Within-Row Variability Resulting From Diagonal Versus Parallel Pre-Plant NH_3 Applications

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Introduction

The majority of spring pre-plant anhydrous ammonia (NH_3) using traditional tool-bar applicators at conventional depths (~20cm) occurs on the diagonal in an attempt to prevent subsequent seedling injury to corn (Zea mays L.) rows; secondary tillage normally follows. John Deere recently introduced a new shallow applicator (Model 2510H; John Deere, 2012). Limited or no studies have been conducted on agronomic consequences of shallow NH_3 placement on corn when diagonal application occurs, or the possible gains in corn response that could be achieved when precise automatic guidance is used to consistently apply pre-plant NH_3 in close proximity to every intended row. Much of high yield management is focused on minimizing plant-to-plant variability in corn. This study investigated the effect of application direction on plant-to-plant variability at different fertilizer rates in different tillage systems.

Materials and Methods

Study was conducted on a Chalmers silty clay loam (Fine-silty, mixed, mesic Typic Hapluaquolls) in 2010 and on Drummer (Fine-silty, mixed, mesic Typic Hapluaquolls) soils in 2011 at Purdue University's Agronomy Center for Research and Education near West Lafayette, IN (40.4855246, -87.0006963).

Experiment parameters:

Experimental design: Randomized Complete Block Design with split-plot arrangement in 6 replications

Application direction (Main plot):

- Traditional diagonal to the future corn row (Figure 1A), and
- Parallel, but 15cm offset to the future corn row

Tillage and N rates (Split-plot):

1. No-till and N rate of 200 kg N ha^{-1}
2. No-till and N rate of 145 kg N ha^{-1}
3. Conventional tillage and N rate of 200 kg N ha^{-1}
4. Conventional tillage and N rate of 145 kg N ha^{-1}

(Conventional tillage consisted of fall chisel plow and shallow spring secondary tillage following the NH_3 application)

Crop rotation: Soybean – Corn rotation

Hybrid: Pioneer 1395 XR (2010)
Pioneer 1567 XR (2011)

Seeding rate: 85200 seeds ha^{-1}

Planter: JD1780 6 row unit delivering 140 l ha^{-1} 10-34-0 starter fertilizer in a typical 5cm by 5cm placement (20 kg N ha^{-1})

Plot dimensions: 68.6 m length and 9.15 m (12 row) width

Table 1. Date of key field activities during 2010 and 2011 growing season

Field activity	2010	2011
Pre-plant NH_3 application	April 13	May 12
Planting	April 17	May 13
Silking time	July 4-13	July 15-25
Machine harvest	September 24	October 7

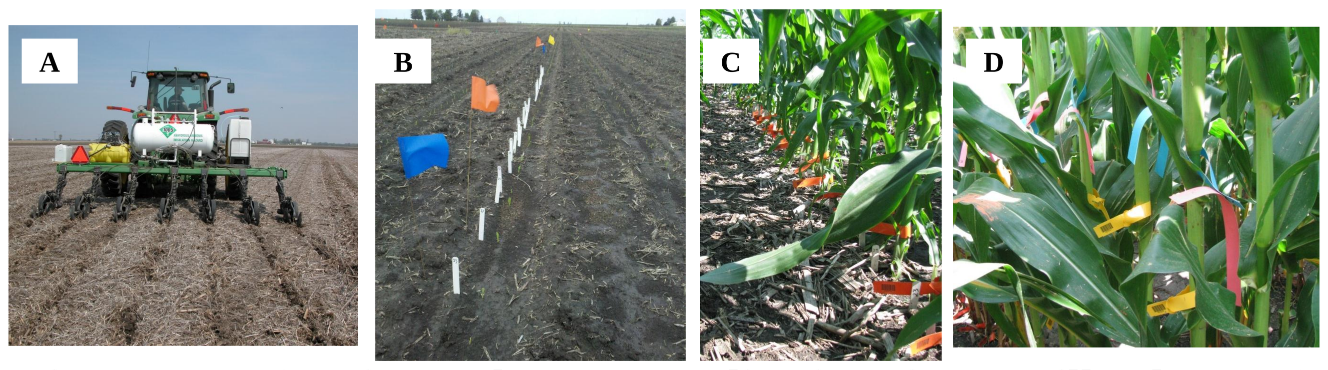

Figure 1. A) Diagonal NH_3 application in no-till plots; B) individual seedling emergence date notes marked by stakes; C) individually barcoded plants with the emergence notes; D) Silk and anther emergence dates marked individually, and plant identification barcodes on each plant.

