

# **APPLICATION RATE STRATEGIES TO OPTIMIZE USE OF PELLETTED LIME IN CORN AND SOYBEAN PRODUCTION**

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## **ABSTRACT**

Research has shown inconsistent results about the efficiency of pelleted lime at increasing soil pH or crop yield compared with aglime. Our previous Iowa research (2015-2016) showed that pelleted lime manufactured with limestone from northern Iowa quarries attained maximum soil pH with the same rate and at the same time than finely ground calcium carbonate, but more time was needed for aglime. However, there were no yield differences between the sources for corn-soybean rotations when one-time rates of 560 to 7,300 lb/acre of effective calcium carbonate equivalent (ECCE) were applied before corn. This new study (2020-2021) with corn-soybean rotations and 2-year trials at six locations was conducted with very low to high pelleted lime rates. Initial soil pH in fall 2019 was 5.1 to 5.9 across sites. Pelleted lime rates of 0, 100, 200, 400, 800, 1600 and 6400 lb/acre (89% ECCE) were applied in fall 2019 and were incorporated by disking for corn in 2020. After corn harvest each plot was divided into two halves to apply two sets of treatments for soybean in 2021. No pelleted lime was applied to one subplot to evaluate residual effects of the initial applications on soybean. The same initial rates were reapplied to the other subplot to evaluate effects of freshly applied lime, except that for the initial 6400-lb rate only a 1600-lb rate was applied. The freshly applied lime was not incorporated, and no-till soybean was planted. In 2020, soil samples were taken from all plots in March, June, and October after corn harvest. In 2021, soil samples were taken in March from all plots and in October only from the control and plots that received annual applications. On average across the six sites and by spring of 2021 soil pH for initial rates of 0, 100, 200, 400, 800, 1600 and 6400 was 5.53, 5.60, 5.65, 5.71, 5.78, 6.01, and 6.5, respectively. Soil pH for plots receiving annual applications was 5.63, 5.71, 5.82, 5.87, 6.15, and 6.59. Soil pH of 6.0 to 6.5 is considered optimum for corn and soybean in Iowa depending on the region. Maximum yield (means of replications) at each trial was 199 to 285 bu/acre for corn and 68 to 74 bu/acre for soybean. Grain yield increased exponentially to a maximum plateau for both crops. Relative yield increases across both crops to initial rates were 1.9, 2.5, 3.9, 6.2, 7.5, and 9.0% whereas for annual rates were 2.8, 3.5, 4.5, 7.2, 8.8, and 9.1%, respectively. Overall, the study showed that application of pelleted lime rates lower than needed to increase soil pH to 6.0 or 6.5 limited crop yield significantly at several sites.

## **INTRODUCTION**

Pelleted lime was developed mainly to facilitate and improve uniformity of lime application, and typically is ground limestone granulated using a binding agent. Scarce research in other states from the middle 1980s until 2013 provided inconsistent results about the efficiency of pelleted lime at increasing soil pH or crop yield compared with

aglime. Reasons for the inconsistent results of few field trials could not be identified mainly due to insufficient information about the pelleted lime manufacturing, such as chemical properties and fineness of the limestone used and final granule size. Additional research is needed because pelleted lime is more expensive than aglime and in recent years its offer to farmers has increased in Iowa and neighboring states.

A previous field study by our group in six Iowa sites showed that the efficiency at increasing soil pH and both corn and soybean yield of pelleted lime manufactured with limestone from Iowa quarries was similar to finely ground calcium carbonate and better than for calcitic aglime. However, the lowest application rate used was 2000 lb/acre of calcium carbonate equivalent (CCE). Therefore, the objective of this new field study was to develop application rate strategies for cost-effective use pelleted lime application for corn and soybean production by using very low to high rates of the same pelleted lime used before.

### SUMMARY OF PROCEDURES

Six 2-year trials were established in fall 2019, with corn planted in 2020 and soybean planted in 2021. The trials were established at fields of Iowa State University research farms with contrasting soils located in different areas of the state, which were in the center (two trials) near Ames and near Boone, northeast near Nashua (NERF), northwest near Calumet (NWRF), southeast near Wyman (SERF), and southwest near Lewis (SWRF). Table 1 shows information about locations, soils, and soil-test results from samples collected in fall 2019 before treatments application. First-year plot size was 20 feet wide (for eight 30 inches corn rows) by 15 feet long and treatments replicated three times were pelleted lime rates of 0, 100, 200, 400, 800, 1600, and 6400 lb/acre. After corn harvest in fall 2020, each plot was divided into two subplots, one did not receive lime to evaluate the residual effects on soybean and the other received similar rates except for 1600 lb/acre to plots with the highest first-year rate. Treatments were replicated four times.

