field operations guided by GPS also are linked with the specific locations within each field boundary, an opportunity is available to provide through GIS a record of field operations for each IP field. Currently, premiums for certain crops are provided through contracts that range from $1 to $2/bushel for non-GMO soybeans.

Environmentally, the existence of spray application GPS records helps verify the application. This information is particularly important when restricted-use pesticides are applied. In addition, GPS information regarding a spray application may be extremely useful in spray drift litigation (both for and against a plaintiff) as well as directing the sprayer to the correct field location and avoiding application to the wrong field and crop.

Avoiding a single load of pesticide or fertilizer applied to the wrong field may result in savings to the applicator from a few to many thousands of dollars.

Variable-rate fertilizer

The purpose of variable-rate fertilizer is to place fertilizer where it is needed. One would think that many examples of profitability with the use of variable-rate fertilizer would exist. In a three-state project conducted in North Dakota, Montana and Minnesota from 2000 to 2003, fields were divided into variable-rate plots and uniform-rate plots with respect to nitrogen fertilizer. An economic analysis of the fields found that using the fertilizer recommendations available at the time in a zone approach did not result in economic advantage to variable-rate N compared with uniform-rate N directed by a composite soil test (Haugen and Aakre, 2005). These results spurred research into updating N recommendations based on our ability to vary rates within fields. In Montana, the study quickly showed that in its fields, the areas with higher organic matter on lower slopes did not respond to N; this meant that minimal supplemental N was required even if soil N levels were low. In contrast, lower-yielding areas on hilltops and eroded slopes required more N per productive bushel than previously expected.

The facing page is a case study of a 40-acre field near Valley City, N.D., that was examined site-specifically for about 10 years.

Environmental economics

In the Valley City case study, the use of variable-rate N application reduced N to the field by about 600 pounds. If the crop did not use the N, where did it go? Understanding that the N cycle is complex and that about one-half of the N fertilizer at best went into the wheat crop, the rest of the wheat N uptake was from soil and residue N release. Also, some of the fertilizer was sequestered at least temporarily in microbial biomass or intermediate organic matter compounds; however, 600 pounds of N/acre less was applied in the variable-rate system than the uniform-N system. In the case of Valley City, most of the 600-pound N difference came from preplant reductions in most of the field and a split-application in the hilltops and slopes. Reducing N or at least splitting the N application likely would reduce leaching in this 10-acre area. In a normal year, 20 bushels/acre of wheat would be raised on the hilltops due to early season N leaching. If we estimate that in a 100-pound N/acre application to these areas, about one-half of the N is lost to leaching, then about 500 pounds of N in the field usually is lost to groundwater. Cleanup of nitrates documented in Khan and Spalding (2004) cost about $0.16/1,000 liters for about 12 parts per million (ppm) of nitrate (NO_3) in groundwater to be reduced below 10 ppm NO_3 under a municipality in Nebraska. This is about 35 cents/2 grams of N. If the amount of N entering a groundwater aquifer contributed to nitrate levels higher than 10 ppm (the U.S. EPA maximum drinking water standard) then cleanup of the 500 pounds of N that went into the aquifer would be $80,711.

In addition, Zone 1 is a wet area, with denitrification in wet years and significant N mineralization in other years. Extra N applied to Zone 1 will denitrify. In addition, extra N applied to Zone 3 and Zone 4 tends to flow into Zone 1 through subsurface water flow and then is denitrified. If 10 pounds of N/acre from Zone 3 and Zone 4 flowed into this area and 50 pounds of N/acre also were denitrified after application within Zone 1, a total of 420 pounds of

CASE STUDY

The acreage components of each zone (Figure 1) are:

Zone 1 – depressions, high organic matter, poorly drained soils, 3 acres

Zone 2 – sandy or loamy ridge tops, yields generally poor with low-ending soil N, 10 acres

Zone 3 – high-yielding loam soils with argillic subsurface horizon that limits leaching, 16 acres

Zone 4 – highest-yielding loam soils with argillic subsurface horizon and high-ending soil N, 11 acres

Average fall nitrate-N is about 40 pounds/acre after barley. For spring wheat, the normal grower N rate is about 100 pounds of N/acre. Total N used – 4,000 pounds.

