Corn and Soybean Grain Yield with Differential Soil Drainage in Minnesota

Fabián G. Fernández, Karina P. Fabrizzi, and Seth Naeve

University of Minnesota, St. Paul, Minnesota

Introduction

- Split-nitrogen (N) applications for corn (*Zea mays* L.) and N application for soybean [*Glycine max* L. (Merr.)] are approaches often suggested to increase yield.
- Soil drainage characteristics can influence these approaches, but studies that evaluate these variables concomitantly are lacking.

Objectives

To determine the effects of soil drainage in a poorly drained soils and N fertilization on:
1) corn and soybean yield, and 2) residual soil nitrogen.

Materials and Methods

- A field study (2014 to 2016) was established near Wells, Minnesota in a Marna silty clay loam and Nicollet silty clay loam soil.
- Tile drainage was installed in 2011 in all plots but since installation some have been open and others closed to create drainage treatments (Drained and Undrained).
- N management for Corn included: 0, 45, 90, 135, 180 and 225 kg N ha^{-1} applied pre-plant, and split application (pre-plant/sidedress at V4 development stage) of 135 kg N ha^{-1} (45/90-Split) and 180 kg N ha^{-1} (45/135- Split). Soybean in the rotation received no N.
- N management for Soybean included: No N [Check (135/0)], and 45 kg N ha^{-1} applied at pre-plant (45-PP), V4 (45-V4), R1 (45-R1) and R3 (45-R3) development stage. Corn in the rotation received 135 kg N ha^{-1} pre-plant. One additional treatment (0) received no N where corn in the rotation also received no N.
- N fertilizer was applied as urea (46-0-0) broadcast and incorporated (5 cm) by tillage.
- Corn and soybean yield was measured at harvest. Corn economic optimum N rate (EONR) was calculated at N/corn price ratio of 0.0056 [$1.10 kg^{-1} fertilizer N ($0.50 pound^{-1}) and $196.84 Mg^{-1} of corn ($5.00 bushel^{-1}).
- Soil total inorganic N (TIN) (ammonium-N plus nitrate-N) was measured at 0-90 cm depth at harvest and the following Spring.
- Statistical analysis was conducted using the PROC GLIMMIX procedure of SAS with drainage systems, and N management as fixed effects and block and year as random effects.

Acknowledgements

Research Funding Provided by the Minnesota Soybean Research and Promotion Council. Thank you to the soil fertility field crew of the U of MN for their help.

Results and Discussion

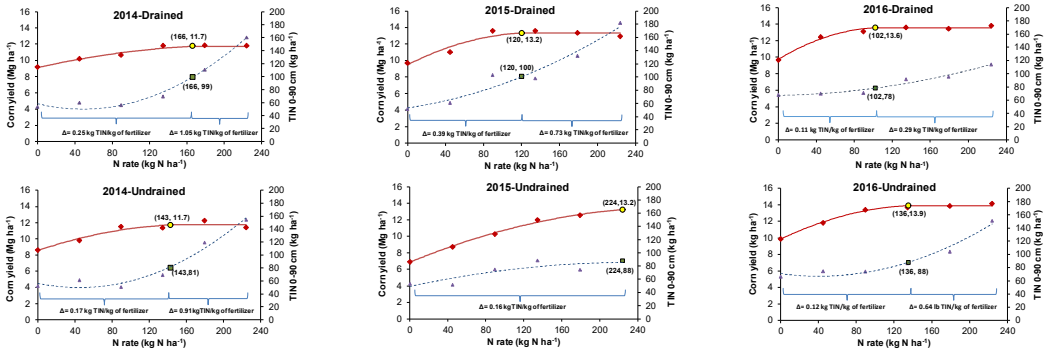

Figure 1. Corn yield response to pre-plant N rate (solid red line) including economic optimum N rate (EONR) and yield at the EONR (in parenthesis) and post-harvest residual total inorganic N (TIN) (dash blue line including TIN at the EONR in parenthesis) in drained and undrained soils during the 2014, 2015 and 2016 growing seasons.