Table 1. Locations, soils, and soil-test results (6-inch depth) in fall 2019 before treatment application for 2020.

Site	Nearest City	Soils†	Previous Crop	Soil-Test Results‡				
				pH	Ca	Mg	Na	OM
					----- ppm -----			%
1	Ames	Clarion loam	Soybean	5.8	8826	1269	12	2.9
2	Boone	Nicollet loam	Soybean	5.3	9013	1188	14	3.1
3	Nashua	Floyd loam	Corn	5.6	6566	879	11	2.7
4	Calumet	Galva SCL	Soybean	5.6	13450	2422	15	4.4
5	Wyman	Mahaska SCL	Corn	5.9	11039	2056	15	3.4
6	Lewis	Marshall SCL	Soybean	5.1	9791	1819	17	3.2

† SCL, silt clay loam; extractable Ca, Mg, and Na with ammonium-acetate; OM, organic matter.

The pelleted lime used (Calcium Products 98G pelletized limestone) is made from mined ground calcitic limestone from quarries near Gilmore City and Fort Dodge, Iowa. The pellets are manufactured by pan agglomeration using finely ground limestone (99% passing mesh 60, 90% passing mesh 100, and 75% passing mesh 200) and calcium lignosulfonate as the binding agent. Pellet diameter ranged from 2.0 to 4.0 mm. The lime was analyzed by methods required by the Iowa Department of Agriculture and Land Stewardship for sale of liming products. Pelleted lime CCE was 90.1% and effective CCE (ECCE) was 89%. In the first year, the pelleted lime was incorporated to a depth of 4 inches. In the second year, the new applied lime was not incorporated, and no-till soybean was planted. Soil (6 inches) was sampled for pH analysis in late March, June, and October 2020. All plots were sampled in March 2021 and only plots receiving the annual rates were sampled in October.

## **RESULTS AND DISCUSSION**

### **First-year pelleted lime effects on soil pH**

The overall pH levels and pelleted lime effects varied across sites and the three sampling dates (not shown). Large pH variation over time even without lime application often has been observed. Differences among sampling dates were probably due to weather and for the June sampling date the N application. The pH of unlimed soil in June was much more acidic than in fall 2019 or March 2021, being 4.7 to 5.6. At the Ames, Boone, and SWRF sites, soil pH levels were the highest for the October 2020 sampling date, the lowest for the early summer sampling date (about 5 weeks after the N application), and intermediate for the early spring sampling date. At the other sites there were no large or clear differences in overall soil pH among the three sampling dates. Also, by October 2020, one year after the initial applications, the 6400-lb rate increased soil pH above 6.5 at all sites. The second-high 1600-lb rate increased pH to 6.0 or above at the Ames, NERF, NWRF, and SERF sites but not at the Boone and SWRF sites. Optimum pH for corn and soybean in Iowa is 6.0 in the region of the Ames, Boone, NWRF, and SWRF sites (calcareous subsoil); and pH 6.5 in the region of the NERF and SERF sites (acidic subsoil). Pelleted lime rates of 100, 200, and 400 lb/acre increased soil pH by about 0.3 pH units or less.

### **Second-year pelleted lime effects on soil pH**

The residual effects of the initial pelleted lime applications in fall 2019 and the annual applications on soil pH during 2021 (not shown). By March 2021, the residual effects on soil pH of the initial pelleted lime applications in fall 2019, were approximately maintained. The highest initial 6400-lb rate maintained soil pH near 6.5 or above at most sites with the exceptions of the NERF and SWRF sites where pH decreased to about pH 6.2 or 6.3. The second-high 1600-lb rate maintained pH near 6.0 or above only at the Ames and SERF sites, but not at the other four sites where pH decreased to about 5.6 to 6.8. Initial pelleted lime rates of 100, 200, and 400 lb/acre did not maintain soil pH above that of the control except at the Ames and NWRF sites.

The pelleted lime reapplications in fall 2020 before soybean did not have much effect by March 2021 and increased only slightly soil pH over values for the residual plots for most application rates. By October 2021, two years after the initial pelleted lime

applications and one year after the second applications, only the two highest pelleted lime rates increased soil pH further than did in the March 2021 sampling date and only at the NERF, SERF, and SWRF sites.

