Efficient Fluid Fertilizer Management for Corn Producers with Automatic Guidance Systems: Year Two

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ABSTRACT

The most precise GPS-controlled automatic guidance system currently available for agricultural equipment is the RTK system. This tool provides new opportunities for varying crop row position relative to recent (or older) nutrient bands and prior crop rows. Our objective in this research was to evaluate optimum corn row positions following pre-plant UAN application at various N rates. We applied UAN bands with 3 N rates (50, 100 and 200 pounds per acre) at a depth of 4" and seeded no-till corn the same day in rows positioned 0, 5 or 10 inches from these bands. All plots, including a no pre-plant UAN control, received the same total 200 pounds per acre of N by adjustments made in side-dress UAN application after corn emergence. In 2007, our second year of research, we tested corn response at 3 locations in NC and NW Indiana. We determined that corn yields were reduced significantly at the 100 pound and 200 pound pre-plant N rates at 2 of 3 locations when rows were planted directly over the UAN band. Lower plant populations (aggravated by limited rainfall) seemed to be the primary cause of the latter yield reductions, though stunted early growth was also evident. Starter fertilizer application as 10-34-0 in a 2" by 2" band had no effect on corn population, height or yield response to proximity of the pre-plant UAN bands. We tentatively conclude that RTK guidance is advantageous when planting no-till corn soon after banded UAN application, and that the optimum corn row position for a "safe" response shortly after UAN application at high rates is about 5 inches from, and parallel to, the UAN band. Negative effects on yield are most likely when corn rows are directly over the UAN bands at N rates above 100 pounds per acre, but – in very dry situations after planting - negative effects of 0" displacement on plant population can also be evident at N rates as low as 50 pounds per acre.

INTRODUCTION

Recent developments in GPS-guided automatic steering systems have opened up many new management options for corn producers. Automatic guidance devices have provided benefits in terms of improved timeliness of field operations, less operator fatigue, reductions in overlapping applications of pesticides and fertilizers, controlled traffic system opportunities, as well as reduction in capital expenses (such as the possible elimination of row markers on corn planters, or the use of strip tillage tools that are only ½ to 2/3 of the corn planter width). The economic merits of automatic steering devices are still being debated, as are the relative merits of automatic guidance systems with various degrees of accuracy. Many farmers question the extra cost associated with the RTK system, which provides up to 1 inch accuracy.

However, until now, there has been very little research or extension emphasis on the possible benefits of automatic steering systems for improved efficiencies in fertilizer application and crop utilization. About the only generalization to have emerged from the discussion thus far is that automatic guidance systems should lessen the total fertilizer applied because of less overlap (associated with more precision of the driving patterns of wide applicators, especially in non-rectangular fields). Clearly, there are many more new opportunities to be explored as possible fertilizer efficiency gains and improved profitability for corn producers who can now purchase various GPS automatic guidance systems for their

tractors (and soon for the implements that are pulled behind the GPS guided tractors to correct for side-slopes), and who may also want to be capable of integrating their corn planting row placement with their own, or custom, band fertilizer applications.

Our interest in combining no-till and strip tillage operations with liquid fertilizer banding grew over years of researching and promoting strip tillage and deep banding of dry fertilizers for high yield corn production systems. When the Cropping Systems Research Division of John Deere was able to loan us RTK equipment in the fall of 2005, and with funding from both the Fluid Fertilizer Foundation and the Mary S. Rice Farm Fund at Purdue University, we were able to initiate research related to fluid fertilizer placement and corn row position.

The objectives of this research were to:

1. Determine the realistic joint benefits associated with automatic guidance systems for both UAN fertilizer banding and planting systems in no-till corn production.
2. Quantify the effects of various degrees of planter precision - relative to pre-planting UAN fertilizer bands - on corn nutrient uptake, growth and yield.
3. Determine whether the combination of automatic guidance systems and pre-plant banded UAN fertilizer application would circumvent the need for liquid starter fertilizer applicators on corn planters.

