N Use Efficiency Improved On Dryland Corn

Clemson algorithm successfully used in Southeastern Coastal Plains.

Dr. Pawel Wiatrak

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Summary: *High nitrogen (N) rates are often not fully utilized under dryland corn production systems and may lead to environmental pollution, especially in sandy and less productive soils. Significantly higher corn grain yields were obtained from split applications than from all-at-plant N applications, and higher from 160 lbs/A of N when compared to other treatments. Plant normalized difference vegetation index (NDVI), N content in corn leaves, test and grain weight, and grain N content generally improved with higher N rates. Higher soil nitrate-N concentration was recorded from zones 2 and 3 than from zone 1. The predicted sidedress rate of 90 lbs/A of N, using Clemson algorithm, was 30 lbs/A N less than fixed rate and did not significantly reduce yields compared to fixed N rate. Therefore, Clemson algorithm can be successfully used in improving N use efficiency (NUE) of dryland corn in the Southeastern Coastal Plains.*

Nitrogen is not uniformly utilized in the field in the Southeastern United States due to high variability in soil texture. Application of N at one rate over the entire field is not effective and may decrease environmental quality. Standard procedures for N application on corn, based on soil spatial variability, are not available for the Coastal Plain soils. Determination of the extent to which the crop will respond to additional N as side-dressing can help growers to apply only what is needed.

Numerous studies have shown high correlations between vegetation indices and crop yields. Plant normalized difference vegetation index (NDVI), defined as NIR-Red/NIR+Red, is used for mapping plant growth. The Red and NIR values represent the reflectance in the Red and NIR bands, respectively. Higher positive NDVI values indicate increasing proportion of green vegetation.

The algorithm for predicting N requirements in corn grown in the Southeast has to take into account the soil spatial-variability due to high variability in soil texture. A commercially available soil electrical conductivity (EC) measurement system (Veris Technologies 3100) can help to identify variations in soil texture across the field and create soil EC zone maps using global position systems (GPS) and geographic information systems (GIS).

The main objective of this project was to evaluate application methods, rates, and Clemson N algorithm on corn under different soil electrical conductivity (EC) zones to improve NUE and yields of corn.

Methodology

Soil/location. The study was conducted on Dothan loamy sand (fine loamy, kaolinitic, thermic Plinthic Kandiudult) in a production field at Clemson University, Edisto Research and Education Center (REC) near Blackville, SC in 2012. Winter wheat cover crop was killed in early spring. The experimental area was divided into four soil texture zones, based on soil electrical (EC) conductivity measurements, which were derived from Veris system measurements (Veris Technologies 3100), global positioning system (GPS), and geographic informational system (GIS). Soil zone 1 (lowest soil EC readings) was very sandy with low water and nutrient-holding capacity and soil zone 4 (highest soil EC reading) was mostly clay with high-water and nutrient-holding capacity in this experiment. Three (1-3) zones were used for analyses.

"Significantly higher N concentration was recorded."

N rates. Each soil EC zone consisted of two N application methods (as all-at-once at planting and as split applications) and five N application rates (0, 40, 80, 120, and 160 lbs/A of N) under a strip-tillage system. The methods and N rates for corn were randomized within each soil zone. To validate the Clemson algorithm for variable site-specific application, N rates were calculated using the Clemson N-prediction algorithm and compared to conventional practice for the region. The conventional practice consisted of applying about 40 lbs/A of N at planting and 120 lbs/A of N as sidedress at V6 corn stage, totaling 160 lbs/A of N. The sidedress N treatments were replicated four times in each zone of the test field. Nitrogen Rich Strips (plots with highest N rates) were established in each EC zone to determine the response index (RI) for predicting yield potential when N was applied. All test plots received 40 lbs/A of N at planting, followed by sidedress N application rates:

- Based on Clemson algorithm separately for each zone
- Averaged across soil zones
- Using a conventional rate at V6 corn growth stage.

Additionally, rates 25 percent below and above the averaged predicted rate across zones were also calculated and applied at V6 stage.

Planting. On 14 March, Pioneer 31G71 corn was planted in strip-till at 28,000 seeds/A using a 4-row Univerferth Riper-Stripper implement and John Deere 1700 MaxEmerge XP Vacuum planters.

Plot size was 4 rows wide by 20 feet long and 38-inch row spacing.

Sidedressing. Using a Reddick fluid fertilizer applicator, N (25S – fluid formulation of 25% N and 3.5% sulfur) was sidedressed applied to selected corn plants on March 21. Selected corn plots, including algorithm testing, were sidedressed with remaining N on May 9.

Weed control was based on the South Carolina Extension recommendations.

Evaluation. During corn vegetation, corn was evaluated for NDVI, total N in corn ear leaves, grain yields and yield parameters (grain moisture, test weight, kernel weight), total N in grain, and soil NO_3-N. Plant NDVI was measured in the center of two rows using a GreenSeeker.

