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The Impact of Precision Farming Strategies on Profitability

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The majority of all research and technical developments in site specific management (precision farming) are in the areas of weed control and variable rate application of fertilizers and lime. Site specific management can be defined as the application of specific inputs based on the varying need of that input within a field, as opposed to management of inputs based on the mean of the field. However, the difference in conventional agriculture production systems and site specific production systems is the resolution or "field size" at which we manage. That resolution can range from a farm within the farming enterprise, to a field within a farm, to a management zone, to a fundamental field element or cell, or to an individual plant. Except at the individual plant level, all areas are managed "on the average". The following discussion focuses three technologies that can be agronomically and economically viable: nutrient management zones defined by yield mapping or remote sensing; variable rate application of nitrogen fertilizers using real-time sensing and application; and optical sensing and spot spraying weeds. In addition, the issue of the resolution at which yield variability is managed will be discussed.

Nutrient Management Zones Defined by Yield Mapping or Remote Sensing

Over the last ten years, significant effort has been expended to use combine yield monitor data to define regions with a field that are managed differently. Results have been mixed, and current thinking is that, to be usable, 5 to 7 years or more of yield data will be needed to define these areas. Landsat TM satellite image data are an alternative to yield monitor data that enable farmers to acquire the mulitemporal data needed to identify these regions or management zones. Oklahoma State University researchers have been able to calibrate these data to wheat yield and have successfully used the calibrated data to predict wheat yield by field and yields within regions within a field. To do this, seven years of satellite estimated yield data were normalized. Average percentage yield by pixel (data were resampled to a 25 x 25 m pixel size during georeferencing) were calculated. Results showed that management zones could be defined that were stable over years in certain fields. These fields were characterized by greatly differing soil types, significant changes in landscape (slope and aspect), and were not irrigated. Regions could be identified with high multitemporal variation and causes ascribed to that variation. Fields with limited slope, good drainage, and productive uniform soils showed no stability in yield patterns. The latter fields will not benefit by variable rate application of fertilizer at this resolution. The former fields, "hill ground", can benefit from variable rate application of fertilizers at this resolution. Because yield patterns persist, N fertilizer can be applied on the basis of N removal, a practice commonly used by Oklahoma farmers. Returns are positive when costs of data acquisition, analysis, and custom variable-rate application are considered. Potential return may be greater when management zones are fertilized using soil test recommendations from random samples collected within the zones. Combine yield monitor data should produce similar results. The advantage of using satellite data is that a farmer can purchase the historical estimated yield data needed to implement the practice. Costs of acquiring the data should be similar for both methods.

Optimum Resolution for Sensing and Treating Nutrient Variability

With the increased interest in remote sensing, there has been a movement to increase the resolution at which yield potential is sensed and treated. Research at Oklahoma State University has shown that the optimum resolution for optically sensing wheat biomass is less than 1.5 m. Geostatistical analysis of soil sample data collected at 0.3 by 0.3-m resolution indicates that the distance at which the soil nutrients N, P, and K are highly related is about 0.8 m. Greatest gross returns on variable rate application should occur when soil nutrients are variably applied at that resolution.

Real Time Sensing and Variable Rate Application

Real-time sensing and variable rate application provides the tools needed to sense at 1-m resolution. Oklahoma State University research have developed sensor/variable-rate applicators that can sense and variable apply N fertilizers at resolutions as high as 0.3 by 0.3 m. This equipment utilizes integral lighting and can operate independent of sunlight. A calibration algorithm relating sensor readings to wheat yield potential, and fertilizer requirements is being developed. Initial field tests indicate that wheat yields can be increased and fertilizer rate reduced compared to fixed-rate top-dress application at conventional rates. Although yields of the fixed-rate application could be increased to that of the variable-rate treatment, an additional $10.00/ac of N fertilizer would need to be applied.

Variable Rate Application of Herbicides

Equipment similar to that used at Oklahoma State University for real-time, sensor-based, variable-N-fertilizer application is commercially available for detecting and spot spraying weeds. A positive economic return can be realized with this equipment considering only herbicide savings.

Most economic analyses have not considered environmental benefits of these technologies. Increasing N use efficiency, reducing the potential of ground water and surface water contamination, spot spraying individual plants, reducing herbicide drift, elimination of weed escapes and the consequent shifts in weed populations all have measurable environmental benefits. Environmental benefits can provide the incentive to adopt these and other site specific management technologies, provided there is a net positive economic return.