# Corn Growth and Yield Responses to Pre-plant and In-Season Nitrogen Combinations

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## Introduction

- Increased weather variability and concern for Great Lakes Basin water quality require improved corn (*Zea mays* L.) nitrogen (N) management strategies that simultaneously deliver N to the crop and reduce the risk for N loss.
- Michigan corn growers utilize spring pre-plant incorporated (PPI) N, in-furrow 'pop-up', or '2x2' N applications as strategies to supply N at planting and increase early season growth.
- Rates of corn N uptake increase near V6 to V8 suggesting opportunities to delay N application and reduce probabilities for N loss due to volatile early-season weather.
- In-season N applications as late as V16 have resulted in minimal yield loss in the Midwest but validation of this practice has not occurred in Michigan (MI) where shorter-season hybrids and a narrower growing season impact crop development.

## Objective

To develop a series of N management strategies based on 4R nutrient stewardship that account for N placement, N timing, and N source in order to improve corn N use efficiency.

## Materials and Methods

- Field studies initiated on a Mollisol soil in Richville, MI and an Alfisol soil in Lansing, MI.
- Richville: conv. tillage following soybean, 2.8% OM, 7.7 pH, 24 ppm P, and 164 ppm K.
- Lansing: conv. tillage following soybean, 2.8% OM, 6.5 pH, 47 ppm P, and 114 ppm K.
- Randomized complete block design with four replications; Experimental units measured 15 ft x 40 ft.
  - 10 treatments: 9 N-management programs + untreated control.
  - Treatments were combinations of N placement, N timing, and N source equalized at site-specific maximum return to nitrogen rate (MRTN): Richville=180 lbs N $A^{-1}$; Lansing=140 lbs N $A^{-1}$.
  - Programs grouped into three strategies utilizing PPI, pop-up, or 2x2 (Table 1).
  - Corn was planted in 30-in rows at 34,000 seeds/$A^{-1}$.
- Data measurables included: stand counts at V3 and R6, SPAD meter, NDVI readings, and plant height measurements at V6 and R1-2, tissue N analysis at V6, R1, and R6, and end of season stalk nitrate and residual soil nitrate testing at 1 to 3 weeks after black layer.
- Grain moisture, test weight, and yield were taken at harvest and adjusted to 15.5% moisture.
- Plot details:

| | Richville | Lansing |
|---|---|---|
| Corn planted: | 08 May | 19 May |
| PPI application: | 08 May | 19 May |
| V4-6 sidedress: | 04 June | 09 June |
| V10-12 sidedress: | 30 June | 07 July |
| V6 observations: | 13 June | 16 June |
| R1 observations: | 17 July | 22 July |
| Harvest: | 07 Nov | 05 Nov |

**Table 1.** Nitrogen treatment combinations utilized at Lansing and Richville, MI sites, 2014.

| Trt. | Total N Rate | PPI | Popup | 2x2 | V4-6 | V10-12 |
|---|---|---|---|---|---|---|
| | --lbs $A^{-1}$-- | ----------At Planting---------- | | | ---Sidedress Timing--- | |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | MRTN | | AmP | | UAN | |
| 3 | MRTN | | AmP | | | UAN |
| 4 | MRTN | | AmP | | UAN | UAN |
| 5 | MRTN | Urea (100%) | | | | |
| 6 | MRTN | PCU (75%) Urea (25%) | | | | |
| 7 | MRTN | Poultry Manure | | | | UAN |
| 8 | MRTN | | | UAN | UAN | |
| 9 | MRTN | | | UAN | | UAN |
| 10 | MRTN | | | UAN | UAN | UAN |

Abbreviations: AmP=ammonium polyphosphate 10-34-0; UAN=urea ammonium nitrate 28-0-0; PCU=polymer coated urea.