Following planting 5.34 m section of a row was selected in each plot. During the growing season intensive plant measurements (i.e seedling emergence, silk emergence, plant spacing) were taken on the individual plants in these selected zones (Figure 1).

Ears from selected zones were individually hand harvested after physiological maturity in 2010, but at late R3 growth stage in 2011 (because of a devastating hailstorm on August 13th). Kernel numbers were recorded for each ear and all ears were individually shelled. Grain from individual ears were weighed and corrected to 155 g kg^{-1} moisture content. Frequency distributions were calculated from individual-plant grain weights. Seedling emergence, plant spacing and silk emergence were plotted against ear weight. The first and last 10% of silk emergence were grouped as early or late silking respectively.

Results

Parallel application to subsequent corn rows resulted in numerically (but not statistically significant) higher yields except for the no-till 200 kg N rate (Figure 2).

Mean grain weight per plant were consistently higher at the higher N rate (Table 2) but statistical differences associated with N rate were only evident in no-till tillage system (except with RTK-guided parallel application in 2011).

Parallel NH_3 placement resulted in higher grain weights per plant in 2010 but not in 2011. However, the latter reduction is likely to be the result of the short time interval between NH_3 application and planting in 2011 (Table 1).

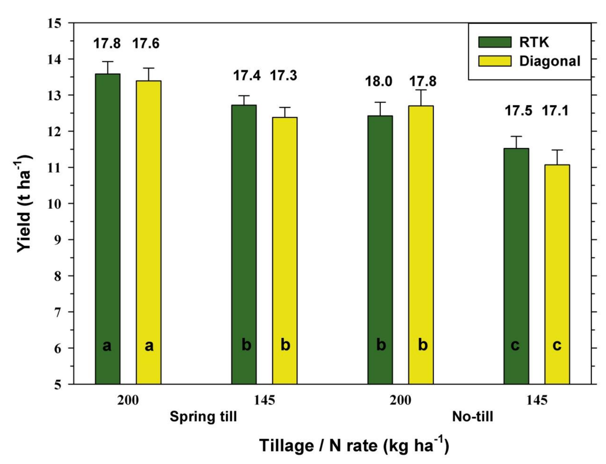

Figure 2. Anhydrous ammonia application direction and rate effects on machine harvested yields (average of 2010 and 2011) in two tillage systems. Treatments with different letters are statistically significantly different at P=0.05. Values above bars present the grain moisture content at harvest.

Parallel NH_3 placement resulted in higher grain weights per plant in 2010 but not in 2011. However, the latter reduction is likely to be the result of the short time interval between NH_3 application and planting in 2011 (Table 1). Kernel number per ear were somewhat higher in conventional tilled plots in both years but statistical differences were only observed following diagonal application.

Table 2. Effects of shallow NH_3 application on mean kernel weight and number per individual plant in 2010 and in 2011 near.

Pre-plant NH_3 Placement, N Rate (kg ha^{-1}), and Tillage Treatment Combination	2010 Mean grain weight (g $plant^{-1}$)	2010 Mean kernel number (kernels $plant^{-1}$)	2011 Mean grain weight (g $plant^{-1}$)	2011 Mean kernel number (kernels $plant^{-1}$)
Diagonal, 200 N, No-till	160.4 abc[1]	461 b	73.84 ab	480 ab
Diagonal, 145 N, No-till	145.9 d	474 ab	64.38 c	460 b
Diagonal, 200 N, Spring-till	166.4 ab	504 a	79.06 a	493 ab
Diagonal, 145 N, Spring-till	159.0 bc	503 a	78.99 a	502 a
RTK 6" from row, 200 N, No-till	168.4 ab	487 ab	69.54 bc	469 ab
RTK 6" from row, 145 N, No-till	151.2 cd	468 ab	67.95 bc	490 ab
RTK 6" from row, 200 N, Spring-till	172.7 a	502 a	74.41 ab	485 ab
RTK 6" from row, 145 N, Spring-till	165.7 ab	497 ab	68.53 bc	462 ab

[1] Treatments with different letter are statistically significantly different at p=0.05.

Distribution of ear weights (Figure 3) and kernel numbers (Figure 4) show similar uniformity regardless of NH_3 application direction. Greater frequency of higher ear weights were observed following RTK-guided parallel application in 2010, and these contributed to the gain in mean ear weights (Table 2) and bulk yield (Figure 2) in these treatments in 2010.