METHODOLOGY

Equipment and Locations: John Deere loaned us a RTK base station plus a 7930 tractor equipped with Automatic Guidance (RTK) and front-wheel assist for research purposes at the Agronomy Center for Research and Education (referred to as ACRE, and located near West Lafayette, IN), at the Throckmorton-Purdue Agricultural Center (referred to as TPAC, and located south of Lafayette, IN) and the Pinney-Purdue Agricultural Center (referred to as PPAC, and located near Wanatah, IN). We used a 7-coulter DMI Nutri-Placr 2800 for pre-plant and side-dress UAN application on our research plots at these 2 locations. We were able to plant corn with 6-row no-till planters at all 3 locations (a JD 1780 planter, also donated by the Cropping Systems Group of John Deere in 2000), and a JD 1770 planter at PPAC. Both planters have liquid fertilizer attachments for the traditional 2"x2" placement. The soil at ACRE is a Brookston silty clay loam with about 4% organic matter, the soil at TPAC is a mixture of Lauramie silt loam and Throckmorton silt loam with about 2.4% organic matter, and the soil at PPAC is a Raub sandy loam with about 2.5 % organic matter.

Treatments, Experimental Design, and Cultural Practices: Field experiments established as either split-plot (ACRE) or RCB (PPAC) with 6 replications involved no-till corn planting on soybean stubble shortly after (on the same day) pre-plant UAN application in May of 2007. Individual plot lengths were 90 feet at ACRE and 135 feet at PPAC. All plots received the same total rate of N fertilizer (i.e. 200 pounds/acre of actual N as UAN), but the amount of pre-plant UAN varied from 0 to 200 pounds actual N per acre. Pre-plant UAN was banded to a depth of approximately 4". The side-dress UAN application rates (applied between the corn rows at approximately the V-4 stage) also varied from 0 to 200 pounds N per acre. The cultural practices for each location are outlined in Tables 1 to 3.

Main treatments: Corn Row Proximity to Pre-plant UAN Fertilizer

1. Control (no pre-plant UAN band),
2. Pre-plant UAN at 50 pounds, Planter 0" (on-row)
3. Pre-plant UAN at 50 pounds, Planter ± 5"
4. Pre-plant UAN at 50 pounds, Planter ± 10"
5. Pre-plant UAN at 100 pounds, Planter 0" (on-row)
6. Pre-plant UAN at 100 pounds, Planter ± 5"
7. Pre-plant UAN at 100 pounds, Planter ± 10"
8. Pre-plant UAN at 200 pounds, Planter 0" (on-row)
9. Pre-plant UAN at 200 pounds, Planter ± 5"
10. Pre-plant UAN at 200 pounds, Planter ± 10"

Sub-treatments: Starter at planting (at ACRE and TPAC only)

1. Without 2” x 2” starter-band placement of 10-34-0 at 20 gallons/acre
2. With 2” x 2” starter band placement of 10-34-0 at 20 gallons/acre

Table 1. Cultural Practices Used in 2007
Field 117, ACRE, 2007

Field Operation	Date	Application Details
Hybrid planted	4/24	Pioneer 33N12
Seeding rate		34,000 seeds/a. Planting speed was 5.6 mph.
Starter fertilizer/planter		10-34-0 @ 20 gallons/a., 2-inches to the side and 2-inches below the seed. Starter fertilizer was applied to south half of each plot.
Insecticide/planter		Force 3G, 5.5 oz/1000 row feet
Weed control	4/24	Burn-down and pre-emergence: Roundup Original Max at 24 ounces/a. Harness Extra 5.6 at 5 pts/a.
	6/1	Post-emergence: Roundup Original Max at 22 ounce/a. Ammonium sulfate at 8 lbs/100 gallons water
Nitrogen fertilizer	4/24	Pre-plant UAN per treatment
	5/24	Post-plant UAN per treatment
Harvest	10/5	Machine harvest 2 rows of each 6 row plot, 90 feet.

Table 2. Cultural Practices Used
Meigs South 5, Throckmorton PAC, 2007

Field Operation	Date	Application Details
Hybrid planted	5/1	Pioneer 31N12
Seeding rate		34,000 seeds/a. Planting speed was 5.6 mph.
Starter fertilizer/planter		20 gallons/a. of 10-34-0, 2-inches to the side and 2-inches below the seed. Starter fertilizer was applied to south half of each plot.
Insecticide/planter		Force 3G, 5.5 oz/1000 row feet
Weed control	4/24	Burn-down: Cornerstone at 32 ounces/a. Amaze Gold 2.5 gal/100 gal water
	5/5	Pre-emergence: Degree Xtra 7 pt/a. Atrazine 4L 0.75 pt/a.
	5/30	Post-emergence: Cornerstone at 32 ounces/a. Callipso at 3 ounces/a. Alliance 1 gal/100 gal water
Nitrogen fertilizer	5/1	Pre-plant UAN per treatment
	5/3	Post-plant UAN per treatment
Harvest	10/10	Machine harvest all 6 rows of each plot, 90 feet.