**Table 2.** Nitrogen placement, timing, and source combination effects on corn grain yield, moisture, and test weight across locations, 2014.

| | | Yield (bu $A^{-1}$) | | Moisture (%) | | Test Weight(lbs $bu^{-1}$) | |
|---|---|---|---|---|---|---|---|
| Trt. | N Strategy | Lansing | Richville | Lansing | Richville | Lansing | Richville |
| 2 | Pop-up | 231 a* | 224 cd | 18.8 ab | 16.7 cd | 52.9 a | 52.1 a |
| 3 | Pop-up | 213 c | 217 d | 17.2 c | 18.3 a | 52.6 a | 53.7 a |
| 4 | Pop-up | 229 ab | 230 abc | 18.7 ab | 17.7 ab | 52.2 a | 52.6 a |
| | | | | | | | |
| 5 | PPI | 217 bc | 239 a | 17.6 bc | 16.3 d | 52.0 a | 52.8 a |
| 6 | PPI | 212 c | 234 ab | 18.0 bc | 16.8 cd | 52.2 a | 52.9 a |
| 7 | PPI | 234 a | 230 abc | 19.6 a | 17.9 a | 52.1 a | 52.8 a |
| | | | | | | | |
| 8 | 2x2 | 222 abc | 229 bc | 19.4 a | 17.1 bc | 52.4 a | 53.4 a |
| 9 | 2x2 | 213 c | 218 d | 19.3 a | 16.8 cd | 52.4 a | 53.1 a |
| 10 | 2x2 | 227 ab | 233 abc | 19.5 a | 16.7 cd | 51.7 a | 54.6 a |
| ***Pr > F*** | | 0.0289 | 0.0141 | 0.0424 | 0.0013 | 0.2726 | 0.1639 |
| Untreated Control§ | | 115 | 96 | 16.7 | 18.3 | 49.5 | 50.2 |
| | | | | | | | |
| **Multiple df Contrasts** | | | | | | | |
| Popup Strategy | | 224 a | 224 b | 18.3 b | 17.5 a | 52.6 a | 52.8 b |
| PPI Strategy | | 221 a | 235 a | 18.4 b | 17.0 b | 52.1 a | 52.8 b |
| 2x2 Strategy | | 220 a | 227 b | 19.4 a | 16.9 b | 52.2 a | 54.3 a |
| ***Pr > F*** | | 0.6080 | 0.0102 | 0.0367 | 0.0220 | 0.1262 | 0.0956 |

*values with the same lower case letter are not significantly different (α=0.1).
§not included in statistical analysis.

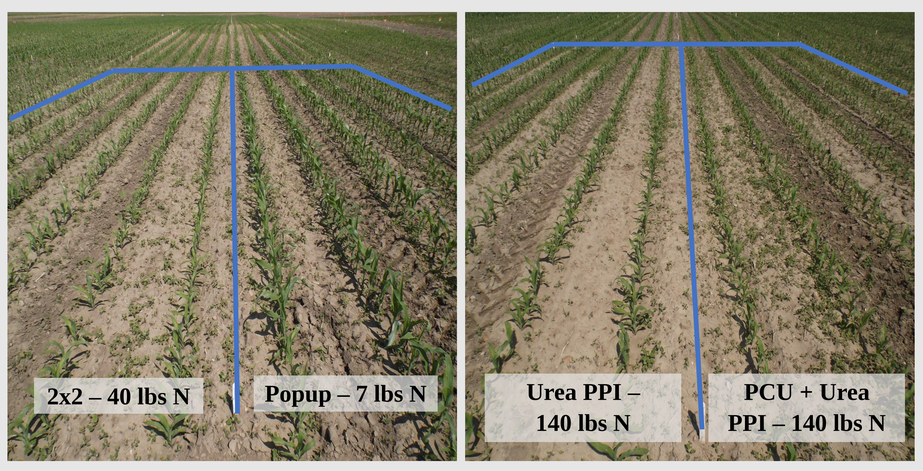


Figure 1. Differences in V4 corn vegetative growth as affected by at-planting N applications.

