Impact of Lime Placement on Corn Grain Yield Response and Soil Properties

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INTRODUCTION

- Missouri claypan soils managed for corn (*Zea mays* L.) exhibit stratification of soil pH with often optimum surface pH for production paired with largely acidic subsoils.
- Acidic subsoils may inhibit root growth leading to drought sensitivity and decreased yields.
- Conventional lime applications are known to increase soil pH while improving soil structure and adding nutrients to the soil.
- Surface applications of lime in the topsoil may not affect subsoil horizons leading to possible yield reductions.

OBJECTIVES

- To determine the effect of lime placement, including deep banding, and lime application rate on soil properties.
- To evaluate the effect of these treatments on corn grain yields.

MATERIALS AND METHODS

- Three field sites were established over the course of three years at the Greenley Memorial Research Center in Northeast Missouri (Fig. 1) from 2012 to 2014.
- Sites were arranged in a split-plot design with four replications.
- Field trial #1 was established in 2012 on a Putnam silt loam, Field trial #2 in 2013 on a Killwinning silt loam and Field trial #3 in 2014 on a Putnam silt loam.
- Sites were divided into main plots of corn with subplots of lime treatments applied once to each site at its establishment and analyzed for residual effects in subsequent years.
- Treatments consisted of surface applications of pelletized lime at 0, 3.4, and 6.3 Mg ha^{-1} (CO, S-LO, S-HI) and deep banded placement at 0, 3.4, and 6.3 Mg ha^{-1} (D-NO, D-LO, D-HI) via a conservation subsoiler attached with a custom built shank (see Figs. 2 and 3) to deliver lime at depths of 13, 25, 38 and 51 cm.
- The center two rows of corn were harvested for grain and reported at 150 g kg^{-1} moisture.
- Soil samples were collected in the fall after harvest at depths of 0 to 13, 13 to 25, 25 to 38 and 38 to 51 cm. and analyzed for pH (0.01 M $CaCl_2$).
- All data were subjected to ANOVA and means separated using Fisher's protected LSD at P=0.10.

