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GPS-guided Systems Open New Management Options For Corn Producers

Benefits include timeliness of field operations, less operator fatigue, reduction in input expenses (e.g., less overlap in seed and fertilizer applications), and the opportunity to achieve optimum positions of corn rows relative to nutrient bands.

Summary: *In using the most precise automatic guidance system available (real-time kinematic or RTK), planting corn directly over preplant UAN bands (at all nitrogen [N] rates) increased plant N concentrations in whole plant samples taken approximately one month after seeding at each of three locations. Micronutrient concentrations of manganese (Mn) and/or zinc (Zn) also tended to be higher as corn rows were positioned closer to preplant UAN bands. Corn plant populations and grain yields were frequently reduced when corn rows were positioned directly over UAN bands at N rates of 100 or 200 lbs/A of N, but not when preplant N rates were 50 lbs/A or when corn rows were positioned 5 or 10 inches away from the higher preplant N rates. Starter fertilizer application had little effect on corn population, height or yield response to proximity of the preplant UAN bands, but starter did increase early-season heights and plant N and phosphorus (P) concentrations as expected. We conclude that RTK guidance is highly advantageous when planting no-till or tilled corn soon after preplant banded UAN application, and that the optimum corn row position for a "safe" response shortly after UAN application at high rates is at least 5 inches from and parallel to the UAN band.*

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 half to two-thirds 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 varying degrees of accuracy. Our interest in combining no-till and strip-till operations with fluid fertilizer banding grew over years of researching and promoting strip tillage and deep banding of fertilizer for high-yield corn production systems. The objectives of this three-year research (2006 to 2008) were to:

- Determine the realistic joint benefits associated with automatic guidance systems for both UAN banding and planting systems in no-till corn
- Quantify the effects of various degrees of planter precision (relative to preplanting UAN bands) on corn nutrient uptake, growth, and yield
- Determine whether the combination of automatic guidance systems and preplant banded UAN application would circumvent the need for fluid starter applicators on corn planters.

West Lafayette

Over a three-year period (2006 to 2008), corn plant heights following preplant UAN application were most

stunted in the corn rows planted directly over the UAN band at the N rate of 200 lbs/A (Table 1). Mean corn plant populations for 2006-2007 were not lowered dramatically by on-row planting at this location because of relatively moist soils--its high silt-plus-clay content and timely rains after planting. But there is some evidence of lower final stands with corn planted directly over the 50- and 200-lb/A N rates when starter fertilizer was present. All plant populations were reduced by soil crusting in 2007. Overall grain yields for the 3 years without starter were lowest when corn was planted 10 inches away from the UAN band at the low 50-lb/A N rate. However, when both preplant N and starter fertilizer were applied, overall grain yields were lowest with a zero-inch displacement of the corn rows from the UAN band at the 200-lb/A N rate. Corn yields with the latter treatment combination were similar to that following the treatment with starter but with no preplant UAN. The overall starter benefit was a yield gain of 4 bu/A and a reduction of 0.6 percent in mean grain moisture content at harvest. Highest corn yields occurred with the combination of corn planted 5 inches away from the 200-lb/A preplant N rate with starter fertilizer. The 3-year data confirm the benefits of a minimum displacement of the corn rows from high rates of recently applied preplant UAN.

Corn plant nutrient analyses over the last two years confirmed that plant N concentrations were highest when corn rows were planted directly over the preplant UAN bands at the 100- and 200-lb/A rates of N (Table 2). Lowest plant N concentrations occurred in the control plots that had no preplant UAN. The addition of 10-34-0 starter increased plant N and phosphorus (P) concentrations as expected. The starter influence on whole-plant N and P concentrations was strongest in the treatment with zero preplant UAN. Plant N, but not plant P concentrations, was affected by proximity of the corn rows to the UAN bands. In a somewhat odd development, plant potassium (K) concentrations were lowest with on-row planting at the 200-lb/A N rate when there was no starter fertilizer, but plant K concentrations were highest for the same treatment when

Table 1. Corn response to preplant banded UAN application and RTK-guided corn row placement at West Lafayette, 2006-2008 †

