# Soil pH and Planting Timing Effects on Yield

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## Introduction and Objectives

Within the region, minimal differences have been observed between April and May planted soybeans, although cooler weather and disease may reduce yields with earlier planting. Another issue uncovered in recent DSB research projects is the effects of Al and Fe uptake on reducing early planted soybean yields. One way to reduce the effects of these metals is maintaining a higher soil pH, reducing the solubility of Al and Fe. By increasing soil pH, soybean producers may find that earlier planting on our coastal soils can take advantage of a longer pre-solstice growing season and obtain greater yields.

Alternatively, higher pH may reduce the availability of other metal micronutrients, including Mn, Zn and Cu. It may also give rise to greater edge site cation exchange capacity, allowing for greater leaching of B and SO4 from the soil surface. Rather than having a net sum reduce the effectiveness of liming, we must determine the liming effects on all nutrients taken up in these soils. The objective of this study were to examine yield and nutrient uptake of full season soybeans under different liming rates (0 – ton/acre) and two planting timings (early and late).

## Methods

Soybeans were on a cooperating farmers field in Laurel, DE in section of a field with a burned down rye cover crop. Plots (10 by 30 feet) were setup as a randomized complete block design (RCBD), with one factor being liming rate (0, 0.25, 0.5, 0.75, and 1.0 tons acre-1) and the other planting timing (April and late May). Lime was applied on April 12, 2023 and incorporated through vertical tillage (Turbo Till). Based on the initial field soil test, a calcitic lime (high Ca) was chosen. There were three replications for a total of 30 plots. The first planting was performed in late April 2023, however deer feeding limited growth until the rest of the farmers crop was planted in late May. To adjust for deer damage, the established beans were turbo tilled, then the "early" planting was done again on May 26, 2023, followed by a late planting on June 28, 2023.

Pre-plant soil samples (8" depth) were be taken prior to lime application to establish each plots baseline. Soybean tissue samples were taken at V3 and R1 to establish nutrient uptake over the season. Post-harvest soil samples were taken from the upper 8 inches of each plot. All samples were submitted to the UD soil testing lab for analyses. Yield were be collected at the end of the growing season using a plot combine. Using SAS statistical software, we will compare the plot data as a factorial RCBD to determine treatment effects. Tissue nutrient content was correlated to yield and initial soil nutrient levels. Some initial results were reported at the 2024 Delaware Ag Week.

## Results and Discussion

*Soybean Yields as Affected by Liming Rate and Planting Timing*

There were no differences by liming rate or any interaction between liming rate and planting timing (Figure 1). There is a *trend* with the late May planted soybeans, where yields may hae improved by 10 bushels with liming, but it was not statistically significant. For soybeans planted a month later (Figure 1a), the trend is fairly flat. Based on planting timing, yields were 7 bushels higher when planted in late May. Based on correlation analyses, higher yields were associated with soil properties such as organic matter, P, K, and Mg contents.