In a site-specific application with current knowledge, the rates follow (total N/zone):

Zone 1 – 40 pounds of N/acre (120 pounds of N)

Zone 2 – 60 pounds of N/acre preplant with 20 pounds of sulfur (S)/acre, 60 pounds of N/acre stream bar at 4-leaf (1,200 pounds of N plus 200 pounds S as ammonium sulfate)

Zone 3 – 80 pounds of N/acre preplant (1,280 pounds of N)

Zone 4 – 70 pounds of N/acre preplant (770 pounds of N)

Total N used – 3,370 pounds (additional 200 pounds of S)

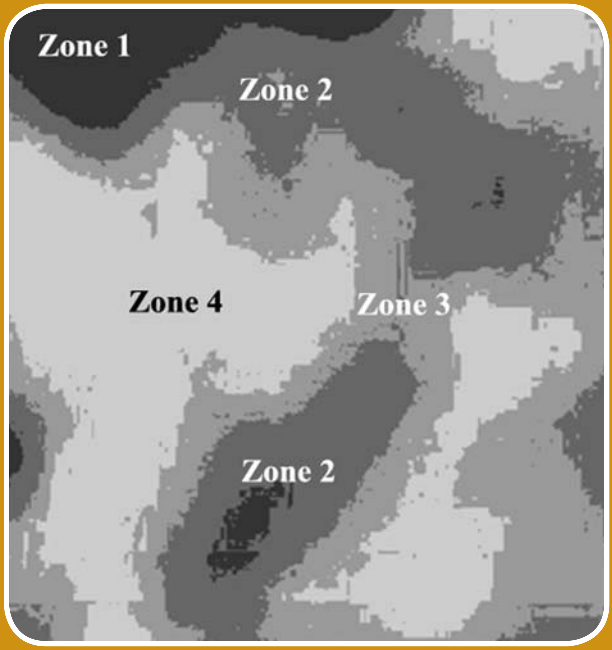

Figure 1. A 40-acre field near Valley City, N.D. The zones were developed using Erdas Imagine to layer and cluster topography, satellite imagery and soil electrical conductivity (EC) data.

Based on results from previous years, the following would be expected with each system:

Uniform N - 45 bushels/acres spring wheat, high protein

Ending N – 40 pounds/acre 2 feet

Variable-rate N:

Zone 1 – 40 bushels/acre, high protein

Zone 2 – 40 bushels/acre, high protein

Zone 3 – 50 bushels/acre, high protein

Zone 4 – 60 bushels/acre, high protein

Average yield 49.5 bushels/acre

Ending N – 30 pounds/acre 2 feet.

Economically, the cost of N at current 40 cents/pound of N is:

$1,600 for uniform

$1,398 for variable plus $40 for an extra stream-bar application

Sulfur at 25 cents/pound is $50.

Total fertilizer for variable – $1,488

The variable-rate addressed chronic S deficiencies on the hilltops as well as excessive N applications to several areas and the leaching problems in zone 2 that resulted in higher yields.

The variable-rate N system would net an additional 4.5 bushels/acre, or at $6/bushel wheat; the yield increase would be a net gain of $1,080 for the field. The combination of lower fertilizer costs and higher yields would result in a total net gain of $1,202 for the field. Additional costs for this program through a consultant might run between $10 and $20/acre depending on the services provided. The net return for this case study field would range from $402 to 802.

Environmentally, expected residual N would be 10 pounds/acre lower in the variable-rate compared with the uniform rate. Total N applied to the field is reduced by about 15 percent, and the N applied is applied in a timelier manner and the efficiency of crop uptake is increased.

In a Colorado study, Koch et al. (2004) found in irrigated corn that zone-directed N required from 6 percent to 46 percent less N and net returns ranged from $7/acre to $11.60/acre for the practice.