Harvesting. On August 13, corn was harvested using a Kinkaid 8XP small grain combine and grain samples were analyzed for moisture, test weight, and kernel weight. Grain yield and kernel weight were adjusted to 15.5% moisture.

Soil samples were collected following corn harvest from a depth of 36 inches and divided into 6-inch increments for NO_3-N content and movement in the soil.

Table 1. Influence of soil zone, N method, and N rates on plant normalized difference vegetation index (NDVI).

Treatment	NDVI						
	17-May	22-May	30-May	7-Jun	15-Jun	20-Jun	29-Jun
Zone							
1	0.766	0.787	0.748	0.784	0.766	0.554	0.661
2	0.822	0.836	0.807	0.829	0.822	0.700	0.737
3	0.819	0.827	0.780	0.825	0.819	0.681	0.737
LSD(0.05)	NS	NS	NS	0.035	NS	0.081	0.030
N method							
At plant	0.801	0.812	0.776	0.806	0.801	0.626	0.700
Split	0.804	0.821	0.781	0.819	0.804	0.664	0.723
LSD(0.05)	NS	NS	NS	0.010	NS	0.030	0.022
N rate (lb/A)							
0	0.752	0.754	0.744	0.767	0.752	0.567	0.653
40	0.769	0.789	0.769	0.798	0.769	0.619	0.698
80	0.826	0.846	0.800	0.827	0.826	0.659	0.716
120	0.827	0.846	0.789	0.831	0.827	0.672	0.730
160	0.837	0.849	0.790	0.840	0.837	0.709	0.762
LSD(0.05)	0.044	0.041	0.024	0.018	0.044	0.055	0.037

Table 2. Influence of soil zone, N method, and N rates on N content in ear-leaf at R1 stage, grain moisture, weight, test weight, grain yield, and grain N content.

Treatment	N in ear-leaf	Grain moisture	Test weight	100 kernel weight	Grain yield	Grain N
	R1					
Zone	**%**	**%**	**lb/Bu**	**gms**	**Bu/acre**	**%**
1	2.2	13.0	51.9	17.7	40.0	1.00
2	2.4	14.3	53.5	22.2	81.0	0.97
3	2.3	14.4	53.3	21.9	88.2	0.99
LSD(0.05)	0.162	1.09	NS	1.666	22.5	NS
N method						
At plant	2.1	13.9	52.3	20.3	60.0	0.96
Split	2.4	13.8	53.5	20.9	79.5	1.02
LSD(0.05)	0.058	NS	1.1	NS	4.7	0.04
N rate (lb/A)						
0	1.8	13.7	51.6	18.4	32.6	0.92
40	2.0	13.5	51.4	19.1	47.5	0.90
80	2.4	14.1	52.9	20.5	66.1	0.97
120	2.6	14.3	54.0	22.4	88.5	1.04
160	2.7	13.9	54.5	22.7	114.1	1.09
LSD(0.05)	0.131	NS	1.6	1.984	17.9	0.05

Table 3. Influence of soil zone, N method, and N rates on NO3-N content in soil samples at 6 inches increments and up to 36 inches soil depth.

Treatment	Soil depth					
	0-6	12-Jun	18-Dec	18-24	24-30	30-36
Zone						
1	1.97	1.79	1.93	2.96	3.11	3.53
2	3.43	2.96	2.74	2.51	3.39	4.16
3	4.57	3.89	3.37	3.42	3.24	3.87
LSD(0.05)	1.55	NS	NS	NS	NS	NS
N method						
At plant	3.33	2.93	2.73	2.69	2.80	3.54
Split	3.32	2.83	2.63	3.26	3.68	4.15
LSD(0.05)	NS	NS	NS	NS	NS	NS
N rate (lb/A)						
0	2.65	2.13	2.17	2.45	2.05	1.87
40	2.93	2.42	2.35	2.14	2.79	2.46
80	3.59	3.21	2.26	3.04	2.23	3.18
120	3.88	3.50	3.03	3.09	3.31	3.94
160	3.59	3.14	3.58	4.12	5.77	7.70
LSD(0.05)	NS	NS	NS	2.01	1.72	2.48

Table 4. Testing predicted sidedress N rates based on Clemson algorithm for each zone and across zones in comparison to a fixed N rate of 120 lb N/acre.