Table 3. Cultural Practices Used in 2007 Field I-7, Pinney PAC, 2007		
Field Operation	Date	Application Details
Lime	5/3	1 ton/a.
Phosphorous		None
Potassium	4/21	0-0-60 @ 110 lbs/a.
Hybrid planted	5/9	Pioneer 34A20
Seeding rate		33,000 seeds/a. Planting speed was 5.6 mph.
Starter fertilizer/planter		19-17-0 @ 20 gallons/a, 2-inches to the side and 2-inches below the seed
Insecticide/planter		Force 3G @ 5.5 oz/1000 row feet
Weed control	4/21	Burn-down: 2,4-DLV @ 1 pt/a. Buccaneer Plus @ 2 pt/a.
	5/14	Pre-emergence: Buccaneer Plus @ 7 pts/a. Balance Pro @ 1.5 ounce/a.
Nitrogen fertilizer	5/9	Pre-plant UAN per treatment
	5/31	Post-plant UAN per treatment
Harvest	10/15	Machine harvest center 6 rows of each 12 row plot, 135 feet.

RESULTS and DISCUSSION

Location 1 (ACRE)

The overall negative effects of on-row planting on early plant establishment after pre-plant UAN banding at high N rates were less than anticipated at this location (Table 4). Corn plant populations were much lower than expected because of significant crusting (due to intense rain shortly after planting was completed). Plant populations were lower for on-row planting at the 200 pound rate when starter was also applied. However, plant populations were unaffected by starter fertilizer.

Corn yields were lowest when the rows were planted directly over the 100 pound N rate (with both starter treatments) or over the 200 pound N rate when starter fertilizer was also applied (Table 4). Corn yields were highest following the 200 pound N rate provided the rows were 5” or 10” away from the UAN band. Corn yields were and corn moisture content were unaffected by starter fertilizer.

For this environment and year, it seems that there was no advantage to starter, and no disadvantage to planting directly over the UAN band unless the N rate was 100 or 200 pounds per acre. This contrasted with the results from this same location in an adjoining field in 2006, when there was no yield disadvantage from seeding over a UAN band at any N rate (Vyn and West, 2007). Another contrast with the 2006 results was that starter fertilizer resulted in a 13 bushel/acre yield boost in 2006, but none in 2007.

Table 4. Corn response to pre-plant banded UAN application and RTK-guided corn row placement at ACRE, 2007.†

Starter Fertilizer?	Pre-plant N rate and Placement	Stand 4 weeks	Plant Height V6	Harvest Moisture	Yield @ 15.5%
		ppa	in	%	bu/a.
None	0 pre-plant UAN	23667ab		19.5ab	205.9ab
	50 lbs on row	23417ab		19.5ab	201.2ab
	50 lbs 5 inches	24708ab		19.6ab	207.8a
	50 lbs 10 inches	23500ab		19.7ab	208.3a
	100 lbs on row	23542ab		19.8ab	187.9b
	100 lbs 5 inches	24000ab		19.6ab	205.4ab
	100 lbs 10 inches	24208ab		19.5ab	209.3a
	200 lbs on row	24208ab		20.1a	200.9ab
	200 lbs 5 inches	25542a		19.4b	214.0a
	200 lbs 10 inches	22375b		19.5ab	215.4a
	LSD (5%)	2619		0.58	18.2
Yes	0 pre-plant UAN	24042a		19.5ab	206.2abc
	50 lbs on row	21917ab		19.5ab	202.9abc
	50 lbs 5 inches	23875a		19.7ab	203.5abc
	50 lbs 10 inches	22917ab		19.4ab	202.4abc
	100 lbs on row	22708ab		19.8a	189.0c
	100 lbs 5 inches	22333ab		19.6ab	203.4abc
	100 lbs 10 inches	23667a		19.1b	199.9bc
	200 lbs on row	20625b		19.5ab	197.3bc
	200 lbs 5 inches	24542a		19.7ab	223.5a
	200 lbs 10 inches	22500ab		19.5ab	219.3ab
	LSD (5%)	2905		0.61	22.2
None	Mean of 10 treat.	23917		19.6	205.6
Yes	Mean of 10 treat.	22913		19.5	204.8

† Average of 6 replications
‡ Means with the same letter are not significantly different.