Figure 5 illustrates an example of grain yield variability per plant for one treatment (200 kg N diagonally applied in conventional-tilled plots) from 2010. Variability in seedling emergence uniformity, or in mean per-plant spacing had little influence on final per-plant grain yields. Delays in silk emergence had a much higher influence on per-plant grain yields, and variation in silking dates had little relationship to the variation in seedling emergence or plant spacing.

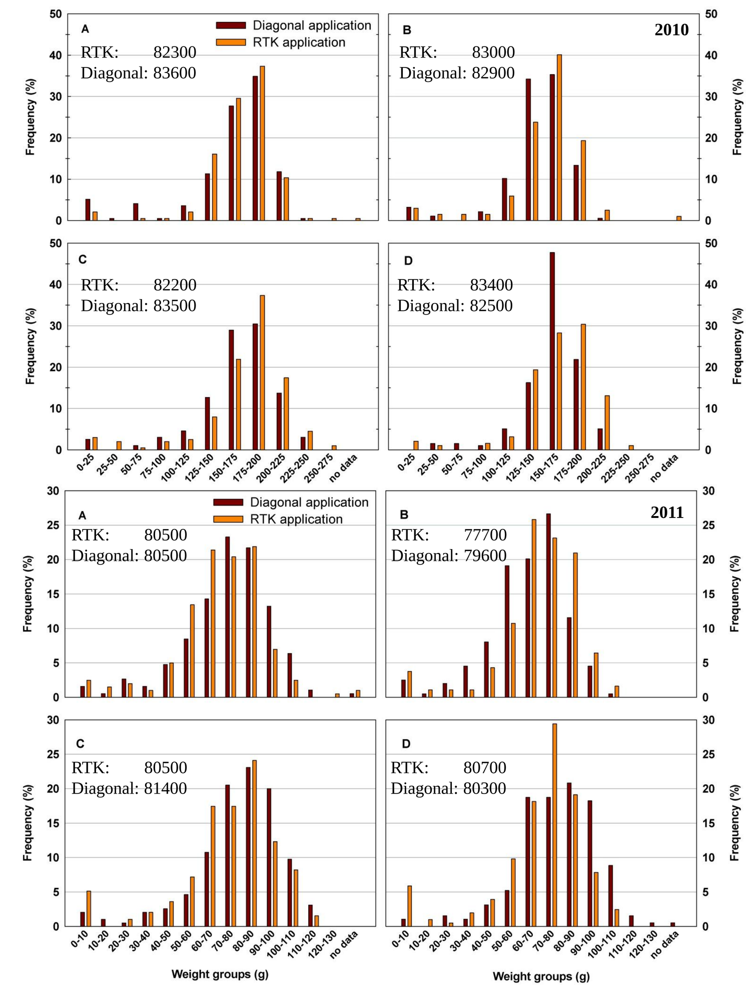

Figure 3. Effects of shallow NH_3 application on individual plant grain weight frequency distribution in 2010 and in 2011. Diagonal and RTK-guided parallel directions are paired in the following treatment combinations: No-till 200 N rate (A), No-till 145 N rate (B), spring till 200 N (C), and spring till 145 N rate (D). Plant population (plants ha^{-1}) are presented for each treatment.