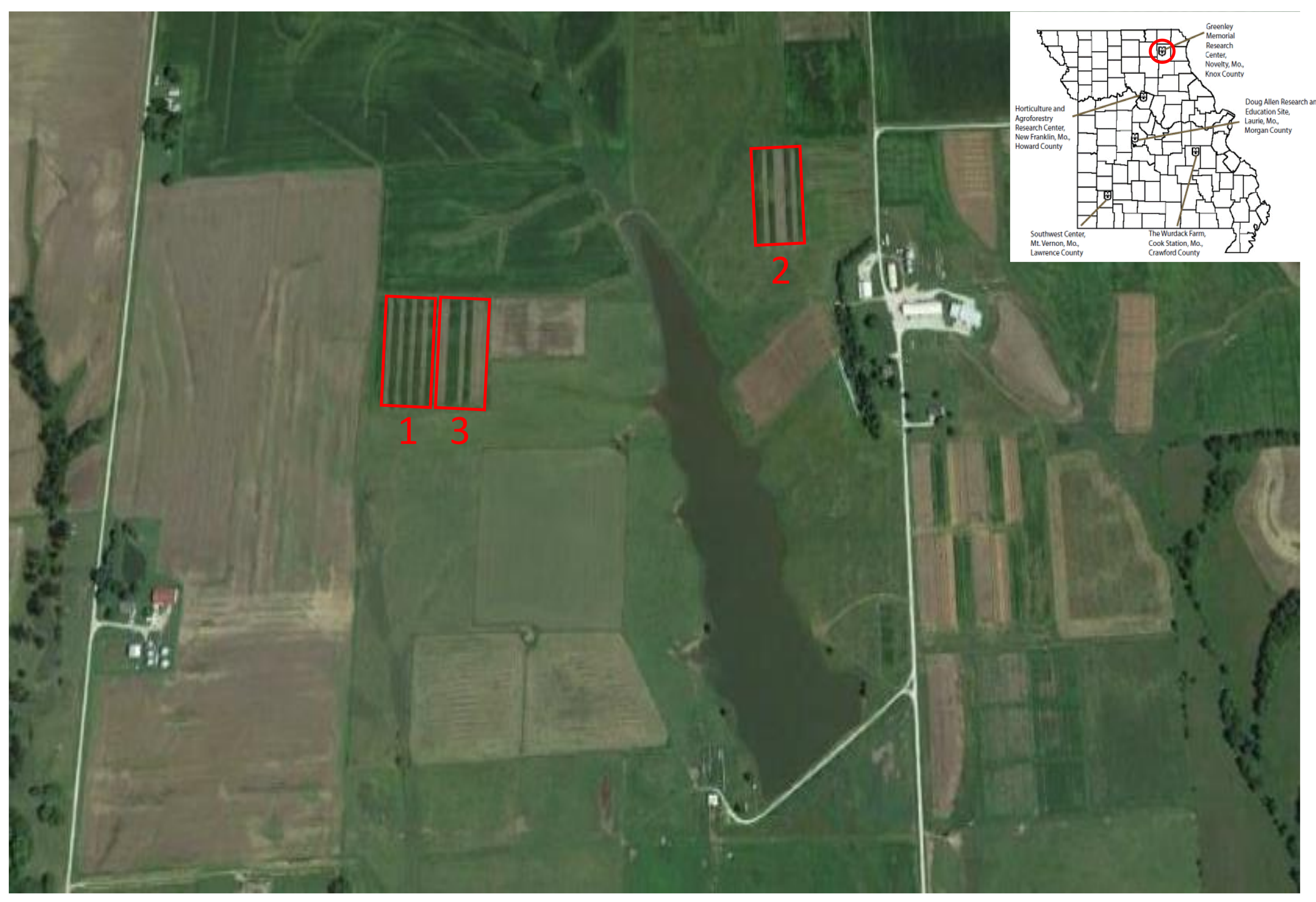

Figure 1. Locations of Greenley Memorial Research Center in Missouri and field trial sites #1, #2 and #3 at the Center.

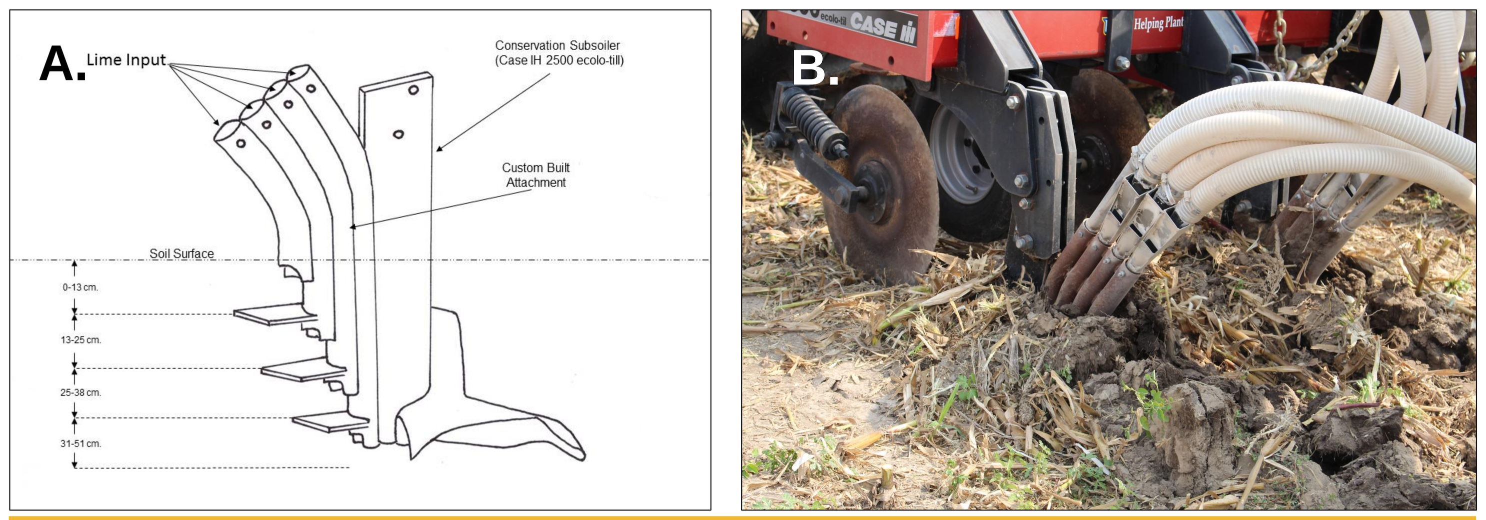

Figure 2 A. & B. Diagram of custom built shank applicator (A.) and custom built applicator shank during deep placement lime application (B.).