Starter Fertilizer?	Preplant N rate and Placement	Stand 4 weeks ‡	Plant Height	Harvest Moisture	Yield @ 15.5%
		ppa	in	%	bu/A
None	0 pre-plant UAN	27111ab*	17.0d	22.3a	218.1a
	50 lbs on row	26763ab	19.5a	21.5c	218.8a
	50 lbs 5 inches	27798ab	19.6a	21.6bc	215.7ab
	50 lbs 10 inches	26833ab	18.7abc	21.9abc	207.2b
	100 lbs on row	27437ab	19.5a	21.69bc	214.3ab
	100 lbs 5 inches	27138ab	18.7abc	21.8abc	214.8ab
	100 lbs 10 inches	27243ab	18.7abc	21.4c	214.3ab
	200 lbs on row	27854a	18.0c	22.2ab	214.8ab
	200 lbs 5 inches	28048a	19.2ab	21.8abc	218.7a
	200 lbs 10 inches	26270b	18.4bc	21.9abc	216.1ab
	LSD (5%)	1561	1.0	0.6	10.0
Yes	0 pre-plant UAN	27076ab	21.5ab	21.4	215.96b
	50 lbs on row	25791b	22.0a	21.1	220.9ab
	50 lbs 5 inches	27687a	22.2a	21.0	217.0ab
	50 lbs 10 inches	26569ab	21.7ab	21.1	216.9ab
	100 lbs on row	26687ab	21.4ab	21.1	216.7ab
	100 lbs 5 inches	26694ab	21.9a	21.1	221.4ab
	100 lbs 10 inches	27027ab	22.1a	21.0	218.1ab
	200 lbs on row	25534b	20.7b	21.5	215.5b
	200 lbs 5 inches	27520a	21.7ab	21.2	226.7a
	200 lbs 10 inches	26277ab	21.5ab	21.3	225.3ab
	LSD (5%)	1626	1.1	0.7	10.2
None	Mean of 10 treat.	27250a	18.7b	21.8a	215.3b
Yes	Mean of 10 treat.	26686b	21.7a	21.2b	219.5a

† Averate of 6 replications
‡ Includes years 2006 and 2007 only.
* Means with the same letter are not significantly different.

Table 2. Corn plant nutrient concentration response to preplant banded UAN application and RTK-guided row placement at West Lafayette, 2007-2008 †

Starter Fertilizer?	Preplant N rate and Placement	Nitrogen	Phosphorus	Potassium	Zinc	Manganese
		%	%	%	ppm	ppm
None	0 pre-plant UAN	3.55e ‡	0.36	4.02ab	33.9	39.6c
	50 lbs on row	4.64ab	0.38	3.49b	39.3	53.5abc
	50 lbs 5 inches	4.12cd	0.39	4.14a	33.7	62.5a
	50 lbs 10 inches	3.92d	0.39	3.69ab	35.1	45.4bc
	100 lbs on row	4.69ab	0.37	3.78ab	36.7	57.5ab
	100 lbs 5 inches	4.39bc	0.36	3.87ab	38.2	50.8abc
	100 lbs 10 inches	4.00d	0.37	3.87ab	36.6	47.5abc
	200 lbs on row	4.74a	0.37	3.55b	39.9	54.8abc
	200 lbs 5 inches	4.48ab	0.37	3.97ab	36.3	52.6abc
	200 lbs 10 inches	4.08cd	0.35	3.92ab	39.0	39.5c
	LSD (5%)	0.32	0.04	0.57	7.0	15.8
Yes	0 pre-plant UAN	4.11e	0.43	3.76ab	27.2b	37.6e
	50 lbs on row	4.59b	0.44	3.81ab	34.9a	54.1abc
	50 lbs 5 inches	4.49bc	0.43	3.86ab	31.6ab	45.0cde
	50 lbs 10 inches	4.22de	0.45	36.0ab	31.8ab	39.6de
	100 lbs on row	4.89a	0.44	3.97a	35.0a	58.4ab
	100 lbs 5 inches	4.55bc	0.44	3.67ab	32.2ab	50.7bc
	100 lbs 10 inches	4.32cde	0.44	3.51ab	33.2a	48.9bcd
	200 lbs on row	5.04a	0.46	3.99a	32.9a	62.6a
	200 lbs 5 inches	4.83a	0.45	3.73ab	34.5a	54.3abc
	200 lbs 10 inches	4.45bcd	0.46	3.35b	30.1ab	46.6cde
	LSD (5%)	0.24	.04	0.56	5.5	9.9
None	Mean of 10 treat.	4.3b	0.37b	3.8	36.9a	50.4
Yes	Mean of 10 treat.	4.5a	0.44a	3.7	32.3b	49.8

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

NP starter was present.

Micronutrient concentrations were also affected by fertilizer treatments and planter positions. Plant Zinc (Zn) concentrations were significantly lower (i.e., about 4.6 ppm) in the presence of starter fertilizer. Plant Mn concentrations were lowest when no preplant UAN was applied or when the corn rows were positioned 10 inches away from the preplant N bands. It is possible that UAN band influences on localized soil pH may have had something to do with the variation in plant-available Mn concentrations at this location. Mean soil pH was about 6.5.

