CORN MARKETING PROGRAM
CMPM
OF MICHIGAN

2017 Research Report

In-Season N Applications Using Applicator Assisted Technologies

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Location: Saginaw Valley Research and Extension Center	**Tillage**: Conventional
Planting Date: April 28, 2017; 30 in. rows	**N Timing, Rate, and Source**: See below
Harvest Date: October 12, 2017	**Population**: 34,000 seeds/ acre
Soil Type: Tappan-Londo Loam; 2.8 OM, 17 CEC; 23 ppm P; 173 ppm K; 7.8 pH	**Replicated**: 4 replications
Variety: DKC51-38RIB	

Location: MSU Agronomy Farm	**Tillage**: Conventional
Planting Date: May 12, 2017; 30 in. rows	**N Timing, Rate, and Source**: See below
Harvest Date: October 10, 2017	**Population**: 34,000 seeds/ acre
Soil Type: Capac Loam; 2.8 OM, 12.7 CEC; 13 ppm P; 82 ppm K; 7.1 pH	**Replicated**: 4 replications
Variety: DKC51-38RIB	

Introduction: Nitrogen (N) is often regarded as the most essential nutrient in corn production due to the high N requirements for chlorophyll, starch, amino acids, and plant protein. In corn, 41% of grain yield is dependent on N fertilizer. Volatile spring weather conditions and earlier corn planting dates continue to place greater emphasis on improved N management strategies. Nitrogen placement and timing are key factors more closely synchronizing N availability with peak corn N demand. Applying less N early in the growing season allows the grower to avoid periods of intense rainfall and N loss. However recent data now demonstrate that under both wet and dry soil conditions, opportunities to improve corn yield were reduced when early season N applications were skipped in favor of late season N application.

New technologies have been developed in response to the need for more efficient N applications, including the 360 Yield Center Y-Drop. The idea is to place N directly at the base of the plant to improve nitrogen use efficiency as compared to traditional coulter-injected sidedress applications which are placed 15 inches away from the base of the plant. While the 360

Y-Drops suggest more efficient N applications, few data exist directly comparing conventional corn N management strategies with more modern N application methods under Michigan field conditions.

Objective 1: Evaluate the impact of new N placement and timing strategies on corn grain yield and economic return. Our *working hypothesis* is that placing N closer to the plant will positively affect nitrogen use efficiency, grain yield, and net economic return.

Methods and Procedures: Field studies were initiated to evaluate the impact of nitrogen placement and timing strategies using modern applicator assisted technologies. Trials were planted on 28 April 2017 in Richville on a non-irrigated Tappan-Londo loam soil and on 12 May 2017 in Lansing on a non-irrigated Capac loam soil. Richville was previously cropped to non-inter-seeded wheat and Lansing was previously cropped to soybean.

Experiments were designed as a randomized complete block with four replications. The corn hybrid used in both trials was DKC 51-38 in 30-inch rows to achieve a final seeding rate of 34,000 seeds A^{-1}. Triple-superphosphate (0-45-0) and muriate of potash (0-0-62) were applied based on pre-season soil test recommendations at both locations. Nitrogen rates were determined using MRTN recommendations resulting in an N rate of 170 lbs N per acre in Richville and 145 lbs N per acre in Lansing. Treatment design can be seen in Tables 1 and Table 2 for Richville and Lansing, respectively.

Pre-emerge (PRE) applications were made immediately following planting with no incorporation as compared to PPI applications which were applied and incorporated prior to planting. Sidedress applications were made at V5-6 on 6 June 2017 in Richville and on 9 June 2017 in Lansing. Yield was determined by harvesting the two center rows in each plot and adjusted to 15.5% moisture. Statistical analyses were performed using PROC GLIMMIX in SAS at $\alpha = 0.10$ to determine the impact of N strategy on yield and economic return. Additional observations not included in the results and discussion include NDVI (Greenseeker) at V4, V6, and V10; SPAD at V6, R1, and R4; plant height at V6 and R1; visual leaf firing ratings every two weeks after R1; soil residual nitrate samples (0-12 inch) at harvest.

Table 1. Treatment design for Richville, MI, 2017.