Location 2 (TPAC):

Corn plant establishment at TPAC was very negatively affected by placing corn rows on directly over some pre-plant UAN bands. Considerable plant death occurred with on-row planting at N rates of 100 pounds and 200 pounds per acre, but not with on-row planting at the 50 pound rate (Table 5). Only 80% of the plants survived with on-row planting at 100 pounds N, and less than 60% of the plants survived at the 200 pound rate of N. Dry weather conditions prevailed after planting, and this might have aggravated the toxic effect of the urea fraction in UAN on seedling emergence. Corn plants that did survive were not severely stunted in these same two treatments relative to other row placement treatments. Plant populations were also lower when the corn rows were 5" away from the 200 pound N rate and no starter fertilizer was applied, but the same detrimental effect was not observed with starter.

Grain yields were dramatically affected by corn row position relative to the pre-plant UAN bands, but not by starter treatment or the row position and starter interaction (Table 5). At the 100 pound N rate, planting on-row reduced corn yields by an average 24 bushels per acre relative to planting 5" from the pre-plant UAN bands at the same N rate. At the 200 pound N rate, planting on-row reduced corn yields by an average 38 bushels per acre relative to planting 5" from the pre-plant bands, and by 51 bushels per acre relative to planting 10" away from the pre-plant N band. Although yields were slightly lower even with on-row planting at the 50 pound rate, there was no significant effect of on-row planting on corn growth at the 50 pound N rate.

The addition of starter fertilizer resulted in faster early growth (Table 5), but no increase in final corn yields at this location. Overall soil-test P at this location averaged 31 ppm (Mehlich 3 extractant) and soil-test K was only 77 ppm.

Table 5. Corn response to pre-plant banded UAN application and RTK-guided corn row placement at TPAC, 2007.†

Starter Fertilizer?	Pre-plant N rate and Placement	Stand 4 weeks	Plant Height V6	Harvest Moisture	Yield @ 15.5%
		ppa	in	%	bu/a.
None	0 pre-plant UAN	31750a	32.8	18.3	185.5abc
	50 lbs on row	31292a	34.4	17.7	181.0abc
	50 lbs 5 inches	31792a	35.3	17.3	186.8abc
	50 lbs 10 inches	31208a	34.4	18.0	200.5a
	100 lbs on row	23958b	33.7	17.8	181.5abc
	100 lbs 5 inches	30083a	34.4	17.7	193.1ab
	100 lbs 10 inches	31583a	34.3	17.7	174.3cd
	200 lbs on row	16458c	34.2	17.6	151.1d
	200 lbs 5 inches	24333b	32.9	18.1	171.7bcd
	200 lbs 10 inches	31792a	32.8	18.0	189.8abc
	LSD (5%)	3597	4.1	1.14	26.5
Yes	0 pre-plant UAN	31625a	36.7	17.8ab	188.2ab
	50 lbs on row	31167a	37.1	17.6ab	178.3ab
	50 lbs 5 inches	31958a	37.7	17.3b	198.5a
	50 lbs 10 inches	31667a	40.4	17.8ab	187.7ab
	100 lbs on row	22208b	36.5	17.2b	164.5b
	100 lbs 5 inches	30292a	39.0	17.4ab	199.8a
	100 lbs 10 inches	31958a	38.3	17.3ab	177.8ab
	200 lbs on row	15542c	36.0	17.1b	128.8c
	200 lbs 5 inches	31750a	36.7	17.5ab	185.2ab
	200 lbs 10 inches	31208a	35.8	18.1a	192.3a
	LSD (5%)	2705	4.9	0.8	24.3
None	Mean of 10 treat.	28425	33.9	17.8	180.7
Yes	Mean of 10 treat.	28938	37.4	17.5	180.0

† Average of 6 replications
‡ Means with the same letter are not significantly different.

Location 3 (PPAC):

Corn plant establishment at PPAC was very negatively affected by placing corn rows directly over all pre-plant UAN bands (Table 6). At the 50 pound N rate, plant populations were reduced by over 3,000 plants per acre compared to either no UAN or UAN bands at least 5" from the row. At N rates of 100 pounds and 200 pounds per acre, plant populations were reduced by 5,000 and by 13,000 plants per acre, respectively. Fewer than 65% of the plants survived at the 200 pound rate of N. Population reductions were also noted in 2006 when corn rows were directly over the UAN bands, but only for the 100 and 200 pound N rates (Vyn and West, 2006).