South of Lafayette

Corn plant establishment at this location was negatively affected by placing corn rows directly over some preplant UAN bands (Table 3). Considerable plant death occurred with on-row planting at N rates of 100 and 200 lbs/A, but not with on-row planting at the 50-lb/A rate. Less than 90 percent of the plants survived with on-row planting at an N rate of 100 lbs/A and less than 75 percent survived at the N rate of 200 lbs/A. The reduction in plant stand because of N toxicity was more dramatic in 2007 because of dry weather conditions prevailing after planting. Corn plants that did survive were somewhat shorter in the 200-lb/A N rate treatment relative to other row placement treatments. Plant populations were also lower when the corn rows were 5 inches away from the 200-lb/A N rate and no starter fertilizer was applied, but the same detrimental effect was not observed with starter.

Table 3. Corn plant nutrient concentration response to preplant banded UAN application and RTK-guided row placement south of Lafayette, 2007-2008 †

Starter Fertilizer?	Preplant N rate and Placement	Stand 4 weeks	Plant Height	Harvest Moisture	Yield @ 15.5%
		ppa	in	%	bu/A
None	0 pre-plant UAN	30479a	28.4ab	17.5a	212.7abc
	50 lbs on row	30813a	28.5ab	17.0ab	213.4abc
	50 lbs 5 inches	31250a	30.7a	16.7b	215.5ab
	50 lbs 10 inches	30917a	29.1ab	17.2ab	226.2a
	100 lbs on row	27042b	28.4ab	16.9ab	216.5ab
	100 lbs 5 inches	29771a	28.5ab	16.9ab	219.8ab
	100 lbs 10 inches	31104a	28.3ab	16.9ab	206.5bc
	200 lbs on row	22479c	26.8b	17.0ab	196.1c
	200 lbs 5 inches	27188b	27.2b	17.2ab	206.5bc
	200 lbs 10 inches	31208ab	28.2ab	17.1ab	219.0ab
	LSD (5%)	2370	2.6	0.6	17.4
Yes	0 pre-plant UAN	30792a	31.8abc	17.0ab	215.0ab
	50 lbs on row	30313a	32.6abc	16.9ab	212.6ab
	50 lbs 5 inches	30792a	33.4ab	16.6b	220.8a
	50 lbs 10 inches	30563	33.6a	16.9ab	220.2ab
	100 lbs on row	25479b	31.4abc	16.6b	204.7b
	100 lbs 5 inches	29667a	33.1ab	16.8ab	222.1a
	100 lbs 10 inches	31313a	33.6a	16.8ab	210.9ab
	200 lbs on row	20771c	30.2c	16.9ab	179.6c
	200 lbs 5 inches	30250a	30.9bc	16.9ab	213.6ab
	200 lbs 10 inches	30604a	32.3abc	17.1a	220.5ab
	LSD (5%)	2133	2.6	0.5	16.0
None	Mean of 10 treat.	29225	28.4b	17.0a	213.2
Yes	Mean of 10 treat.	29054	32.3a	16.8b	212.0

† Averate of 6 replications. Grain moisture and yield is average of 5 replications in 2008.
‡ Means with the same letter are not significantly different.

Grain yields were dramatically affected by corn row position relative to the preplant UAN bands, but not by starter treatment (Table 3). At the 200-lb/A N rate, planting on-row with starter fertilizer reduced corn yields by an average of 34 bu/A relative to planting 5 inches from the preplant bands, and 41 bu/A relative to planting 10 inches from the preplant N bands. For the same 200-lb/A N rate, corn yield reductions with on-row planting were smaller after planting without starter (just 10 and 23 bu/A loss relative to the 5-inch and 10-inch row displacements). There was no significant effect of on-row planting on corn growth at the 50-lb/A N rate. The addition of starter fertilizer resulted in faster early growth, but no increase in final corn yields at this location. Overall soil test P at this location averaged 31 ppm and 23 ppm and soil test K was only 77 ppm and 116 ppm in 2007 and 2008, respectively.

Whole plant nutrient analyses confirmed that plant N and P concentrations were significantly increased by starter fertilizer application as expected (Table 4). Plant N concentrations at this location were lowest when no preplant UAN was applied but plant N concentrations were not highest for the on-row planting situation following UAN application at high rates. In fact, there were no significant differences in plant N concentrations between the 0- and 5-inch displacements following any of the 3 preplant UAN rates. Thus the N concentration results of Table 4 are in contrast to those at the West Lafayette site (Table 2) where plant N concentrations were highest following on-row planting.

