NORTH CAROLINA

Variable Rate Nutrient Management for Corn-Wheat-Soybean Cropping Systems

By R.W. Heiniger

> What are the benefits of variable rate application and site-specific nutrient management? Research in North Carolina is comparing uniform and variable rate treatments for corn-wheat-soybeans. Economic analysis indicates increased profit potential where variability exists in fields.

A research site was established on a field on Open Grounds Farm, Inc. It included four different soil types which ranged from Ponzer muck to a Tomotley sandy loam. Corn yield potential for each of the soil types as reported in the Natural Resource Conservation Service (NRCS) soil survey did not differ greatly (**Table 1**). However, data collected by a combine yield monitor over the past 3 years showed an 80 bu/A difference among the soil types (**Table 1**). Furthermore, corn and soybean yields were clearly related to soil texture in this field.

A strip plot trial was set up with uniform and variable rate nitrogen (N) as the treatments. In addition, small replicated plots were established to examine a range of N rates for each soil type represented in the field. In the variable rate strips, N was varied by soil type (**Table 2**). Recommendations were made using normalized yields from the 3 years of yield data and the equation:

> N recommended = normalized yield factor for soil type x average whole field yield for corn x 1.25

Uniform rates for N were based on the whole field average yield. Early differences between the strips were noted in aerial photographs and with a chlorophyll meter. Because growing conditions at this site were ideal, corn responded well to N fertilization.

Preliminary analysis of the yield data shows that the variable rate and uniform rate treatments had similar yields (**Table 2**). Where the variable rate application resulted in more N applied, yields were higher than the uniform rate. However, on the Ponzer Muck soil where the uniform rate resulted in more N applied, yields were higher on the uniform strips than on variable rate strips. The overall results showed no advantages to variable rate N application either in reducing the amount of N applied or in increasing corn yield. Clearly, further study is needed on these systems to better determine yield potential for different areas in a field. Yield potential as determined in this study proved to be too low for the good growing conditions encountered.

These results prove that before nutrient management plans can be done for N, a thorough understanding of the yield potential at the site is required. They also show the importance of yield measurements across a number of years.

If site-specific management of nutrients is to become a widely accepted practice, it

TABLE 1. Soil map units, classification, and corn yield potential as reported by NRCS and from farmer field history.

Soil map units	Soil survey yield potential, bu/A	Farmer yield history, bu/A
Belhaven muck	135	100
Ponzer muck	135	100
Wasda	135	140
Deloss sandy loam	135	180
Tomotley sandy loam	130	180

TABLE 2. Nitrogen applied and yield returns from variable and uniform management of N fertilizer across different soils, 1997.

Area measured	Site-specific management N rate, lb/A	Site-specific management Yield, bu/A	Uniform management N rate, lb/A	Uniform management Yield, bu/A	Statistical difference
Whole field	186	165	185	171	NS
Ponzer soil	125	151	185	182	***
Wasda soil	185	176	185	176	NS
Deloss soil	230	174	185	166	NS

***P<0.05

must be proven to be either cost effective or to have some environmental benefits that justify the extra expense involved in sampling and applying nutrients differentially across a field. Unfortunately, side-by-side comparisons of site-specific versus uniform nutrient management are lacking. This is due to the difficulty in identifying matching field conditions for comparing both practices.

A study site with consistent field conditions across a large area was identified in eastern North Carolina in 1997. Intensive soil sampling on 100 ft. x 800 ft. grids was done to determine nutrient levels, pH, and other soil properties. The field was then divided into 16 subunits each with matching soil conditions. Eight of the subunits were randomly selected to receive site-specific applications of phosphorus (P) and potassium (K), and eight were selected to receive uniform applications. Yields were measured with a grain yield monitor. Comparisons were made between the two fertilizer treatments to determine their effects on grain yields.