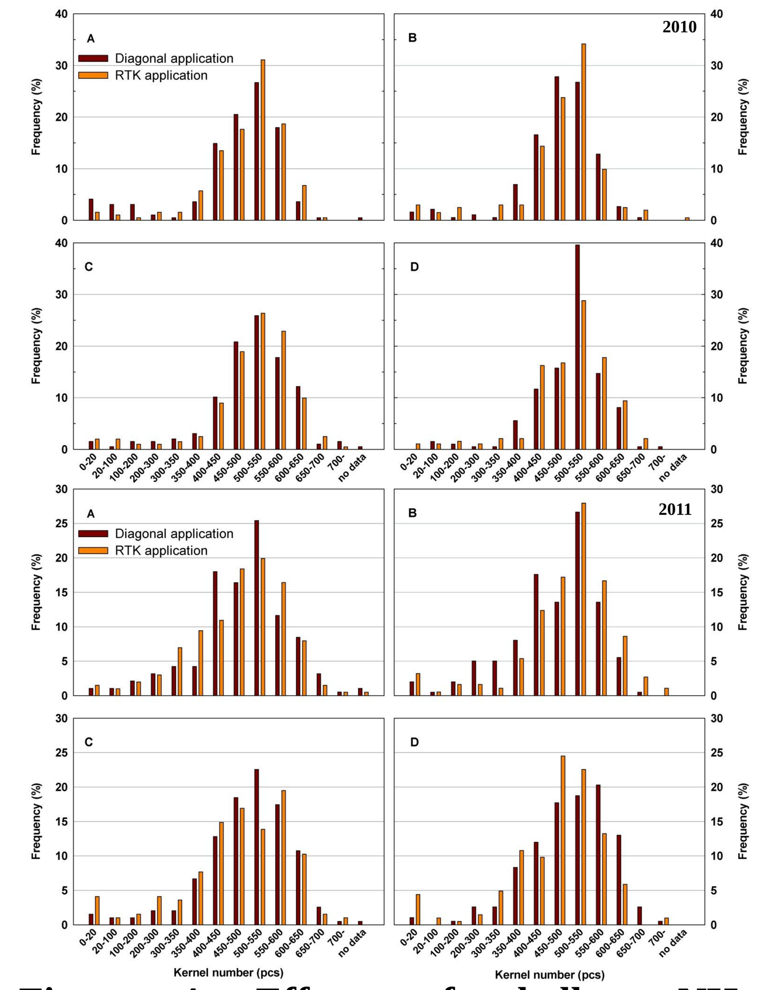

Figure 4. Effects of shallow NH_3 application on per-plant kernel number frequency distribution in 2010 and in 2011. Diagonal and RTK-guided parallel directions are paired in the following treatment combinations: No-till 200 N rate (A), No-till 145 N rate (B), spring till 200 N (C), and spring till 145 N rate (D).

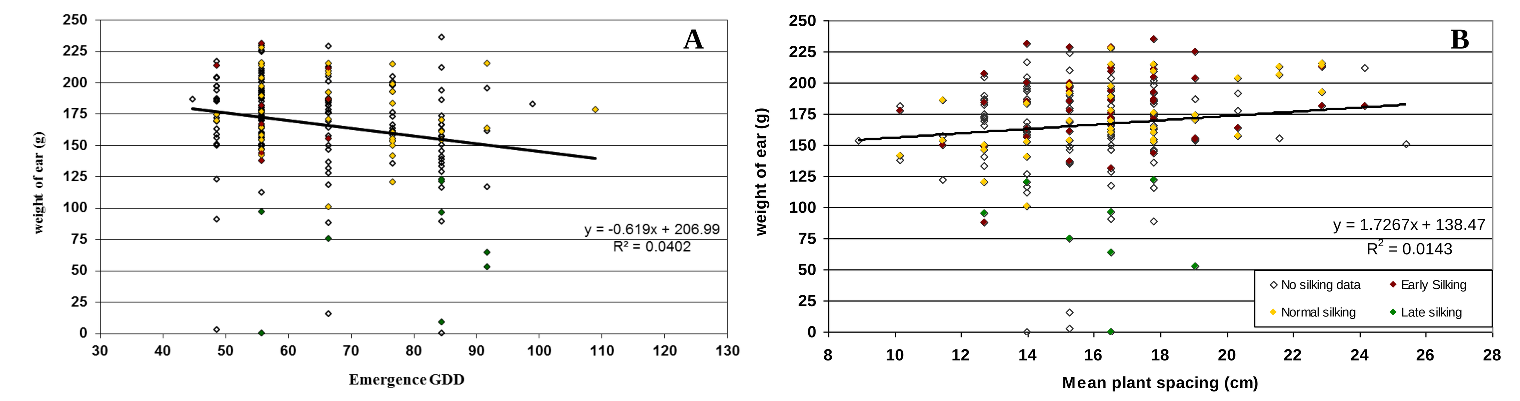

Figure 5. Relationship between seedling emergence GDD and relative silk emergence timing on final grain weight of individual plants (A), and the relationship between mean plant spacing and relative silk emergence timing on final grain weight of individual plants (B), in Diagonal conventional-tilled plots at the 200 kg N ha^{-1} rate in 2010.

Tentative Conclusions

- Slightly higher grain yields per unit area were observed following RTK-guided parallel NH_3 application at both N rates.
- Individual-plant yield component analyses indicated that the gain was the result of higher incidences of heavier ears with RTK-guided application, but not from a reduction in ear weight variability per se.
- Individual plant grain weights were only slightly influenced by small delays in seedling emergence or plant spacing uniformity in the row. However, late silk emergence had much impact on instances of low individual-plant grain weights.

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Reference

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