Plant micronutrient concentrations were also affected by the various N and row placement treatments (Table 4). Plant Zn concentrations in the no-starter treatments were lowest without preplant UAN and highest when corn rows were positioned 5 inches away from the 200-lb/A N rate. Plant Mn concentrations were also lowest without preplant UAN and highest following the 200-lb/A N rate when the rows were either 0 or 5 inches away from the UAN bands. In general, higher N rates were beneficial to achieving higher Mn concentrations, though one could argue that Mn concentrations (>100 ppm) are of no advantage to corn performance.

Wanatah

It is important to emphasize that we did not split the treatments into a starter versus no starter comparison because of resource constraints in the three years of our study at this site. Corn plant establishment was very negatively affected by placing corn rows directly over all preplant UAN bands (Table 5). At the 50-lb/A N rate, plant populations were reduced by over 1,500 plants/A

compared to either no UAN or UAN bands at least 5 inches from the row. At N rates of 100 and 200 lbs/A, plant populations were reduced by over 5,000 and 12,000 plants/A, respectively. Fewer than 65 percent of the plants survived at the 200-lb/A rate of N. At the same time, there was little detrimental impact to plant populations when corn rows were planted just 5 inches away from the UAN bands at even the higher N rate. Significant population reductions were observed when corn was planted directly over the UAN bands at the 100- and 200-lb/A N rates in all three years at this location.

Corn plants during the vegetative growth period were also stunted in all three on-row treatments (Table 5). Plant heights for on-row planting at 200 lbs/A were less than three-quarters as tall as those in comparable treatments planted 5 to 10 inches away. However, a slight reduction in plant height was observed for corn planted 5 versus 10 inches away from the UAN band at the 100- to 200-lb/A N rates (Table 5). In certain years, 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 preplant UAN bands (Table 5). At the 100-lb/A N rate, planting on-row reduced corn yields by an average 20 bu/A relative to planting 10 inches from the preplant UAN bands. At the 200-lb/A rate of N, planting on-row reduced corn yields an average of 58 bu/A relative to planting 10 inches from the preplant bands. There was no significant negative effect of on-row planting on corn growth at the 50-lb/A rate of N. Grain moisture differences were small, but moisture levels were highest with on-row planting at the 100- and 200-lb/A rates of N relative to planting without any preplant N, and this probably reflected delayed development of these corn plants (Table 5).

Whole plant nutrient analyses over the three years confirmed that plant N concentrations were significantly increased by planting corn rows directly over the UAN fertilizer bands at all three N rates (Table 6). Plant N concentrations at this location were lowest when no preplant UAN was applied, or when the UAN bands were 10 inches away from the corn row. Planting corn 5 inches away from the UAN band resulted in significantly higher plant N concentrations compared to planting 10 inches from the UAN band only for the 200-lb/A rate of N. These plant N concentration results are similar to those at the West Lafayette site (Table 2). Plant P concentrations were highest when corn rows were 5 inches away from the 50-lb/A rate of N, and plant K concentrations were highest when there was no preplant UAN, but tended to be lower with on-row planting versus 5 or 10 inches away following UAN banding.

Plant micronutrient concentrations were also affected by the various N and row placement treatments (Table 6). Plant Zn concentrations were highest when corn was planted

Table 4. Corn plant nutrient concentration response to preplant banded UAN application and RTK-guided row placement south of Lafayette, 2007-2008 †

