EFFECT OF SOIL pH ON SOYBEAN YIELD

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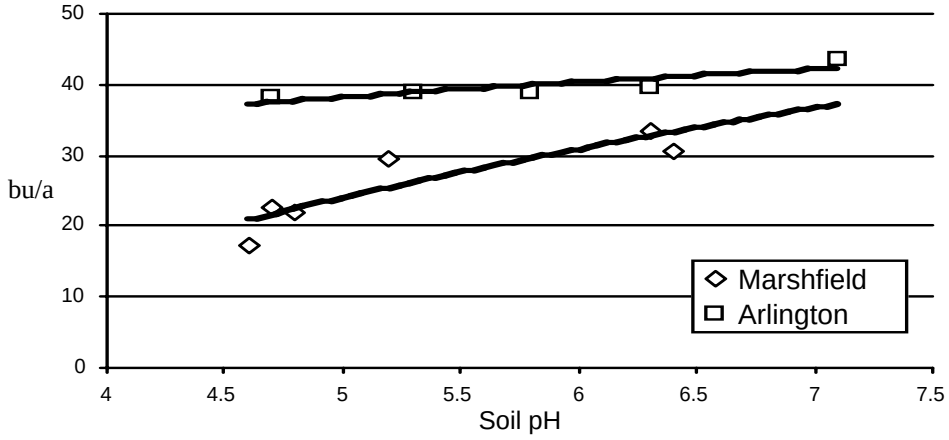
Soybean production has increased very rapidly in recent years. In 1939, Wisconsin grew only about 20,000 acres of soybeans for grain. This figure had increased to around 450,000 acres twenty years ago and is now at approximately 1.7 million acres. The average yield of soybeans in Wisconsin varies a great deal from year to year depending on growing conditions. The average yield in 1972 was about 28 bu/acre, which was the same as the average yield for 2003. Clearly, this average yield is far below yields of 70 to 90+ bu/acre commonly being reported in highly managed test plots.

Nutrient availability can be strongly influenced by soil pH and many of Wisconsin's soils are natively acid, often requiring lime to raise the soil pH. Since many of Wisconsin's soybeans are grown on soils with some degree of acidity, more information on the effect of soil pH on nutrient uptake and yield is needed. Earlier studies conducted at various Agricultural Research Stations in Wisconsin showed that a soil pH of at least 6.3 was required for optimum yields of soybeans. At the Marshfield location in 1984, a soil pH below 5.2 was very detrimental to soybean plant performance and top performance seen when the soil was limed to a pH of 6.3 (Fig. 1). A similar study conducted that same year in southern Wisconsin at the Arlington Research Station, showed that soybean yields may require a soil pH somewhat above 6.3 for optimum production.

This series of studies was designed to evaluate the effect varying soil pH has on soybean production on several soil types across the state.

Figure 1. Effect of soil pH on soybean yield. 1984



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Materials and Methods

This study was conducted in 2004 at the long-term pH plots located at four sites located on or near three UW Agricultural Research Stations. These plots at Spooner, Hancock, and the two locations at Marshfield, have pH levels ranging from about 4.8 to 7.0 in five levels at Spooner and six at all other sites. In addition, Hancock also has two pH levels (6.0 and 7.0) limed with either calcitic or dolomitic lime. In 2003, soybeans were planted on the two sites at Marshfield. Earlier studies were conducted in 1984 at both the Marshfield location as well as an additional site at the Arlington Research Station in southern Wisconsin. Soil pH was the only fertility variable in this study, however, several varieties were evaluated in the 1984 studies, with results reported averaged across all varieties (Fig. 1).

The soil at the Marshfield plot locations was a Withee silt loam. Pioneer 90B73 was the variety planted at both the airport and research station sites in 2004, with 200,000 seeds/a seeded with a grain drill on May 5 and May 19, respectively. On May 23, 2003, NK S08-R4 was drilled at a rate of 225,000 seeds/acre at the airport location and the same variety was seeded at a rate of 190,000 seeds/acre at the research station. In all cases, Roundup herbicide was used for post-emergence weed control. In 2004, both Marshfield locations were harvested on October 12 using a 5-foot wide Massey Ferguson plot combine with samples collected for quality analysis. An Almaco combine with a 5-foot head was used in 2003 with harvests made on October 10 at both Marshfield locations.