### Rates effect on soil pH across the two years

Figure 1 shows that on average across the six sites, soil pH for the control plots varied greatly over time, which has been often observed before, and ranged from 5.3 to about 5.6. During the first year and until the March 2021 sampling dates, soil pH increases over the control from initial pelleted lime applications of 100 and 200 lb/acre kept pH slightly higher than for the unlimed control but not much higher than the initial pH in October 2019. Soil pH was consistently at or above the optimum pH of 6.0 for Iowa soils in northcentral and western Iowa only for the two highest initial rates of 1600 and 6400 lb/acre. The reapplied (annual) rates for the second-year soybean increased soil pH in March 2021 compared with the pH for the residual plots only with the three highest annual rates. These effects were approximately maintained until the last sampling in October 2021.

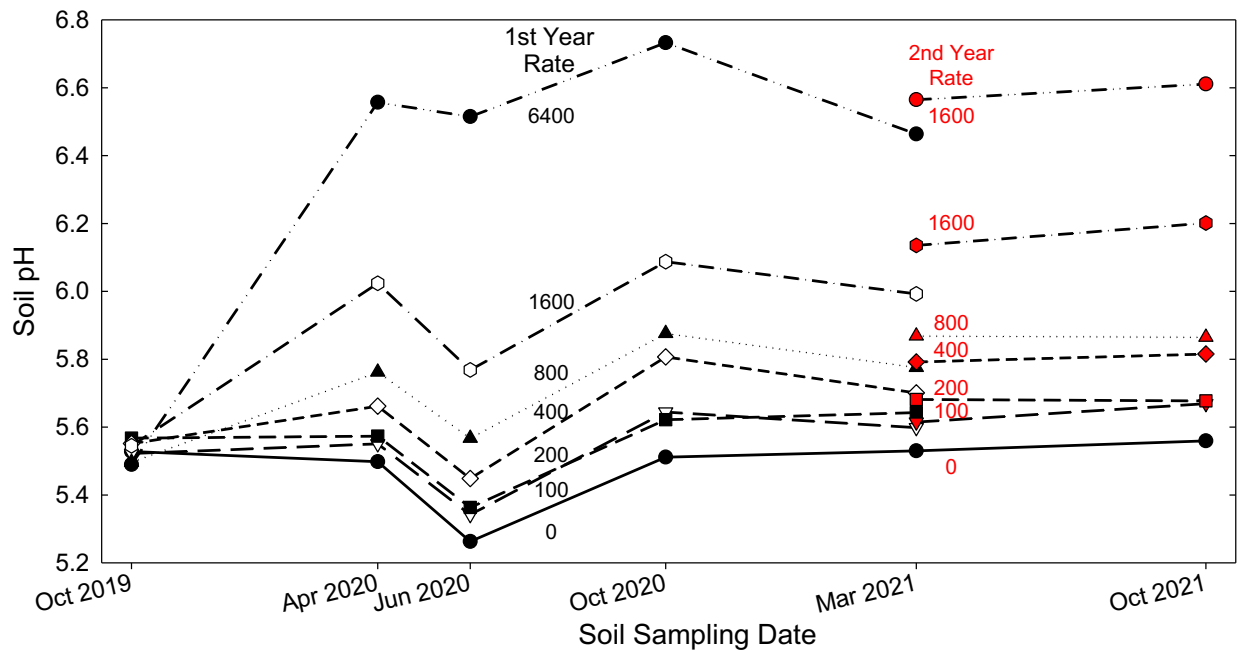


Figure 1. Pelleted lime effects on soil pH across the two years of the study.

### Pelleted lime rate effect on corn yield

Figure 2 shows that there were corn grain yield responses to pelleted lime application at all six sites, which was expected because initial pH was acidic. Corn yield increased exponentially to maximum plateau at all sites. The magnitude of the responses and the differences among rates applied differed among sites. However, the two lowest pelleted lime rates of 100 and 200 lb/acre increased yield very little at all sites (5 to 16 bu/acre) when increases with higher rates was 32 to 46 bu/acre. The yield difference between the two highest rates was less than 6 bu/acre except at NERF and SWRF sites when was 10 and 11 bu/acre, respectively.

