

APPROACHES FOR IMPLEMENTING VARIABLE RATE N APPLICATIONS

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Summary

Effective management of fertilizer nitrogen (N) in corn production is needed to maximize economic return for producers and control N losses that can cause environmental problems. Environmental concerns with N use in corn production are mainly focused on nitrate leaching to ground water and surface water nitrate contributions to Gulf of Mexico hypoxia. The key to improving N management to achieve economic and environmental goals is accurate selection of the optimum N rate needed for profitable production in each production unit. Many corn N response experiments have shown that optimum N rates vary widely from site to site, and substantial within-field variation in optimum N rates is expected, although little work has been done to confirm or quantify the within-field variation of optimum N rates. Variable rate N applications should have potential for applying optimum N rates to all areas of production fields with substantial spatial variation in optimum N rates. If rates of applied N can be matched to actual corn N requirements throughout production fields, the economic and environmental goals of N management could potentially be achieved to a greater extent than would be possible with a single N rate applied to the entire field.

While the potential advantages of variable rate N applications are clear, there is little or no information on what criteria should be used to vary N rates within corn fields. Many factors influence optimum N rates for corn, but we currently do not know which factor, or combination of factors, should be used as the basis for changing N rates in a variable rate N application strategy for corn. Obviously, the basis for changing N rates must be determined to identify the factors that must be measured in the field to guide the variable rate nitrogen applications.

Doerge (2001) recently reviewed the current status of variable rate N technology and strategies for improving N management in corn production. The technology for applying N fertilizers at variable rates to designated areas within corn fields is available now. However, adoption of variable rate N management is inhibited by lack of reliable methods to identify within-field variation in crop N supply or availability and by the absence of consistent improvements in yield, profitability, or environmental protection when variable N rates are compared with a uniform N rate.

A key issue for variable rate N management adoption is development of approaches that will accurately identify the economically optimum N rate for corn and indicate how this characteristic varies spatially throughout the production unit. Historically, N rates for corn were predicted using a yield goal approach that calculated the crop N requirement based on expected yield with adjustments for non-fertilizer N contributions.

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This approach does not appear suitable for variable rate N management because within-field yield variation differs from one year to the next, and numerous studies have shown a poor relationship between yield and economic optimum N rate.

Strategies that have been evaluated or are currently under study to guide variable rate N applications include use of diagnostic N tests such as soil and plant nitrate measurements, chlorophyll meter measurements, remote sensing of plant N status through interpretation of aerial photographs or in-field sensing of crop canopy spectral characteristics, site-specific data from yield monitors, and soil electrical conductivity maps.

In Wisconsin, Wolkowski (1998, 1999) and Bundy et al. (2000) evaluated development of a variable rate N approach for corn using both replicated field-scale strip trials and small plot experiments located in farm fields. In the field scale evaluations, three production fields (15 to 30 acres) were grid point sampled (0.5 to 1.0 acre grid) using the preplant soil nitrate test in each of two growing seasons. Field length strips were treated with a uniform N rate (standard or base N rate according to Wisconsin recommendations) and a variable rate based on the results of the preplant nitrate test. A control treatment that received no N was also included. The variable N rate based on the preplant soil nitrate test was 25 to 70 lb N /acre lower than the uniform N rate recommendation. Yields measured with a yield monitor were not significantly different between the uniform and variable rate N treatments. Costs for the variable rate treatment were higher due to the sampling and analysis costs (\$16/acre) that exceeded the value of the N saved. Post-harvest soil samples showed a small (statistically insignificant) reduction in residual soil nitrate where the variable rate N program was used.

In the small plot studies, four replicated N response experiments were established in each of three production fields in each of two years for a total of 24 N response experiments. Individual sites within fields were selected to cover variation in site characteristics that could influence optimum N rate for corn such as topography, elevation, soil type, and drainage. To determine the economically optimum N rate at each site, fertilizer N was applied at rates ranging from 0 to 210 lb N/acre in 30-lb/acre increments. A range of diagnostic soil and plant tests plus measurements of site characteristics were performed in each study. Results showed surprisingly little variation in economic optimum N rate (EONR) within fields. Specifically, EONR did not vary within fields at five of the six locations and had a minimal difference (20 lb N/acre) at the remaining site. These findings indicate that variable rate N application would not have provided an economic or environmental benefit at these locations due to the lack of significant spatial variation in EONR within fields at five of six locations over a 2-year period. Diagnostic tests (soil nitrate measurements, UV absorbance of soil extracts at 200nm, and chlorophyll meter readings) evaluated in the experiments showed potential for identifying optimum N rates and improving N recommendations for corn on a site-specific basis.

For variable N application strategies to be economically viable, a simple inexpensive method of identifying optimum N rates for corn is needed. Intensive grid soil sampling approaches involving analysis of soils for nitrate or other parameters is probably too costly given the potential savings in N fertilizer costs that could be achieved with a

variable rate technology. Doerge (2001) estimated that this N cost savings is in the range of \$5-\$15/acre. Successful implementation of variable rate N management for corn also requires identification of fields with substantial spatial variation in optimum N rates for corn, since this variation is required for the technology to exert an advantage over a uniform N rate approach. Variable rate methods involving assessment of plant N status through remote or in-field sensing during the growing season may have potential if the cost of these technologies does not exceed the value of the benefits provided. Improved diagnostic tests for N availability such as the amino sugar N test under study in Illinois (Khan et al., 2001) may also contribute to improved variable rate N management for corn.

References

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