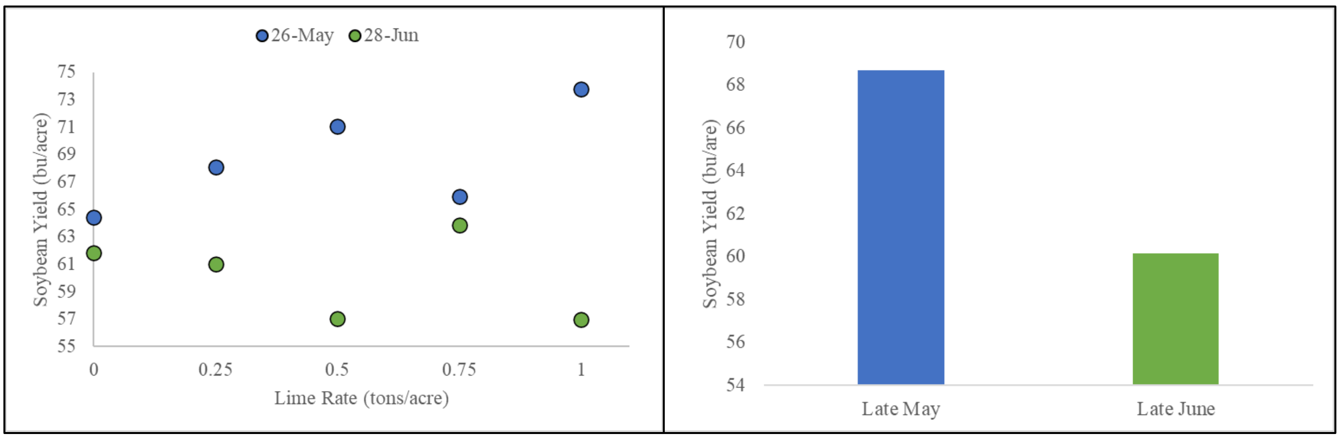


**Figure 1**: Yields based on a) liming rate (no statistical differences) and b) planting date (p = .0023).

*Post-Harvest Soil Characteristics as Affected by Liming Rates*

Soil data presented below (Table 1) are selected from any properties that were significantly different or of interest to the study. The soil pH did not change with liming rate across plots, based on a simple pH measurement. However, by subtracting the pre-plant soil pH from the final pH (ΔpH), we found that plots receiving at least 0.75 tons/acre saw a significant rise in pH, above the control plots (Table 1). Buffer pH was also moderately higher with liming, perhaps signifying a change in surface colloidal chemistry. The lime in this study was calcitic, and there were no changes in Mg content observed with lime additions. Overall, Ca (mg/kg or ppm) was higher when applications were above 0.5 tons/acre, and then was also reflected in the ΔCa (final minus initial soil Ca (Table 1). A similar effect was seen for base saturation (%), with no effects due to ¼ ton rate, but higher (but similar) base saturation between 0.5 to 1 ton of calcitic lime.  Although Al was not different among plots based on liming, extractable values did drop with liming rates. For these soils, liming rates above 1 ton should be explored for effects on extractable Al.

No other differences in soil characteristics were observed, including extractable contents of the metal micronutrients Mn, Zn, or Cu.

**Table 1:** Selected soil characteristics after harvesting soybeans, fall 2023. Differences are by LSD a = 0.1, all other soil nutrients were not significantly different (K, Mg, S, + micronutrients).

| Liming Rates (tons/acre) | pH | ΔpH | Buffer pH | Ca mg kg soil$^{-1}$ | ΔCa | Al mg kg soil$^{-1}$ | Base Saturation % |
|---|---|---|---|---|---|---|---|
| 0 | 6.1 | 0.4 c | 7.82 b | 660.7 bc | 10.58 c | 670.77 | 75.3 c |
| 0.25 | 6.1 | 0.3 c | 7.84 ab | 620.0 c | 35.68 c | 659.66 | 76.2 bc |
| 0.5 | 6.3 | 0.6 bc | 7.86 a | 811.4 ab | 192.92 ab | 634.88 | 81.9 a |
| 0.75 | 6.2 | 0.4 a | 7.85 a | 760.1 abc | 89.13 bc | 653.66 | 80.1 ab |
| 1 | 6.2 | 0.5 ab | 7.86 a | 905.6 a | 298.60 a | 634.62 | 82.4 a |
| p-value | *ns* | *0.0028* | *0.0070* | *0.0482* | *0.0147* | *ns* | *0.0138* |

*Macronutrient Uptake and Tissue Concentrations Based on Planting Timing*

For leaf nutrient concentrations, there was no difference observed based on liming rate or its interaction with planting timing, so only data of the main effect of planting timing are reported below (Table 2). At the early growth stages (V3), all macronutrient concentrations were different based on planting date, with the May planting being higher in N, P, Ca, and S (Table 2). The later, June planting date was higher in K and Mg. The differences are not very great and fall within expected sufficiency ranges.

By the reproductive stages (R2), only Ca was greater in leaf tissue with the May planting, while K and S were greater with the June planting date. It appears that early growth with June planting dates may have had some limited uptake or stress associated with nutrient availability, particularly when considering N. Most loss in yield from late planting comes from lack of leaf area, or the photosynthetic ability of the plant. So, these differences in nutrient concentration appear to be pretty minor, and are mostly lost when grain fill begins. Based on correlations, vegetative N, P, and S were associated with higher yields, while Ca was important at R2.