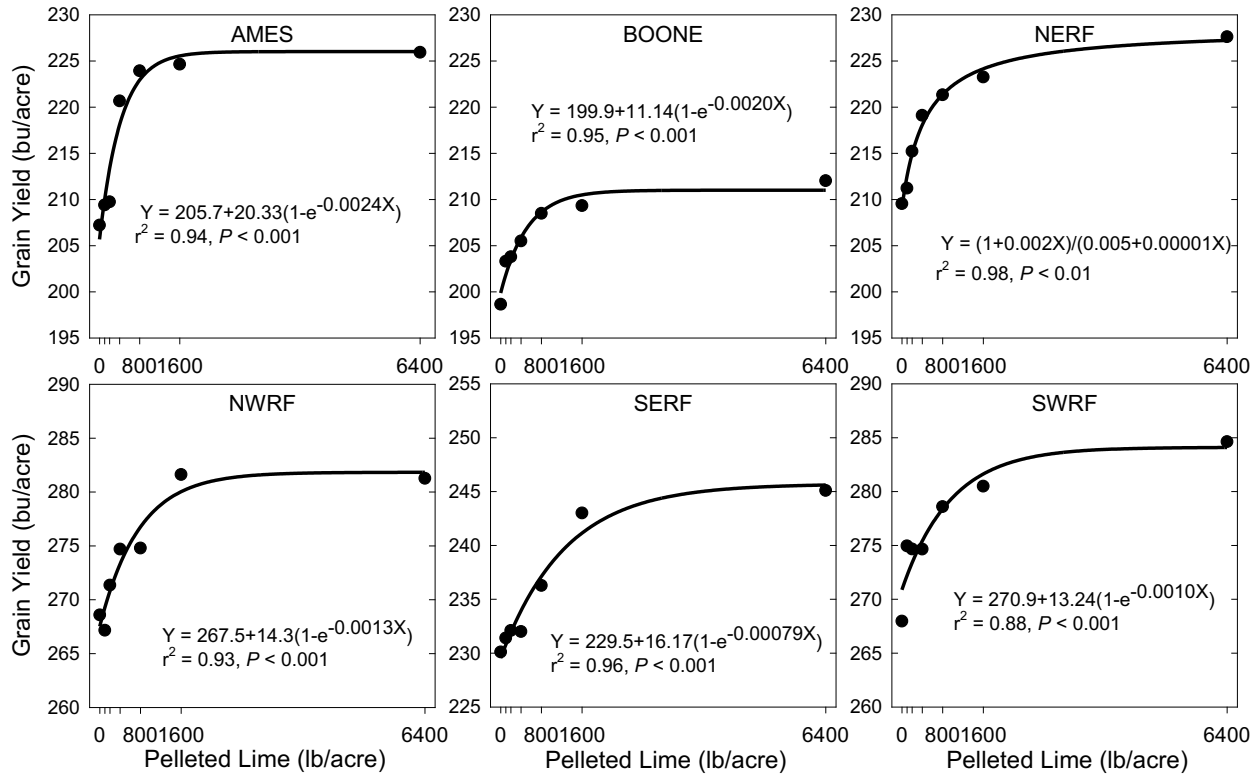


Figure 2. Effect of pelleted lime on corn grain yield in 2020.

### Pelleted lime rate effect on soybean yield

Figure 3 shows that in the second year there were large soybean yield increases from the initial pelleted lime application at all sites. Yields increased exponentially with decreasing increments to a maximum plateau at most sites, except for NERF and SWRF where yield increased up to the highest initial rate used. These high residual effects were expected mainly for the higher two rates because initial pH was very acidic and these rates maintained pH at pH 6.0 or 6.5 (optimum values for soybean in Iowa). However, we did not expect the clear residual effects of initial rates lower than 400 lb/acre, which increased yield over the unlimed control yield, although differences ranged only from 2 to 8 bu/acre. Single initial pelleted lime applications of less than the highest initial rate of 6400 lb/acre resulted in large yield losses at the SWRF site. Initial rates lower than the 1600 lb/acre resulted in large yield losses at the NERF, SERP, and SWRF sites.

Figure 3 also shows that the highest annual pelleted lime rates for second-year soybean did not increase yield over residual effects of the highest initial rates at any site, and no annual rate increased yield at the Ames, Boone, and NWRP sites. However, annual rates 3200 lb/acre (1600 lb/acre each year) significantly increased yield over the single initial rates at the NERF, SERP, and SWRF sites. On average across the six sites (not shown), yield for the reapplied (annual) rates was significantly higher than for residual effects of the initial applications except for the highest rate for which the difference was only 1 bu/acre. Therefore, although on average across sites annual applications of the 800-lb rate (1600 lb over two years) optimized second-year soybean yield, this rate resulted in large yield losses for the previous-year corn.