Corn plants were also stunted in all 3 on-row treatments (note that plant heights at V-8 for on-row planting at 200 pounds were just half as tall as those in comparable treatments planted 5" to 10" away). At the same time, there was no deleterious impact to plant populations or to early plant heights when corn rows were planted just 5" away from the UAN band at even the highest N rate. This marked suppression of early plant growth was exacerbated by dry conditions following planting at this location.

Grain yields were dramatically affected by corn row position relative to the pre-plant UAN bands (Table 6). At the 100 pound N rate, planting on-row reduced corn yields by an average 18 bushels per

acre relative to planting 10" from the pre-plant UAN bands. At the 200 pound N rate, planting on-row reduced corn yields by an average 62 bushels per acre relative to planting 5" or 10" from the pre-plant bands. There was no significant negative effect of on-row planting on corn growth at the 50 pound N rate.

Grain moisture differences were small, but moisture levels were highest with on-row planting at all N rates relative to planting without any pre-plant N, and this probably reflected delayed development of these stunted corn plants (Table 6).

For this environment and year (sandy loam soil plus relatively dry conditions after planting), the best corn row positions were either 5" or 10" away from pre-plant UAN bands. The population and yield consequences of planting directly over the N band were even more detrimental in 2006 at N rates of 100 and 200 pounds per acre (Vyn and West, 2007). However, in contrast to 2006, the 2007 results suggest some detrimental effects of planting corn directly over the UAN band at the 50 pound N rate.

Table 6. Corn response to pre-plant banded UAN application and RTK-guided corn row placement at PPAC, 2007.

Pre-plant N rate and Placement	Stand 4 weeks	Plant Height V8	Harvest Moisture	Yield @ 15.5%
	ppa	in	%	bu/a.
0 pre-plant UAN	33542a	27.6ab	19.4b	203.7ab
50 lbs on row	30250b	25.7b	20.4a	207.3ab
50 lbs 5 inches	33167a	26.8ab	19.8ab	212.9a
50 lbs 10 inches	34375a	29.2a	19.5b	213.4a
100 lbs on row	28417b	24.6b	20.6a	192.8b
100 lbs 5 inches	33875a	25.5b	20.3ab	205.0ab
100 lbs 10 inches	34500a	29.9a	19.8ab	210.4a
200 lbs on row	20750c	20.1c	20.7a	142.8c
200 lbs 5 inches	33375a	24.7b	20.6a	205.3ab
200 lbs 10 inches	34167a	27.2ab	19.9ab	211.6a
LSD (5%)	2570	3.2	0.9	17.0
Significance Level	.01	.01	.04	.01

* Values followed by different letters are significantly different at P=0.05.

ACKNOWLEDGMENTS

This research was made possible by 2 modest grants received in 2007. The first was from the Fluid Fertilizer Foundation, and the second was from the Mary S. Rice Farm Fund at Purdue University.

The Cropping Systems group at John Deere provided the JD 7930 tractor with the RTK receiver and base station to provide precise accuracy of our planting operations. We are particularly indebted to Jamie Bultemeier of the Cropping Systems unit of Deere & Co. at Columbus, OH for his technical expertise in getting the RTK guidance equipment set up properly, and for making the many arrangements with local dealers required to secure the 7930 tractor loans. In 2000, John Deere also donated the 6/11 JD 1780 planter used at ACRE and TPAC to support our cropping system research efforts.

In-kind Donations: Waters Agricultural Laboratories agreed to analyze some of our plant samples at no cost, and these will improve our interpretation of the results from this experiment. Mr. Keith Dominey is our contact person at this laboratory in Camilla, GA. Pioneer Hi-Bred (Dupont) donated seed for this and other cropping systems experiments in 2006.

We are also indebted to the exceptionally good technical help provided by Alicia Coon, Rafael Salerno, Adam West, and graduate students Chris Boomsma and Matias Cánepa of the Agronomy Department at Purdue University (both advised by Dr. T. Vyn). Farm superintendents Jim Beaty (ACRE), Jay Young (TPAC), and Jon Leuck (PPAC) were very helpful in assisting us with pesticide application and harvesting operations, plus the designation of field sites for these large experiments.

Reference:

Vyn, T.J., and T.D. West. 2007. Efficient fluid fertilizer management for corn producers with automatic guidance systems. Year 1 results as recorded in the 2007 Proceedings, Fluid Fertilizer Foundation.