Crop Yield and Nitrate Losses from Sidedressing N at Canopy Closure

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Introduction

Previous studies have shown that applying N preplant or sidedressing at the V6 plant growth stage can reduce NO_3 leaching losses compared to fall application. Sidedressing may be even more efficient if the N rate is adjusted for available soil N as determined by soil testing (Jaynes et al, 2004). Sensing crop deficiencies using ground or remote based sensors may substitute for soil testing, but V6 in corn is typically too early in the growing season to reliably detect N deficiencies. Alternatively, N deficiencies are usually detectable by the R1 growth stage in corn, but we have shown (Jaynes and Colvin, 2006) that delaying sidedressing of N this late in rainfed fields lowers yield and increases NO_3 leaching losses to tile drains compared to earlier application. Thus, some compromise between these two growth stages is required.

In this study, we examine the water quality (NO_3) and crop yield benefits to sidedressing N at canopy closure (V10) – a time when remote sensing may be expected to detect N deficiencies in corn and yet the plant can still fully utilize the added N.

Methods

- Research conducted on a 22-ha production field in central Iowa
- Soils in the Kossuth (fine-loamy, mixed, superactive, mesic Typic Endoaquolls) – Ottosen (fine-loamy, mixed, superactive, mesic Aquic Hapludolls) association
- A corn-soybean rotation was used starting with corn in 2006
- 3 blocks with 3 N treatments were used. Treatments were:
  - V2 – 157 kg ha^{-1} at emergence (10-yr economic optimum rate)
  - V6 – 157 kg ha^{-1} sidedressed at V6 leaf stage
  - V10 – 78 kg ha^{-1} at emergence and 78 kg ha^{-1} at V10 leaf stage
- 28% UAN was slot injected at emergence and V6, and dribble applied at V10
- A single tile drained each 500-m long plot
- Tile flow was continuously measured
- Flow-weighted tile water samples were collected and analyzed for $[NO_3]$
- A transect was harvested from each plot and yield computed by weight corrected to 155 g kg^{-1} for corn and 130 g kg^{-1} for soybean
- The late spring nitrate test (LSNT) and end-of-season corn stalk test (EoSCST) were conducted in corn years
- Six 120-cm deep soil cores were taken from each plot after harvest for residual $[NO_3]$, [NH4], and total inorganic N [TIN]

Results

Nitrate concentration in tile drainage

- There was no significant difference among treatments in any year in flow-weighted NO_3 concentrations (FWNC) in tile drainage (Table 1).
- There was a significant difference in FWNC (P=0.08) when pooled over the 4 yr, with the V10 N treatment having a slightly lower FWNC than the other two treatments.

Table 1. Flow-weighted NO_3 concentrations by year and N application timing.

N treatment	2006	2007	2008	2009	2006-2009
	corn	soybean	corn	soybean	all
	---------------------------------- mg N L^{-1}				-------------------------------
V2†	11.4	9.4	11.8	7.0	10.1
V6	12.0	9.5	11.5	6.6	9.9
V10	10.2	8.4	10.3	6.9	9.1
$LSD_{0.05}$	1.9	1.8	2.1	1.2	0.08§

† N was applied at V2 = 2 leaf stage, V6 = 6 leaf stage, V10 = equally split between 2 leaf and 10 leaf stage
‡ Not included in statistical analysis
§ Probability of a greater F by repeated measures

Nitrate mass loss in tile drainage

- Tile flow among plots was variable (CV > 25%) for the V6 treatment compared to the other treatments (not shown).
- There was no significant difference among treatments in any year for mass of NO_3 lost in tile drainage (Table 2).
- There was no significant difference in NO_3 mass loss in tile drainage among N treatments when pooled over the 4 yr.

Table 2. Mass loss of NO_3 in tile drains by year as affected by N application timing.