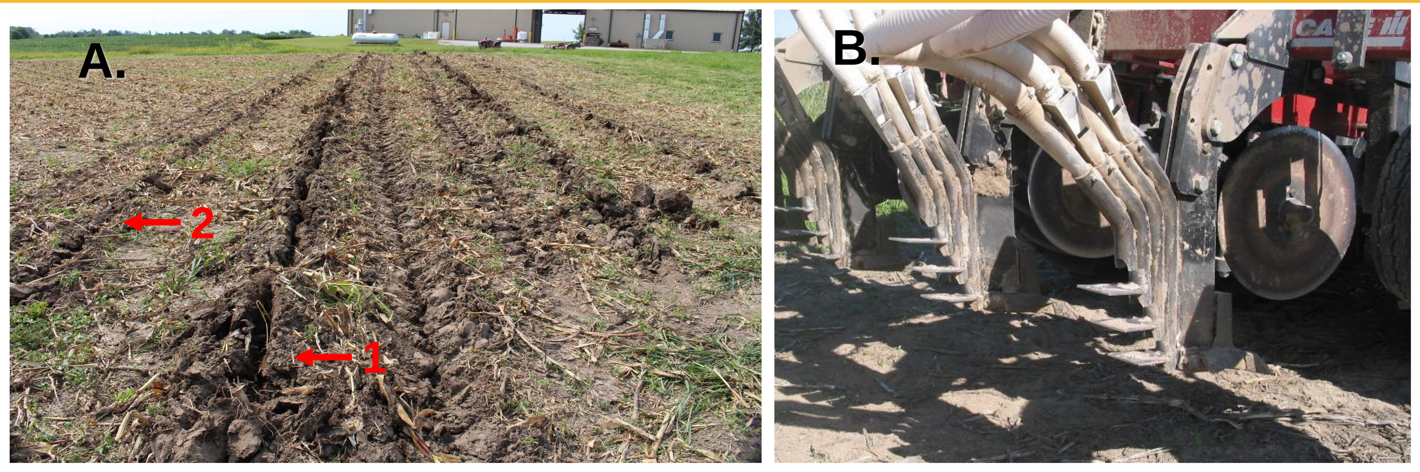

Figure 3 A & B. Soil disturbance from custom built applicator shank (1) versus normal tillage (2) (A.) and raised custom built applicator shank (B.).