Treatment	N rate/acre
Individually for each zone:	
1	40
2	140
3	140
Across soil zones	120
Fixed N rate	120
Increased by 25% compared to predicted across zones	150
Decreased by 25% compared to predicted N rates across zones.	90

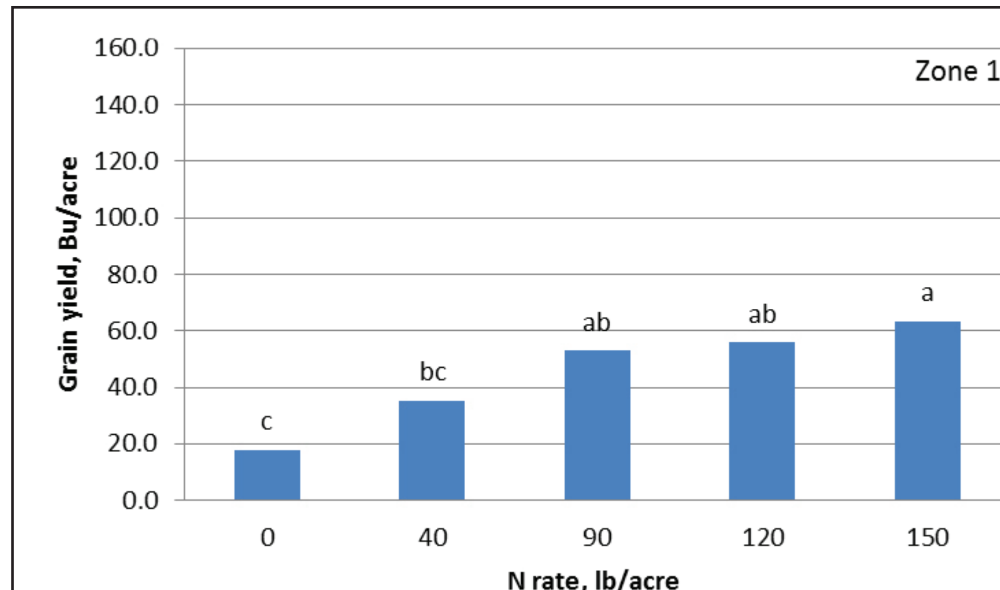

Figure 1: *Influence of predicted sidedress N rates using Clemson algorithm for each zone and across zones in comparison to a fixed rate of 120 lb N/A on corn grain yields in soil zone 1. Letters indicate significant difference at p≤0.05.*

Data were analyzed using the general linear models (SAS, 2011), and means were separated using Fisher's Protected Least Significant Difference (LSD) Test (P≤0.05).

Study results

Generally, higher than average rainfall during the vegetation season, compared to the 30-year average, contributed to greater plant growth and yields. Significantly higher plant NDVI was recorded from soil zones 2 and 3 than from zone 1, and from split than all-at-plant N application rate on June 7, 20, and 29 (Table 1). Plant NDVI was also significantly greater from applications 80, 120, and 160 lbs/A of N than from the control and 40 lbs/A of N.

The N content in corn ear-leaf, grain moisture at harvest, kernel weight, and grain yields was significantly higher in more productive soil zones 2 and 3 compared to less productive sandy soil zone 1 (Table 2). Also, N in corn ear leaves, test weight, grain yield, and grain was greater from split N application than from all-at-plant N application for corn. Compared to control and low N rates, N application at 160 lbs/A of N significantly increased N content in corn ear leaves, grain yield, and grain N. Application rates of 120 and 160 lbs/A of N increased grain test weight and kernel weight.

Significantly higher N concentration was recorded from soil zones 2 and 3 than from soil zone 1, and greater with higher N rates for 18-24, 24-30, and 30-36 inch soil depth (Table 3).

Predicted N rates based on Clemson algorithm were at 40 lbs/A of N for soil zone 1, 140 lbs/A of N for soil zones 2 and 3, 120 lbs/A of N for across soil zones and were comparable to a fixed rate of 120 lbs/A of N and to 25% above and below the average across zones (Table 4). Grain yields from plots with a predicted sidedress rate of 90 lbs/A of N (predicted rate across soil zones and decreased by 25%) were 30 lbs/A of N less than the fixed N rate and did not significantly lower yields compared to higher N rates for soil zones 1, 2, and 3.