Except for 2014 where dry conditions in Jul-Aug likely enhanced N availability in Undrained soil, the EONR was lower for Drained than Undrained soil. Wet soils for most of 2015 likely caused N loss in the undrained soil.

Overall residual TIN at the EONR was 89 kg ha^{-1} and increased substantially above the EONR.

Table 1. ANOVA for Corn grain yield

	Corn grain yield (Mg ha^{-1})		
	2014	2015	2016
Drained	10.9 a	12.6 a	12.9 a
Undrained	10.9 a	10.8 b	13.0 a
0-N	8.9 d	8.3 e	9.8 c
45-N	10.0 bc	9.9 d	12.2 b
90-N	11.1 ab	11.9 bc	13.3 a
135-N	11.3 ab	12.5 abc	13.7 a
180-N	12.0 a	13.0 abc	13.7 a
225-N	11.6 a	13.1 ab	14.0 a
45/90-N	11.3 ab	11.8 c	13.5 a
45/135-N	-	13.2 a	13.7 a
	..... *P* values		
Drainage (D)	0.9659	0.0219	0.4533
N rate (N)	0.0005	<.0001	<.0001
D x N	0.8574	0.0126	0.7251

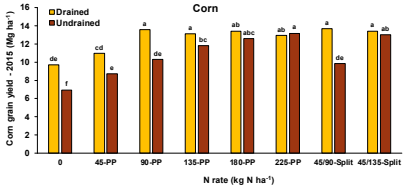

Figure 2. Corn grain yield affected by the significant interaction Drainage x N rate during 2015 growing season.

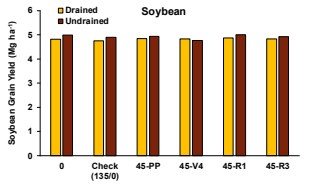

Figure 3. Effect of N timing application on soybean yield for drained and undrained soils average across 2014, 2015 and 2016.

Corn grain yields were similar between Drained and Undrained soils except in 2015 where it was greater for Drained soil (Table 2).

Across drainage, similar corn grain yields were observed in the Split and Single N application (Table 2). In 2015, the interaction D x N showed that Drained had greater grain yield than Undrained for rates ≤135 kg N ha^{-1} (Fig. 2).

Soybean yields were similar among N timing treatments across growing seasons and drainage (Fig. 3).

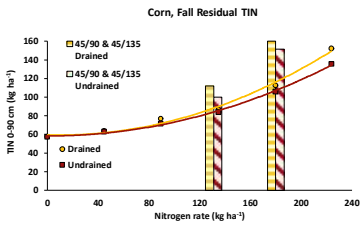

Figure 4. Mean 3-yr fall residual total inorganic N (TIN) measured at 0-90 cm depth. The 45/135 treatment is the average of 2015 and 2016 only.

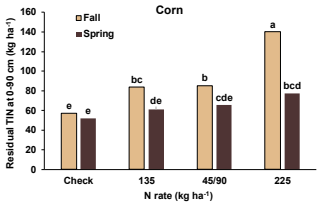

Figure 5. Differences in residual total inorganic N (TIN) at 0-90 cm depth between Fall and Spring sampling for corn averaged across 2014 , 2015, and 2016.

Residual TIN increase when N rate exceeded crop needs especially with Split-N applications (Fig. 4).

N loss between fall and spring occurred regardless of rate, but it was most pronounced when N applications exceeded crop needs (Fig. 5).

Soybean residual TIN was similar to the corn check treatment (not shown).

Conclusions

Generally, similar corn yields were obtained but at a lower EONR in Drained than Undrained soils. Split-N applications did not increase corn yield relative to single pre-plant applications.

Regardless of soil drainage conditions, nitrogen rates above the EONR, especially with split-N applications, increased residual TIN in the Fall and resulted in greater N loss by the spring.

Soybean yields were not affected by drainage or N application.