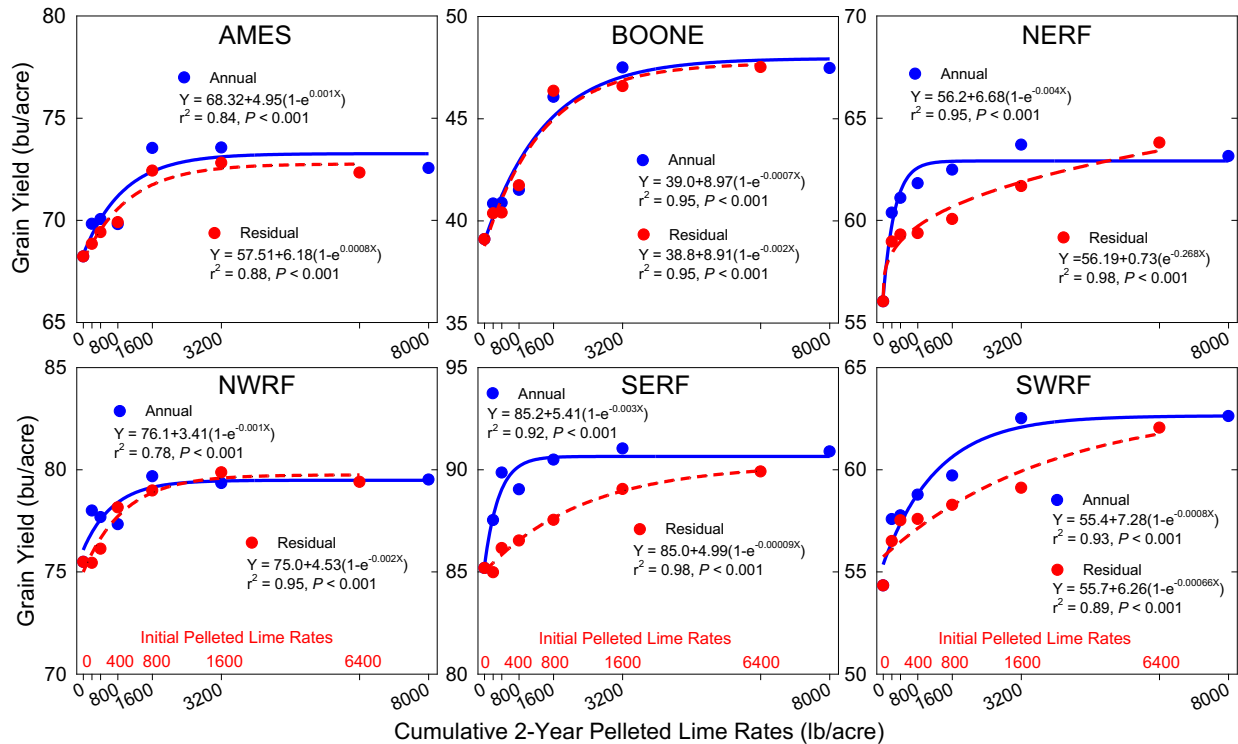


Figure 3. Effect of pelleted lime on soybean grain yield in 2021.

## CONCLUSIONS

On average across six 2-year trials with corn-soybean rotations soil pH for the unlimed control varied from 5.3 to 5.6 over time. Over the two years, soil pH was at or above 6.5 only with the initial 6400-lb pelleted lime rate whereas was at or above pH 6.0 only with initial rates of 1600 and 6400 lb/acre. Soil pH increases from single initial rates of 100 and 200 lb/acre kept pH slightly higher than for the highly variable pH of the control but did not increase pH over the initial pH. Reapplied lime for the second year increased pH over the initial rates only with annual rates of 400 lb/acre or higher.

Unexpectedly, yields were slightly increased by the two lower pelleted lime rates (3 to 7 bu/acre for corn and 1 to 3 bu/acre for soybean across sites). Yield increases from a rate of 1600 lb/acre that increased pH to 6.0 and of 6400 lb/acre that increased pH to 6.5, were 13 to 16 bu/acre for corn and 5 to 6 bu/acre for soybean across sites. Relative yield increases across both crops to initial rates were 1.9, 2.5, 3.9, 6.2, 7.5, and 9.0% whereas for annual rates were 2.8, 3.5, 4.5, 7.2, 8.8, and 9.1%, respectively. Overall, the study showed that application of pelleted lime rates lower than needed to increase soil pH to 6.0 or 6.5 limited crop yield significantly at several sites.

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