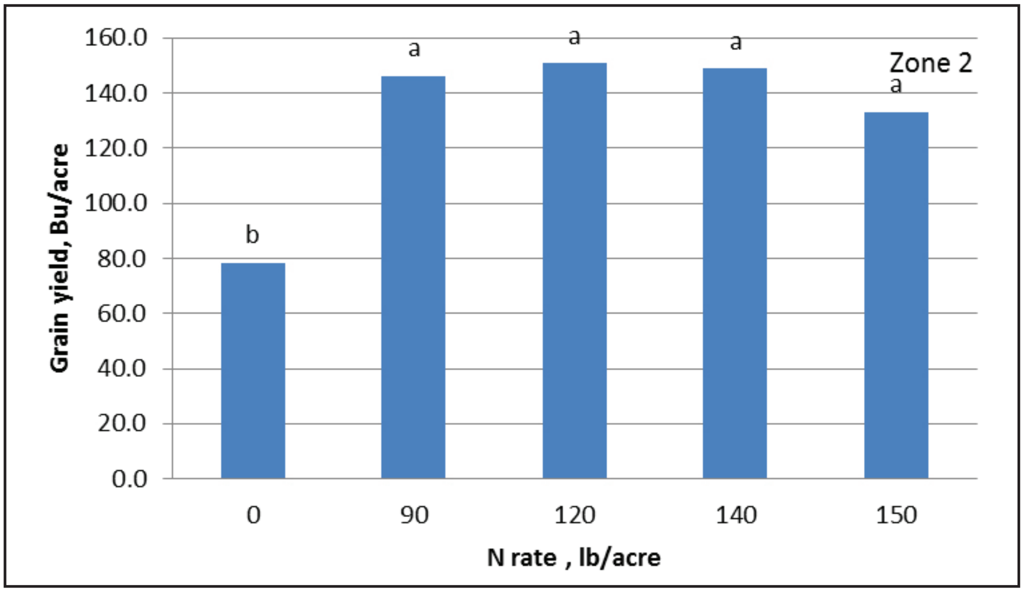

Fig. 2. *Influence of predicted sidedress N rates using Clemson algorithm for each zone and across zones in comparison to a fixed rate of 120 lb N/acre on corn grain yields in soil zone 2. Letters indicate significant difference at p≤0.05.*

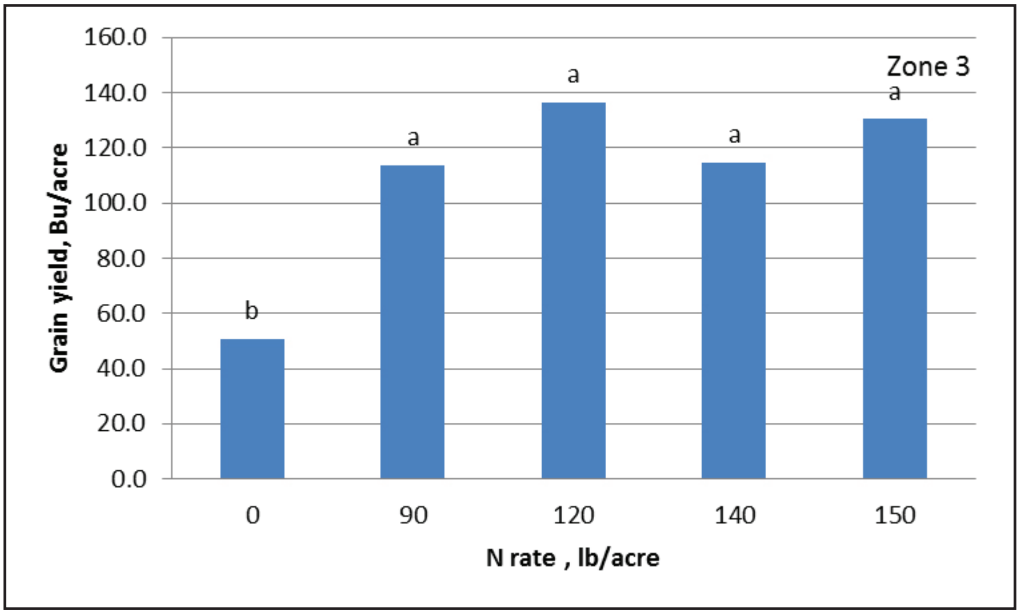

Fig. 3. *Influence of algorithm predicted sidedress N rates for each zone and across zones in comparison to a fixed rate of 120 lb N/acre on corn grain yields in soil zone 3. Letters indicate significant difference at p≤0.05.*

Summing up

Grain yields were significantly higher for soil zones 2 and 3 than zone 1, higher from split than all-at-planting, and higher from the highest rate of 160 lbs/A of N compared to other N treatments of corn (Figures 1, 2 and 3). Higher grain yields were mostly due to:

- Greater plant NDVI
- N content in corn leaves
- Test and grain weight
- Grain N content.

The soil nitrate-N concentration was higher from zones 2 and 3 due to higher holding capacity of these zones compared to zone 1, and higher with high N rates at 18-24, 24-30, and 30-36 inch soil depths, indicating N movement into lower soil profiles with high N rates.

The predicted rate of 90 lbs/A of N using Clemson algorithm and NDVI readings did not significantly decrease grain yields compared to the fixed sidedress N rate of 120 lbs/A of N. Therefore, sidedress N rates could be decreased by 30 lbs/A of N without significant yield reduction for soil zones 1, 2, and 3, indicating that Clemson algorithm could be efficiently used in predicting sidedress N rates and improving NUE and profitability of corn production.

Dr. Wiatrak is Assistant Professor/ Agronomist in the Department of Entomology, Soils, and Plant Sciences at Clemson University in Blackville, South Carolina.