Starter Fertilizer?	Preplant N rate and Placement	Nitrogen	Phosphorus	Potassium	Zinc	Manganese
		%	%	%	ppm	ppm
None	0 pre-plant UAN	3.2c	0.30abc	3.3ab	27.8b	91.7c
	50 lbs on row	3.6abc	0.29bc	3.1ab	33.4ab	116.5bc
	50 lbs 5 inches	3.5abc	0.30abc	3.5a	31.7ab	112.2bc
	50 lbs 10 inches	4.0a	0.36a	3.2ab	29.4b	115.0bc
	100 lbs on row	3.8a	0.30abc	3.3ab	37.4ab	139.9ab
	100 lbs 5 inches	3.7ab	0.34ab	3.5a	35.2ab	122.5abc
	100 lbs 10 inches	3.3bc	0.29bc	3.0b	34.2ab	132.4ab
	200 lbs on row	3.7ab	0.27c	3.2ab	32.6ab	145.0ab
	200 lbs 5 inches	3.7ab	0.29bc	3.2ab	40.8a	155.8a
	200 lbs 10 inches	3.6abc	0.35ab	3.5a	33.1ab	128.1abc
	LSD (5%)	0.4	0.06	0.5	10.7	38.0
Yes	0 pre-plant UAN	3.7b	0.41ab	3.5a	25.3	98.7d
	50 lbs on row	3.8b	0.38bc	3.2ab	25.5	110.1bcd
	50 lbs 5 inches	3.9ab	0.43a	3.6a	30.0	107.7bcd
	50 lbs 10 inches	3.7b	0.40abc	3.2ab	23.5	89.5d
	100 lbs on row	3.9ab	0.39bc	3.1ab	28.8	129.4ab
	100 lbs 5 inches	3.9ab	0.44a	3.2a	32.6	126.9abc
	100 lbs 10 inches	3.7b	0.41ab	3.4a	28.7	102.9cd
	200 lbs on row	3.9ab	0.36c	2.8b	29.9	145.8a
	200 lbs 5 inches	4.4a	0.42ab	3.2ab	32.6	148.7a
	200 lbs 10 inches	3.9ab	0.44a	3.4a	31.9	125.3abc
	LSD (5%)	.03	.04	0.5	9.4	26.4
None	Mean of 10 treat.	3.6b	0.31b	3.3	33.6	126.0
Yes	Mean of 10 treat.	3.9a	0.41a	3.3	28.9	118.3

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

Table 5. Corn response to preplant banded UAN application and RTK-guided corn row placement at Wanatah, 2006-2008†

Starter Fertilizer?	Preplant N rate and Placement	Stand 4 weeks	Plant Height	Harvest Moisture	Yield @ 15.5%
		ppa	in	%	bu/A
None	0 pre-plant UAN	33449ab‡	22.4bc	21.6d	200.9ab
	50 lbs on row	31972b	22.0c	21.9bcd	202.2ab
	50 lbs 5 inches	33694a	23.1abc	21.6d	203.7a
	50 lbs 10 inches	34326a	24.2a	21.5d	202.9ab
	100 lbs on row	28092c	20.3d	22.5ab	183.0c
	100 lbs 5 inches	33523ab	22.2c	21.8bcd	200.2ab
	100 lbs 10 inches	34000a	24.0a	21.5d	202.8ab
	200 lbs on row	20852d	16.0e	23.0a	143.4d
	200 lbs 5 inches	33791a	22.0c	22.4abc	193.6b
	200 lbs 10 inches	34018a	23.9ab	21.8cd	201.3ab
	LSD (5%)	1716	1.5	0.7	9.4
	Significance Level	.01	.01	.01	.01

† Average of 6 replications
‡ Values followed by different letters are significantly different at P=0.05.

directly over the preplant UAN bands at all N rates and were significantly lower in the control treatment (i.e., no preplant N) or when corn rows were positioned farther away from the UAN band. Plant Mn concentrations were also lowest without preplant UAN and highest following the 50-, 100- and 200-lb/A rates of N when the rows were 0 inches away from the UAN bands. In general, preplant UAN resulted in both higher Zn and Mn concentrations, particularly when corn rows were planted directly over the UAN band. However, one could argue that Mn concentrations above 90 ppm are so much higher than the critical levels that these are not likely to result in superior corn plant growth.

Table 6. Corn plant nutrient response to preplant banded UAN application and RTK-guided corn row placement at Wanatah, 2006-2008†

Preplant N rate and Placement	Nitrogen	Phosphorus	Potassium	Zinc	Manganese
	%	%	%	ppm	ppm
0 pre-plant UAN	3.3f ‡	0.32cd	3.61a	39.6c	74.6c
50 lbs on row	4.0c	0.34ab	3.09cd	44.9ab	94.8ab
50 lbs 5 inches	3.7d	0.36a	3.48ab	41.1c	81.7bc
50 lbs 10 inches	3.5de	0.34abc	3.40abc	42.0bc	79.2bc
100 lbs on row	4.3b	0.34abc	2.85d	46.1a	94.7ab
100 lbs 5 inches	3.6de	0.33bcd	3.23bc	41.3c	87.7bc
100 lbs 10 inches	3.5ef	0.33bcd	3.52ab	40.4c	73.3c
200 lbs on row	4.7a	0.31d	3.08cd	45.8a	108.0a
200 lbs 5 inches	4.0c	0.32bcd	3.06cd	41.2c	79.2bc
200 lbs 10 inches	3.4ef	0.32bcd	3.50ab	39.3c	82.5bc
LSD (5%)	0.2	0.02	0.35	3.4	18.5
Significance Level	.01	.01	.01	.02	.01

† Average of 6 replications in 2006, average of 4 replications in 2007 and 2008.
‡ Values followed by different letters are significantly different at P=0.05.

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