N treatment	2006	2007	2008	2009	2006-2009
	corn	soybean	corn	soybean	all
	---------------------------------- kg ha^{-1}				-------------------------------
V2†	23.6	37.8	43.9	13.6	31.2
V6	21.6	34.9	47.4	17.4	34.8
V10	21.6	33.0	40.3	14.6	28.6
$LSD_{0.05}$	6.4	16.9	28.0	11.7	0.48§

† N was applied at V2 = 2 leaf stage, V6 = 6 leaf stage, V10 = equally split between 2 leaf and 10 leaf stage
‡ Not included in statistical analysis
§ Probability of a greater F by repeated measures

Residual soil N

- Residual soil NO_3 was lower in 2008 than the other years as a result of much greater fall 2007 and spring 2008 precipitation (Table 3 and Fig 1 & 2).
- In 2006, significantly more NO_3 remained in the soil for the V2 treatment than the V10 treatment.
- Significantly less NO_3 remained in the soil for the V10 treatment in 2008 than the V6 treatment.
- There was no evidence of unused sidedressed N for the V10 treatment as was found by Jaynes and Colvin, 2006 when N was applied at V16.
- There was significantly more TIN in the soil in 2006 for the V2 treatment compared to the V10 treatment.

Table 3. Residual soil nitrate, ammonium, and total N by year as affected by N application timing.

N treatment	2006	2007	2008	2006	2007	2008	2006	2007	2008
	corn	soybean	corn	corn	soybean	corn	corn	soybean	corn
	------------ kg NO_3-N ha^{-1} ----------			------------ kg NH_4-N ha^{-1} ----------			--------------- kg N ha^{-1} -------------		
V2†	57.9	41.8	22.3	12.6	12.8	10.8	70.5	54.5	33.1
V6	47.3	46.6	21.7	11.3	12.9	9.5	58.6	59.5	31.2
V10	36.3	42.1	31.5	13.9	13.6	9.5	50.2	55.7	41.0
$LSD_{0.05}$	13.1	8.3	9.5	5.1	6.8	3.7	14.2	9.5	11.1

† N was applied at V2 = 2 leaf stage, V6 = 6 leaf stage, V10 = equally split between 2 leaf and 10 leaf stage

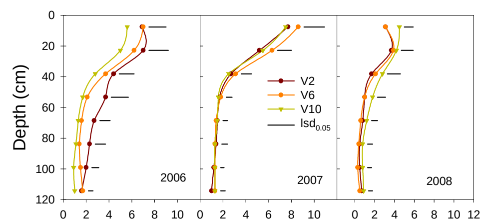

Fig. 1. NO3 concentration (mg N L^{-1})

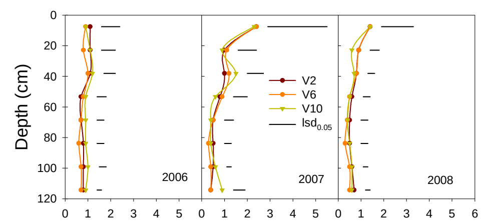

Fig. 2. NH4 concentration (mg N L^{-1})

Yield

- Greater than normal precipitation in 2008 made the corn much more responsive to N application than in 2006 (Table 4).
- All yields were comparable to county averages and previous yields from this field.
- The only significant difference among yields within a year was in 2008 when the V10 yield was greater than the V2 yield by 0.89 Mg ha^{-1}
- When pooled across years using normalized yields, there was again no significant difference among N treatments.

Table 4. Grain yield by year and normalized for 4-yr as affected by N application timing.

N treatment	2006	2007	2008	2009	2006-2009
	corn	soybean	corn	soybean	normalized
	------------------------ Mg ha^{-1}			---------------------	-
V2†	10.54	3.90	13.26	3.93	0.113
V6	10.64	3.83	12.81	3.95	-0.230
V10	10.20	3.90	13.70	3.84	0.171
Check (No N)‡	9.23		4.39		
$LSD_{0.05}$	0.97	0.49	0.52	0.34	0.64§

split
between 2 leaf and 10 leaf stage
‡ Not included in statistical analysis
§ Probability of a greater F by repeated measures

Conclusions

Using plant sensors to fine-tune N application is a promising approach for better managing N fertilizer, but crop deficiencies often are not detectable until after canopy closure. Delaying N application too late (V16) into the growing season can increase NO_3 leaching and reduce yield in rainfed fields. Thus, using sensors to fine-tune N application may require a delicate balance between delaying N application until crop deficiencies can be detected while not delaying too long so that the applied N can be fully used by the crop and not available for leaching after harvest. In this study, we show that applying N at V10 is at least as efficient in supplying N to corn as applying at V2 or V6 and does not increase leaching of NO_3 in tile drains for a corn – soybean field in central Iowa.

References

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