Trt #	N Rate (lb. N/A)	N Placement and Timing
1	0	Untreated Control
2	170	Urea, PRE-Emerge
3	170	Urea w/ Agrotain, PRE-Emerge
4	170	50% Urea (PPI), 50% Sidedress Coulter-inject (UAN)
5	170	50% Urea (PPI), 50% Sidedress Y-Drop (UAN)
6	170	50% Urea (PPI), 50% Sidedress Y-Drop w/ Agrotain (UAN)
7	170	0% Urea (PPI), 100% Sidedress Coulter-inject (UAN)
8	170	0% Urea (PPI), 100% Sidedress Y-Drop (UAN)
9	170	0% Urea (PPI), 100% Sidedress Y-Drop w/ Agrotain (UAN)
10	170	2x2 (40 lbs N), 130 lbs N V6 Coulter-inject (UAN)
11	170	2x2 (40 lbs N), 130 lbs N V6 Y-Drop (UAN)
12	170	2x2 (40 lbs N), 130 lbs N V6 Y-Drop w/ Agrotain (UAN)

-A starter fertilizer was applied at planting, pre-plant incorporated, of 75 lbs P_2O_5

Table 2. Treatment design for Lansing, MI, 2017.

Trt #	N Rate (lb. N/A)	N Placement and Timing
1	0	Untreated Control
2	145	Urea, PRE-Emerge
3	145	Urea w/ Agrotain, PRE-Emerge
4	145	50% Urea (PPI), 50% Sidedress Coulter-inject (UAN)
5	145	50% Urea (PPI), 50% Sidedress Y-Drop (UAN)
6	145	50% Urea (PPI), 50% Sidedress Y-Drop w/ Agrotain (UAN)
7	145	0% Urea (PPI), 100% Sidedress Coulter-inject (UAN)
8	145	0% Urea (PPI), 100% Sidedress Y-Drop (UAN)
9	145	0% Urea (PPI), 100% Sidedress Y-Drop w/ Agrotain (UAN)
10	145	2x2 (40 lbs N), 105 lbs N V6 Coulter-inject (UAN)
11	145	2x2 (40 lbs N), 105 lbs N V6 Y-Drop (UAN)
12	145	2x2 (40 lbs N), 105 lbs N V6 Y-Drop w/ Agrotain (UAN)

-A starter fertilizer was applied at planting, pre-plant incorporated, of 84 lbs P_2O_5 and 95 lbs K_2O

Results and Discussion:

Richville:

Precipitation for the 2017 growing season resulted in a rainfall deficit of 0.7 inches from the 30-year mean (April-September). Spring temperatures were 4.5 degrees above and 0.7 degrees below normal for April and May, respectively. Precipitation for April and May was 2.9 inches above and 1.4 inches below normal (Table 3). Rainfall frequencies for May mostly occurred in the beginning and later part of the month, with few rainfall events between 5 May and 20 May totaling only 0.28 inches (Figure 1). Environmental conditions in late April and early May increased the potential for N loss by volatilization. Larger rainfall deficits occurred during reproductive stages in August and September and were 2.6 inches below normal between the two months. Average air temperatures were cooler than normal in August and September at 66.7 and 64.2 degrees Fahrenheit, respectively.

Table 3. Mean monthly weather data for Richville and Lansing, MI, 2017. Values in parenthesis are deviations from the 30-year average.

Location	Month					
	April	May	June	July	August	September
Richville						
T avg, ˚F	50.6 (+4.5)	56.6 (-0.7)	68.7 (+1.5)	70.2 (-0.8)	66.7 (-2.1)	64.2 (-2.7)
Precipitation, in	5.8 (+2.9)	2.0 (-1.4)	4.8 (+1.9)	1.1 (-1.5)	2.3 (-1.0)	1.6 (-1.6)
Lansing						
T avg, ˚F	52.0 (-4.6)	56.3 (-1.4)	67.8 (+0.2)	71.1 (-0.4)	66.8 (-3.0)	64.3 (-2.1)
Precipitation, in	5.2 (+2.2)	2.6 (-0.8)	3.3 (-0.2)	2.7 (-0.2)	1.4 (-1.9)	1.3 (-2.2)

Nitrogen timing strategies significantly affected grain yield and economic return in 2017. Yield was significantly increased by delaying 100% of the N application (0/100) until V5/6 vs. a 50/50 split (50% at planting and 50% at V5/6) or 100% at planting (PRE). The 0/100 treatment yielded 195 bu A^{-1} while a significant yield reduction occurred with the 50/50 and PRE treatments, resulting in yields of 181 and 176 bu A^{-1}, respectively (Table 4). The corn plant only requires approximately 15% of its N requirement before V10. Thus, plants may have been able to capitalize on favorable early-season environmental conditions and reduce N loss potential by delaying N applications until closer to peak uptake periods. The 2x2 was also able to capitalize on early-season environmental conditions and give the plant a better start-right capacity while reducing N loss potential. Economic return was maximized by delaying N applications until V5/6 and significantly reduced when 100% of the N was applied at planting.