Tables 3 and **4** show a comparison between site-specific and uniform P and K management. Under site-specific management total P applied increased (**Table 3**) while less K was required (**Table 4**).

If we consider the distribution of nutrient levels within a field we can see why this could happen. Whenever the average of all soil tests sites is greater than the median or mid-point, there will be an increase in the amount of fertilizer applied using site-specific grid sampling. This happens because the number of samples that test low are overshadowed by a few high to very high samples.

TABLE 3. Comparison of site-specific and uniform P management (DAP @ 11.25¢/lb).

P index	Acres	Grid sample DAP, lb	Grid sample Cost, $	Uniform sample DAP, lb	Uniform sample Cost, $	Difference, $
0-12.5	25.8	6,493	730.46	1,786	200.93	529.53
12.5-25	16.6	2,948	331.65	1,147	129.04	202.61
25-50	61.6	2,694	303.08	4,260	479.25	-176.17
50-75	20.4	0	0	1,413	158.96	-158.96
75-100	1.1	0	0	76	8.55	-8.55
Totals	125.5	12,135	1,365.19	8,682	976.73	388.46

TABLE 4. Comparison of site-specific and uniform K management (0-0-60 @ 13.75¢/lb).

K index	Acres	Grid sample 0-0-60, lb	Grid sample Cost, $	Uniform sample 0-0-60, lb	Uniform sample Cost, $	Difference, $
0-12.5	0	0	0	0	0	0
12.5-25	4.5	715	98.31	665	91.44	6.87
25-50	82.5	11,245	1,546.18	12,183	1,675.16	-128.98
50-75	35.5	1,893	260.28	5,242	720.78	-460.50
75-100	3.0	0	0	443	60.91	-60.91
Totals	125.5	13,853	1,904.77	18,533	2,548.29	-643.52

TABLE 5. Yield differences between areas of two 125-acre cuts with various soil test P levels, 1997.

P index	Recommended P_2O_5	Acres	Yield, bu Variable	Uniform	Difference
0-12.5	122.5	25.8	4,231	3,870	361
12.5-25	74.5	16.6	2,639	2,058	581
25-50	18.1	61.6	9,979	9,917	62
50-75	0	20.4	3,427	3,468	-41
75-100	0	1.1	191	196	-5
>100	0	0	0	0	0
				Total yield difference, bu	958

TABLE 6. Cost profit analysis for variable rate vs. uniform fertilizer application.

Operation	Cost, $ Grid sample		Uniform sample	Difference, $
Phosphorus	1,365.19		976.73	-388.46
Potassium	1,904.77		2,548.29	643.52
Additional yield income	2.20/bu	X	Yield diff. (958 bu)	2,107.60
Cost of soil sampling	1,004.00		251.00	-753.00
Variable rate spreader	376.50		0	-376.50
			Profit advantage to variable rate	1,233.16

Net return to site-specific fertilizer application. Costs include soil sampling on 2.5-acre grids and a $3.00/A charge for variable rate application. Net return/A is $16.35.

Since the average nutrient value is increased by the few high testing samples, there is a tendency to under-fertilize with the uniform application strategy. In comparison, when most of the samples test high, but with a few very low testing samples, the average soil test is low. In this case, site-specific nutrient management will result in less fertlizer used.

Another way to increase profits by using site-specific nutrient management is to increase yields. **Table 5** shows results from two fields. Nutrients in the first field were site-specific applied using grid samples, while nutrients in the second were uniformly applied using an average soil sample. Site-specific nutrient applications increased yields in the areas of the field testing low in P. This resulted in an overall profit of $1,233.16 on 125 acres or $9.87 more profit per acre using site-specific nutrient management (**Table 6**).

Site-specific fertility management can pay as long as nutrient variability exists within a field. Furthermore, studies have shown that even under site-specific nutrient management, soils that test low in P or K tend to always need more of these nutrients. Therefore, variable rate applications should be tailored to meet nutrient requirements over time. BC

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