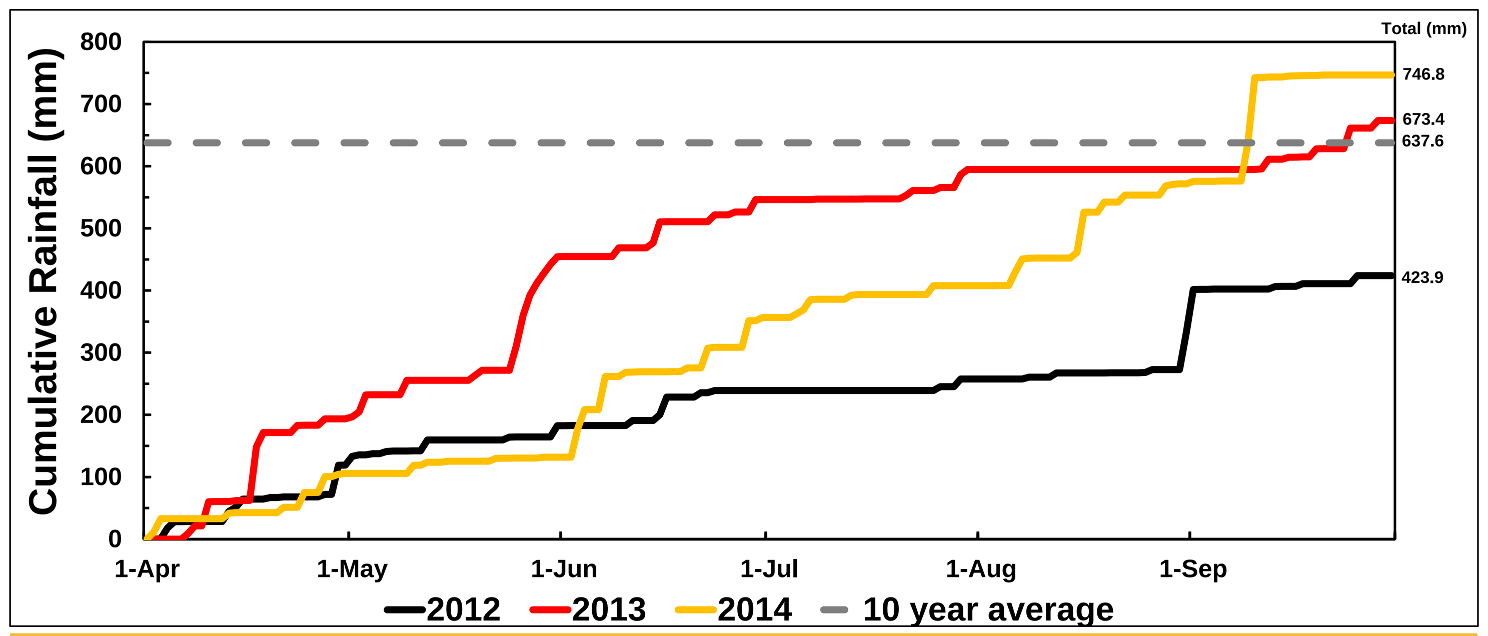

Figure 4. Cumulative precipitation over the growing period (April to September) at Greenley Memorial Research Center compared to 10 year average (2000 to 2009).

Table 1. Average soil pH of each treatment and soil depth after grain harvest.

Depth	Treatment	Field Trial #1 2012	Field Trial #1 2013	Field Trial #1 2014	Field Trial #2 2013	Field Trial #2 2014	Field Trial #3 2014
0 to 13 cm.	CO	5.4	5.8	5.5	4.7	4.6	5.6
	S-LO	5.9	6.3	6.3	5.2	5.2	6.0
	S-HI	6.2	6.5	6.6	5.3	5.5	6.4
	D-NO	5.7	5.8	5.9	4.8	4.6	5.7
	D-LO	5.7	6.0	5.8	4.7	4.6	5.7
	D-HI	5.4	6.0	5.9	4.8	4.6	5.7
	LSD (P=0.10)	0.3	0.2	0.2	0.2	0.2	0.4
13 to 25 cm.	CO	4.9	5.9	5.9	5.0	4.9	5.9
	S-LO	4.7	6.0	6.0	4.7	4.9	6.1
	S-HI	4.8	5.8	6.1	4.9	5.0	6.1
	D-NO	4.8	5.8	5.9	4.9	4.7	6.2
	D-LO	5.0	6.2	6.3	5.2	5.0	6.5
	D-HI	4.8	6.4	6.5	5.0	5.2	6.6
	LSD (P=0.10)	0.4	NS	0.4	0.3	NS	0.4
25 to 38 cm.	CO	4.8	4.7	4.8	4.8	4.7	5.0
	S-LO	4.7	4.7	4.7	4.6	4.6	5.1
	S-HI	4.7	4.7	4.9	4.6	4.7	5.1
	D-NO	4.7	4.9	4.7	4.7	4.7	5.0
	D-LO	5.1	4.7	5.2	4.6	4.9	5.4
	D-HI	4.6	4.8	4.9	5.1	4.7	6.0
	LSD (P=0.10)	NS	NS	NS	NS	NS	0.4
38 to 51 cm.	CO	4.5	4.6	4.4	4.6	4.6	4.5
	S-LO	4.5	4.6	4.4	4.6	4.6	4.7
	S-HI	4.5	4.5	4.4	4.6	4.7	4.8
	D-NO	4.5	4.5	4.4	4.6	4.6	4.6
	D-LO	4.5	4.6	4.6	4.6	4.6	4.6
	D-HI	4.4	4.5	4.5	4.7	4.6	4.7
	LSD (P=0.10)	NS	NS	0.2	NS	NS	NS