**Table 2:** Trifoliate leaf macronutrient concentrations based on planting dates (May and June) at early vegetative (V3) and reproductive (R2) soybean stages.

| V3 | **N** | **P** | **K** | **Ca** | **Mg** | **S** |
|---|---|---|---|---|---|---|
| 05/26 | 5.95 a | 0.52 a | 2.19 b | 1.07 a | 0.43 b | 0.32 a |
| 06/28 | 5.65 b | 0.42 b | 2.48 a | 0.98 b | 0.46 a | 0.29 b |
| *p-value* | *<0.0001* | *<0.0001* | *<0.0001* | *0.0083* | *00576* | *<0.0001* |
| R2 | **N** | **P** | **K** | **Ca** | **Mg** | **S** |
| 05/26 | 6.16 | 0.51 | 2.12 b | 0.9 a | 0.37 | 0.30 b |
| 06/28 | 6.01 | 0.52 | 2.26 a | 0.84 b | 0.37 | 0.33 a |
| *p-value* | *ns* | *ns* | *0.083* | *0.0040* | *ns* | *0.0209* |

*Micronutrient Uptake and Tissue Concentrations Based on Planting Timing*

For leaf nutrient concentrations, there was no difference observed based on liming rate or its interaction with planting timing, so only data of the main effect of planting timing are reported below (Table 3). Similar to macronutrients, the earlier planting date was higher in concentrations at V3, including for Mn, Zn, Cu, and B (Table 3). The largest difference was for Zn, which was 20ppm higher. For this study, the two nutrients of interest by liming rate, Fe and Al, were not different based on liming or planting timing. At the R2 growth stage, only difference in Mn remained, with higher leaf tissue concentrations for the late May planting date.

Based on correlations with yield, vegetative leaf concentrations of Cu, B, and Na were associated with higher yields. At the R2 growth stage, only higher B was related to higher yields, but higher Al indicated a loss in soybean yield. Al concentrations for the June planting were higher (Table 3), although not statistically significant, which may explain the overall relationship. Post harvest soil pH also was associated with reduce concentrations of V3 Zn, V3 B, R2 Mn, and R2 Zn.

**Table 3:** Trifoliate leaf micronutrient concentrations based on planting dates (May and June) at early vegetative (V3) and reproductive (R2) soybean stages.

| V3 | **Mn** | **Zn** | **Cu** | **Fe** | **B** | **Na** | **Al** |
|---|---|---|---|---|---|---|---|
| 05/26 | 85.45 a | 124.52 a | 10.32 a | 178.03 | 30.39 a | 40.92 a | 283.94 |
| 06/28 | 75.62 b | 104.9 b | 8.63 b | 192.65 | 26.91 b | 14.13 b | 357.74 |
| p-value | 0.0098 | 0.015 | <0.0001 | ns | 0.0079 | <0.0001 | ns |
| R2 | **Mn** | **Zn** | **Cu** | **Fe** | **B** | **Na** | **Al** |
| 05/26 | 74.53 a | 122.75 | 8.52 | 94.91 | 44.46 | 18.22 | 12.12 |
| 06/28 | 67.8 b | 120.85 | 9.11 | 88.32 | 43.3 | 18.87 | 24.01 |
| p-value | 0.0171 | ns | ns | ns | ns | ns | ns |

## Conclusions

Even on a soil with a pH initially <6.0, liming rates up to 1 ton/acre did not improve yield. As is already previously established, planting later reduces the ability of the soybean plant to canopy and produce a higher leaf area index, limiting yields. Adding a calcitic lime did improve soil pH above 0.5 tons/acre, which would also be the liming recommendation from UD (67% effective liming rate) based on initial conditions. This also resulted in a higher base saturation, increasing it by about 2%. Liming may have reduced Al concentrations in the soil, but higher rates may need to be performed (>1 ton/acre) before we can be sure.

Tissue nutrient uptake also did not vary by liming rate, but for vegetative stages most macro and micronutrients were moderately higher for the late May planted soybeans. Most of these differences were minor and gone by the time reproductive growth stages were reached, with only B concentrations being tied to higher yields. The early season V3 N, P, and S were important for yields in the May planting, maybe indicating soil differences in their availability across the plots. Although aluminum uptake was not different based on liming or planting dates, leaf concentrations did point to reduced yields at the R2 stage. This project will be repeated in 2024 to continue to observe how Al uptake and reduced yields may be ameliorated.