Coulter-inject sidedress applications produced 199 bu A^{-1} compared to Y-drop applications which yielded 183 bu A^{-1} (Table 4). Dry conditions following sidedress applications may have restricted N movement into the soil. No rainfall events occurred within 8 days of application (Figure 1), which may have increased N losses or limited N mobility with the Y-drop applications. Y-drop applications resulted in a net economic return of \$489 A^{-1} a significant decrease from coulter-injected sidedress applications which resulted in a net economic return of \$547 A^{-1}. The use of a urease inhibitor did not significantly impact grain yield indicating environmental conditions were not sufficient to promote volatile N losses. Nitrogen applied with a UI averaged 181 bu A^{-1} while N without a UI averaged 180 bu A^{-1}. Economic return was also similar between the UI and non-UI treatments.

Table 4. Yield and economic return, Richville and Lansing, 2017.

N Strategy	Grain Yield†		Economic Return	
	Richville	Lansing	Richville	Lansing
	--------------------Bu A^{-1}--------------------		-----------------US$ A^{-1}------------------	
PRE	178 def¶	168 a	$483 ed	$464 a
PRE w/UI‡	173 ef	183 a	$457 ed	$500 a
0/100: Coulter	202 a	185 a	$560 a	$519 a
0/100: Y-drop	192 abcd	171 a	$525 abc	$471 a
0/100: Y-drop w/ UI§	189 abcde	179 a	$506 bcd	$489 a
50/50: Coulter	195 abc	163 a	$529 abc	$443 a
50/50: Y-drop	171 f	157 a	$451 e	$420 a
50/50: Y-drop w/UI§	178 cdef	161 a	$467 ed	$428 a
2x2: Coulter	199 ab	195 a	$550 ab	$549 a
2x2: Y-drop	181 cdef	176 a	$489 cde	$485 a
2x2: Y-drop w/ UI§	185 bcdef	188 a	$495 cde	$518 a
$P_r > F$	0.0476	ns#	0.0160	ns
Untreated††	83.6	94	$257	$290
Multiple *df* contrasts				
PRE	176 c	175 a	$470 c	$482 a
0/100	195 a	178 a	$530 a	$482 a
50/50	181 bc	160 a	$483 bc	$430 a
2x2	188 ab	186 a	$511 ab	$517 a
$P_r > F$	0.0301	ns	0.0167	ns
Coulter	199 a	181 a	$547 a	$504 a
Y-drop	183 b	172 a	$489 b	$468 a
$P_r > F$	<.01	ns	<.01	ns
No UI	180 a	168 a	$487 a	$460 a
UI	181 a	178 a	$481 a	$483 a
$P_r > F$	ns	ns	ns	ns

† Grain yield reported at 15.5% moisture.
‡ Urease inhibitor applied with Agrotain Advanced 1.0 at 2.0 quarts/ton Urea.
§ Urease inhibitor applied with Agrotain Advanced 1.0 at 1.0 quart/ton UAN.
¶ Values within each column followed by the same lowercase letter are not significantly different at $\alpha = 0.1$
# ns, not significant.
†† Untreated control not included in statistical analysis.