N in the field would be denitrified. Since nitrous oxide (N_2O) is rated 310 times as active as a greenhouse gas compared with carbon dioxide (CO_2), the effective CO_2 loss would be 130,200 pounds or 65 tons. If the field was subject to a "cap and trade" and the field was in no-till and the estimated CO_2 sequestered through reduced tillage was about one-half ton carbon (C) per year, the greenhouse gas deficit for this case study would be 65 tons (N_2O loss) less 20 tons (one-half ton/acre CO_2 sequestered multiplied times 40 acres) or 45 tons of CO_2. At the current (Chicago Carbon Exchange, April 1, 2009) C trade price of $2/metric ton (2,200 pounds), the conceivable cost to the grower might be about $81 for the field.

Variable-rate seeding

Many growers are interested in varying the seeding rate across variable-soil fields. The idea seems sound. Too high a plant population of most crops in droughty soils is detrimental in dry years. However, work in the Corn Belt has shown that despite what growers think they know, optimum plant populations of modern corn hybrids fall into a very narrow range from about 26,000 to 30,000 plants/acre (Doerge, www.pioneer.com/growingpoint/agronomy/crop_insight/0905.jsp). This range assumes that corn will emerge similarly on all soils, which is not true. Harvest stand counts show a large range of variability. Even though the field was seeded at a uniform rate, that doesn't mean the stand is uniform. Companies are working on harvest stand counters on combines that can show growers where soils with emergence issues might be found. Once these areas are documented, producers might reasonably expect a return on variable-rate corn seeding. For now, however, little economic incentive exists to adopt variable-rate seeding.

Additional environmental benefits

A review by Bongiovanni and Lowenberg-Deboer (2004) outlined a suite of findings by researchers of environmental benefits for site-specific management of fields. These include:

- Less N lost to the environment and greater nitrogen use efficiency
- Less N loss in zones vulnerable to leaching
- Reduced N rates
- More accurate prediction of P pollution potential
- Helps reduce P movement into surface waters

The potential for site-specific agriculture to increase profitability and decrease environmental concerns has long been acknowledged. Recently, studies have shown that with updated fertilizer recommendations, the use of site-specific fertilization often is profitable. Contributing to the profitability are the increased costs of fertilizer inputs. A number of environmental benefits also have been shown due to the improved placement of nutrients and decreased need for growers to add "insurance" fertilizer rates on fields. The possible use of "cap and trade" policies and excessive groundwater nitrate cleanup around municipalities also may push the profitability of site-specific nutrient use as economics and environment become more closely related through public policy changes.

References

Bongiovanni, R., and J. Lowenberg-Deboer. 2004. Precision agriculture and sustainability. Precision Agriculture 5:359-387.

Doerge, T. New opportunities in variable-rate seeding of corn. Pioneer Growing Point www.pioneer.com/growingpoint/agronomy/crop_insight/0905.jsp.

Griffin, T., D. Lambert and J. Lowenberg-DeBoer. 2008. Economics of GPS-enabled navigation technologies. Proceedings of the 9th International Conference on Precision Agriculture. July 20-23, Denver, Colo.

Haugen, R.H,. and D.G. Aakre. 2005. Analysis of soil fertility testing procedures using uniform, topographical and other site-specific methods. Agribusiness and Applied Economics Report No. 570. North Dakota State University, Fargo, N.D.

Kahn, I.A., and R.F. Spalding. 2004. Enhanced in situ denitrification for a municipal well. Water Research 38:3382-3388.

Koch, B., R. Khosla, W.M. Frasier, D.G. Westfall and D. Inman. 2004. Economic feasibility of variable-rate nitrogen application utilizing site-specific management zones. Agron. J. 96:1572-1580.

Shockley, J.M., C.R. Dillon and S.A. Shearer. 2008. Cost savings for multiple inputs with swath control and auto-guidance technologies. Proceedings of the 9th International Conference on Precision Agriculture. July 20-23, Denver, Colo.

Swenson, A., and R. Haugen. Projected 2009 crop budgets south valley North Dakota. NDSU Farm Management Planning Guide, December 2008. North Dakota State University Extension, Fargo, N.D.

1M-5-09