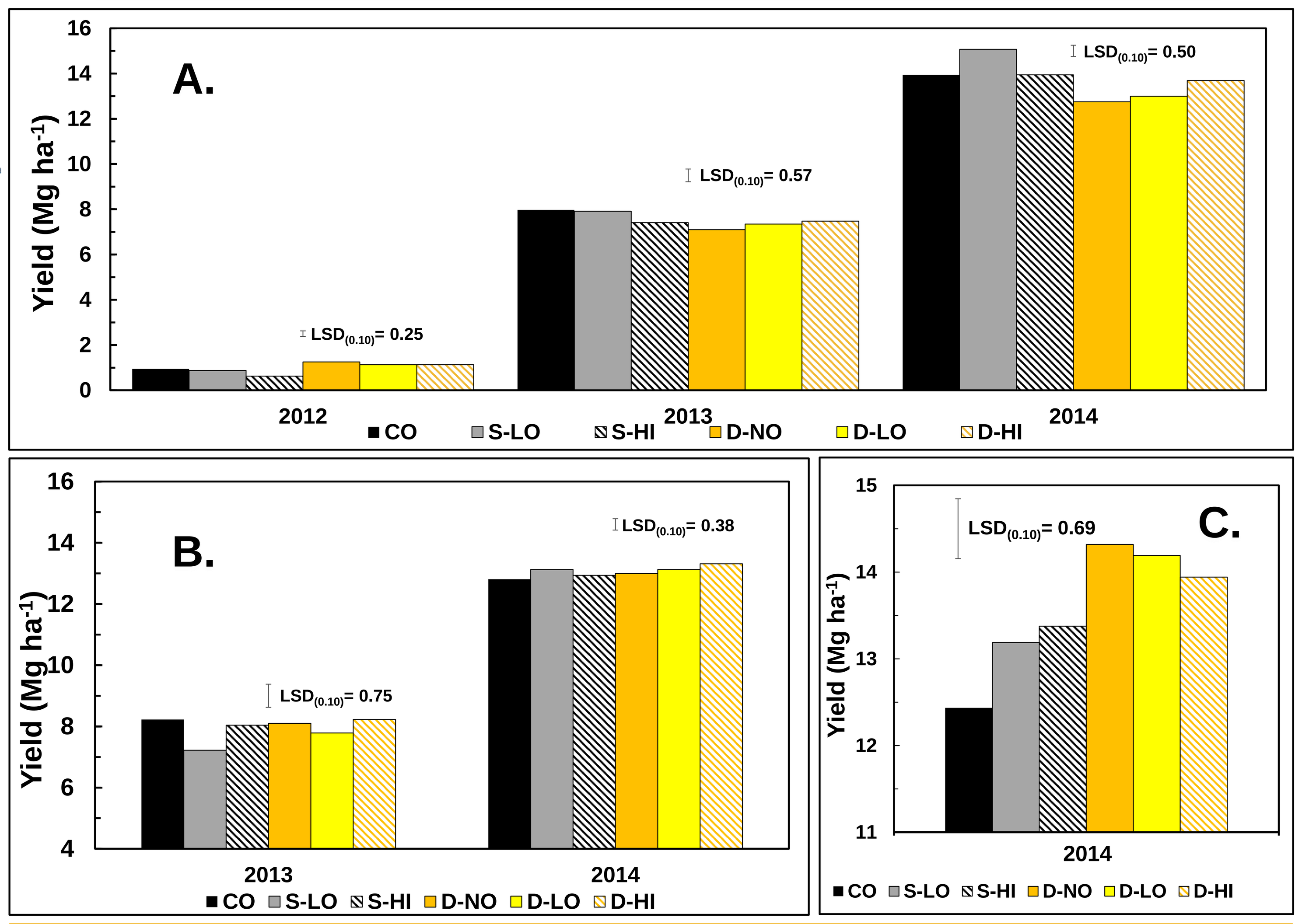

Figure 5 A - C. Corn grain yields for each treatment for field trials #1 (A.) #2 (B.), and #3 (C.) for first year and residual years. Vertical bars show LSD (*P*=0.10).