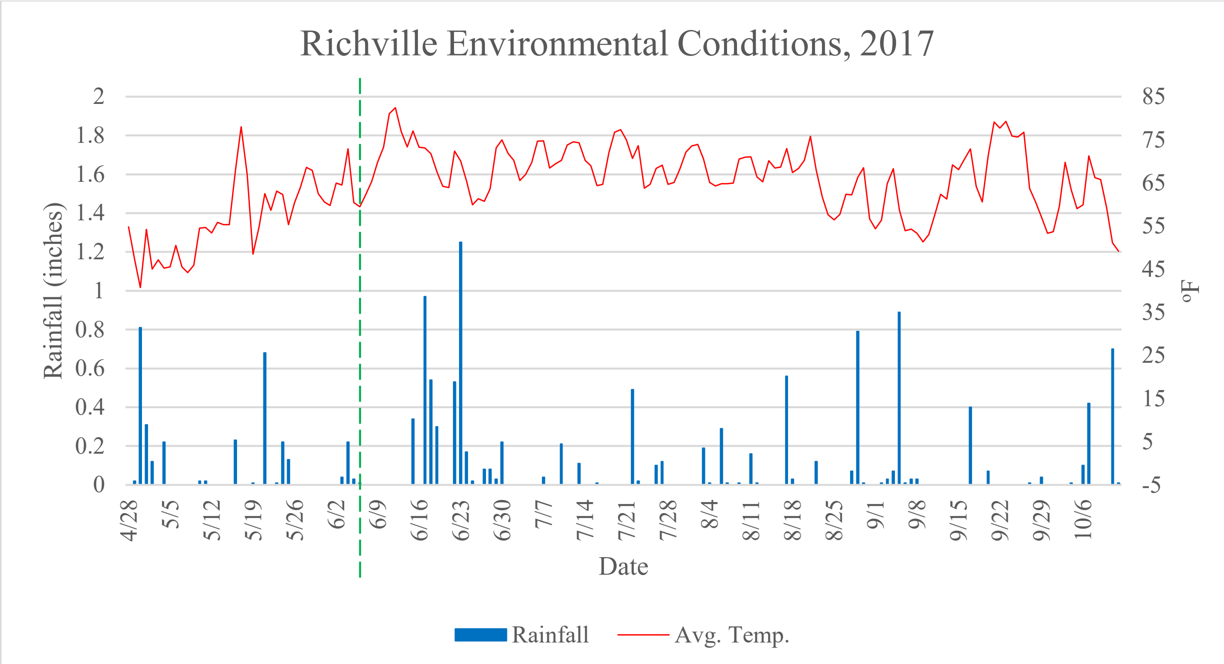

Figure 1. Rainfall frequency and average air temperature, Richville, 2017. Green vertical line indicates sidedress applications (6 June 2017).

Lansing:

Environmental conditions in Lansing varied from Richville. Spring average temperatures for April and May were 4.6 and 1.4 degrees below normal (Table 3). Precipitation in April totaled 5.22 inches, 2.2 inches above the 30-year mean. Precipitation in May was 0.8 inches below normal, with an overall season deficit (April – September) of 3.1 inches. Precipitation during critical reproductive stages (July – September) was 4.3 inches below normal with average temperatures 0.4, 3.0 and 2.1 below normal in July, August, and September, respectively.

Nitrogen placement and timing strategies did not significantly affect yield in Lansing. Yield results from N timing strategies suggest there was no advantage to delaying N applications until V5/6 presumably due to lack of soil moisture and N loss conditions. The 2x2 applied N treatment did appear to improve the start-right capacity of the plant resulting in the greatest yield among N strategies. Economic return increased to \$517 A^{-1} when a 2x2 was used but was not significantly greater than other N strategies. Y-drop N applications were statistically similar but numerically less than traditional coulter-inject sidedress application. The overall rainfall deficit from May – September likely negated differences in N placement. Due to a lack of grain yield differences among treatements, economic return was also not significantly affected by N strategy.

The use of a urease inhibitor resulted in a non-significant increase of 10 bu A^{-1}. Lack of significant rainfall within 8 days of planting and 5 days of sidedress application may have resulted in some N volatilization losses but not large enough to create significant N loss conditions. Economic return was not significantly affected when utilizing a UI.