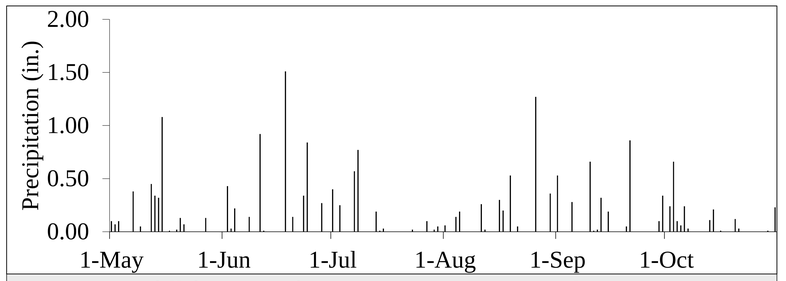


Figure 2. Rainfall frequency for 2014 Lansing, MI research site.

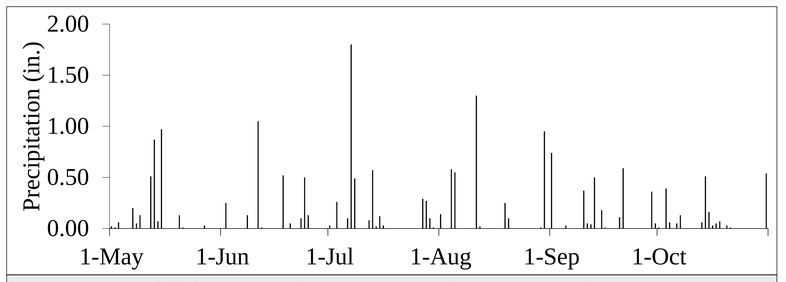


Figure 3. Rainfall frequency for 2014 Richville, MI research site.

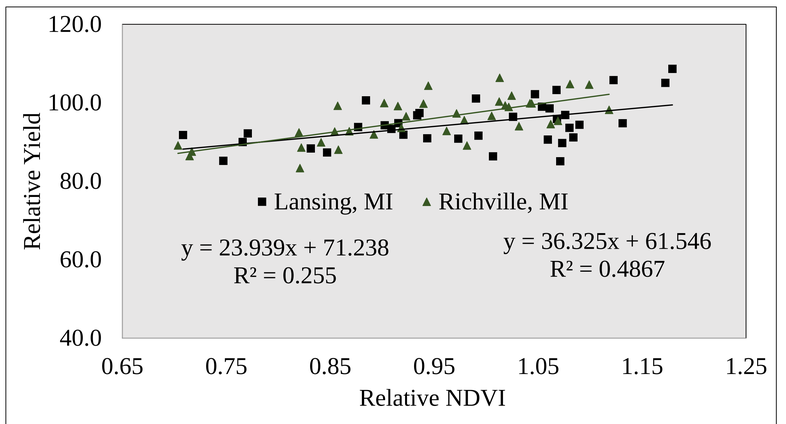


Figure 4. V6 relative normalized difference vegetation index (NDVI) vs. relative grain yield. Relationships were significant ($P \leq 0.01$).

## Preliminary Results and Discussion

***Lansing and Richville, Michigan***

- Lansing: June rainfall was 39% above monthly mean with 3 events > 0.8 in. (Fig. 2). Total rainfall between at-plant N applications and V4-6 sidedress was 1.2 in. while rainfall between at-plant and V10-12 sidedress was 5.9 in.
- Richville: Plots received 2.6 in. of rainfall within 1 week after planting (Fig. 3). This may have diluted effects from popup-N. June rainfall was 22% below the monthly mean. Total rainfall between at-plant N applications and V4-6 sidedress was 3.0 in. while rainfall between at-plant and V10-12 sidedress was 5.5 in.
- Corn N strategies utilizing either popup, 2x2, or PPI N applications resulted in similar grain yields in Lansing (Table 2). Lack of early-season rainfall events > 1.0 in. may have prevented some degree of N loss at both sites (Figs. 1,2; Table 2).
- Pop-up and 2x2 N strategies combined with V10-12 sidedress applications generally reduced grain yield as compared to early season V4 or split sidedress applications. However, late season N applications can still be used to attain corn yields > 212 bu $A^{-1}$ (Table 2).
- Corn yield potential may be realized early. The ability of N strategies to sufficiently supply N until sidedress timings and maintain yield potential may influence the success of sidedress N application timings (Figs. 1,4).