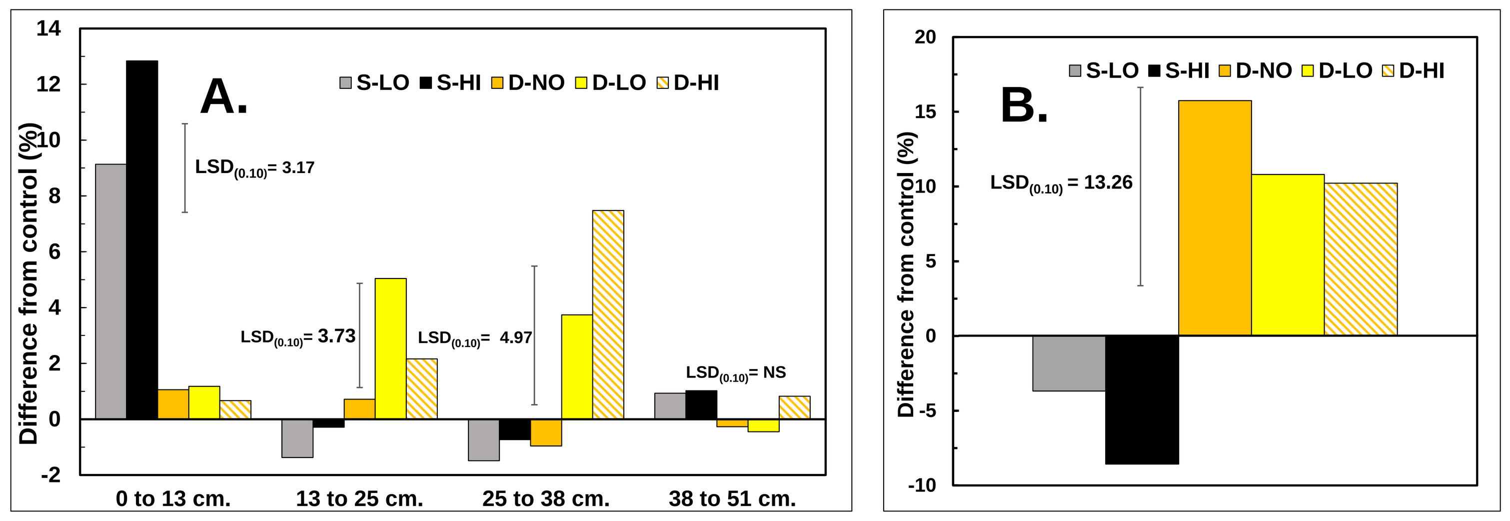

Figure 6 A. & B. Percent difference of soil pH of the treatments compared to the respective controls of field trials #1-3 for the first year after application (A.) and corn grain yield percent different of treatments compared to respective controls of field trial #1-3 for the first year after application (B.).

RESULTS AND DISCUSSION

- The custom built shank effectively delivered lime throughout the soil profile (Figure 2A). This modified shank caused ridge formation and cultivation following application was utilized to reduce this effect (Figure 3A).
- Rainfall varied greatly from 2012 to 2014 with an extensive drought in 2012 resulting in precipitation that was 18.5 cm below the 10 year average. An extended period of drought was observed in the summer of 2013, but overall temperatures were lower than 2012. Precipitation in 2014 was 10.9 cm above the 10-year average (Figure 4).
- All surface applications significantly increase soil pH in the top 13 cm of soil. (Table 1.)
- In 2014, deep placement significantly raised soil pH in the 13 to 25 cm depth for field trials #1 and #3 and the 25 to 38 cm depth for treatment D-HI in field trial #3 (Table 1).
- Deep placement treatments significantly proportionally raised pH compared to the control at the 13 to 25 and 25 to 38 cm depths after the first year application (Figure 6A).
- In 2012, deep placement treatments increased corn grain yields 0.25 to 0.50 Mg ha^{-1} for field trial #1 (Figure 5A).
- Grain yields were not affected by deep placement methods compared to surface application for field trial #2. However in 2014, treatment D-HI significantly increased yields compared to the control (Figure 5B.)
- All treatments significantly increased grain yields in field trial #3 with deep placement methods having the greatest effects (Figure 5C).
- When analyzed by time after establishment, deep placement treatments showed the greatest percent increase in yields compared to that of their respective controls (Figure 6B.)

CONCLUSIONS

- Differences in grain yields over the three years of the study appeared to be affected by lime application rate, reaction time, climatic conditions and whether lime was applied to the surface or deep banded.
- The substantially drier years of 2012 and 2013 possibly led to a lower grain yield response to treatments due to subsequent decreased reactivity of the applied lime.
- As expected, surface applications greatly increased the surface soil pH compared to that of deep placement.
- Slight soil pH changes were observed in subsoil from deep placement methods using the customized shank.
- Further analysis is being conducted to evaluate soil levels of exchangeable Al and Mn along with the spatial distribution of deep-applied lime in the subsoil using the customized shank.

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