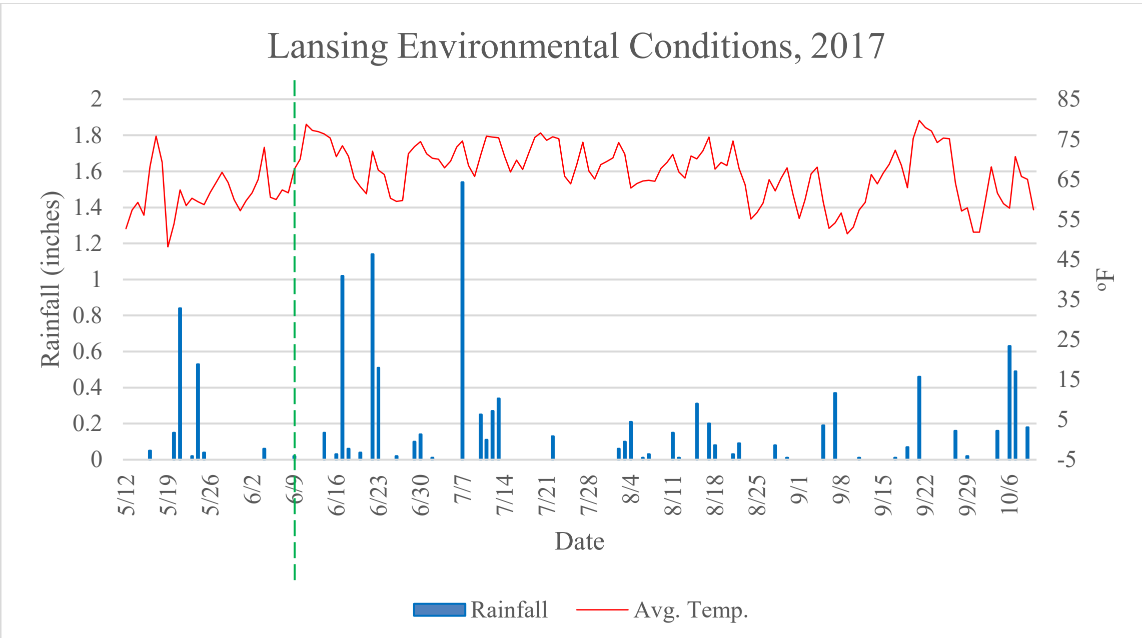

Figure 1. Rainfall frequency and average air temperature, Lansing, 2017. Green vertical line indicates sidedress application (9 June 2017).

Summary:

Nitrogen placement and timing are key factors that may better synchronize N availability with peak corn N demand. In 2017, positive yield gains were not achieved with N placement adjacent to the plant utilizing Y-drop applicators as compared to coulter-inject N application 15 inches away from the base of the plant. In Richville, yield was significantly reduced by 16 bu/A with Y-drop N application compared to coulter-inject while profitability was significantly increased by $58/A using coulter-inject N applications. No statistical differences were evident at the Lansing location as coulter-inject and Y-drop resulted in 181 and 172 bu/A, respectively. Profitability was unaffected at this location but the greater grain yield attained with coulter-inject resulted in $36/A increase over Y-drop applications.

Due to less rainfall and drier soil conditions in Lansing, overall N timing strategy did not affect grain yield or profitability. In Richville, the entire N application at V4-6 resulted in similar grain yield as the 2x2 at-plant and V4-6 combination but significantly greater than the 50/50 or PRE timings. Profitability paralleled grain yield results at this location.

The use of a urease inhibitor did not result in significant grain yield differences at either location. Comparisons of all treatments with a urease inhibitor to all treatments not utilizing a urease inhibitor (i.e., multiple degree of freedom contrasts) revealed a non-significant 1-10 bu/A increase in grain yield and no difference in overall profitability. The Lansing location had less rainfall after N application but not dry enough to observe a significant response to the addition of a urease inhibitor.

Seasonal weather variability will influence N management decisions. Dry mid- to late-summer soil conditions influenced 2017 grain yields. However, the 40 lbs. N applied 2x2 followed by V4-6 sidedress continued to offer the most consistency across locations and supports data collected from 2014-2016. The 2x2 N strategy offers the start-right capacity for early season root and shoot growth to then allow the plant to capitalize upon mid-season environmental variability whether wet or dry. This idea of starting right to finish well is important considering growers cannot predict future rainfall conditions following planting. Nitrogen placement closer to the plant did not improve yield and occasionally reduced yield.

Water is one of four factors required to be in the same place for root nutrient uptake. Surface N placement often places N in a location that is subject to daily wetting/drying cycles which may limit nutrient movement. Soil moisture is often greater beneath the surface rather than at the surface and may explain why coulter-inject N resulted in greater grain yield in 2017, a year where mid-season moisture was limited. Enhanced efficiency fertilizers including urease inhibitors are meant to delay specific forms of N transformation. In the case of urease inhibitors, the mode of delayed N loss is ammonia volatilization from surface-applied N fertilizer. Enhanced efficiency fertilizers require N-loss conditions to result in yield or profitability benefits. Results from this study in 2017 indicated conditions were not dry enough to lead to significant positive changes in grain yield when utilizing a urease inhibitor.