The Spooner location was planted on a Pence sandy loam in 30-inch rows at a seeding rate of 180,000 plants/acre on May 19, 2004. Roundup herbicide was used for weed control with this glyphosate resistant variety, NK S08-R4. Yields were measured and samples collected for quality analysis on October 6, 2004.

The long-term soil pH plots at the Hancock Research Station were planted to NK S24-K4, a glyphosate resistant variety, on May 26, 2004. This location, which consists of a Plainfield loamy sand soil, was treated with Roundup herbicide for weed control and harvested on November 21, 2004 using a plot combine.

Soil samples to measure soil pH were taken at all locations at the time of harvest. In addition, bulk grain samples were collected for quality analysis. All soil analyses were performed by the UWEX Soil and Plant Analysis Laboratories at Madison and Marshfield using methods described by Peters et al. (2004).

Results and Discussion

Results of the two studies conducted at Marshfield in 2003 appeared to support the recommendation of a target pH of 6.3 for soybeans in Wisconsin. At the airport location, soybean yields were optimized at a pH of around 6.2, with no further improvement in grain yield as soil pH was increased above that level (Table 1). At the site located at the research station, the data were a bit variable. The field where these plots are located is a much wetter site and is subject to being saturated following high rainfall events. At this site in 2003, it appears that liming to a soil pH of between 5.5 and 6.0 resulted in optimum yields, although there were no statistically significantly differences in yield (Table 2).

Table 1. Effect of soil pH on soybean yield, Marshfield airport site 2003.

Target pH	Actual pH	Soybean yield bu/acre
4.8	4.5	19.3
5.3	5.3	28.3
5.8	6.2	30.8
6.3	6.4	28.9
6.8	6.6	30.1
7.3	6.7	29.1
Statistical significance Pr>F.		0.27
$LSD_{0.05}$.		<0.01

Table 2. Effect of soil pH on soybean yield, Marshfield station site 2003.

Target pH	Actual pH	Soybean yield bu/acre
4.8	4.5	22.5
5.3	4.9	23.3
5.8	5.4	28.4
6.3	6.0	25.0
6.8	6.7	27.5
7.3	6.9	27.5
Statistical significance Pr>F.		0.25
$LSD_{0.05}$.		NS*

* Not significant

The studies conducted in 2004 at these same two Marshfield pH plot locations showed that there was a significant depression in soybean yield at the lowest soil pH levels found in the study (<5.0). At the airport location, no statistically significant yield response was found as the soil pH was increased above 5.0, but liming to a pH above 6.0 was required to maximize yields (Table 3). As was seen in the previous year, yields at the more poorly drained station location were lower than those found at the airport. At this location, optimum yields were seen as soil pH was increased to at least 6.3 (Table 4).

At the Spooner location, soybean yields responded quite dramatically to liming. Yields increased approximately 400%, from 7.5 bu/acre at a soil pH of 4.5 to around 30 bu/acre as soil pH was increased to between 6.1 and 6.6 (Table 5).

Table 3. Effect of soil pH on soybean yield, Marshfield airport site 2004.

Target pH	Actual pH	Soybean yield bu/acre
4.8	4.3	28.8
5.3	5.0	42.5
5.8	6.1	44.3
6.3	6.6	44.7
6.8	6.7	45.2
7.3	6.9	46.5
Statistical significance Pr>F.		<0.01
$LSD_{0.05}$.		6.85

Table 4. Effect of soil pH on soybean yield, Marshfield station site 2004.

Target pH	Actual pH	Soybean yield bu/acre
4.8	4.6	24.0
5.3	4.9	25.8
5.8	5.4	27.9
6.3	6.3	31.6
6.8	6.9	32.2
7.3	7.1	33.4
Statistical significance Pr>F.		<0.01
$LSD_{0.05}$.		3.27

At the Hancock location, there was very little soybean grain yield response to liming above a soil pH of 5.5 (Table 6). On this irrigated sandy textured soil, liming did not appear to have a significant impact on improving grain production of soybeans. Yield was optimized by liming to a soil pH of about 5.5 or greater.

Taken together, it appears that the yield response of soybeans lies somewhere between that for alfalfa and corn. Figure 2 presents a second-order polynomial fit of all 2004 soybean data from this report where there was a significant effect of soil pH on yield. Also included in this same figure are second-order polynomial fits of alfalfa and corn grain yield from previous studies at these same research study locations.

Table 5. Effect of soil pH on soybean yield, Spooner station site 2004.

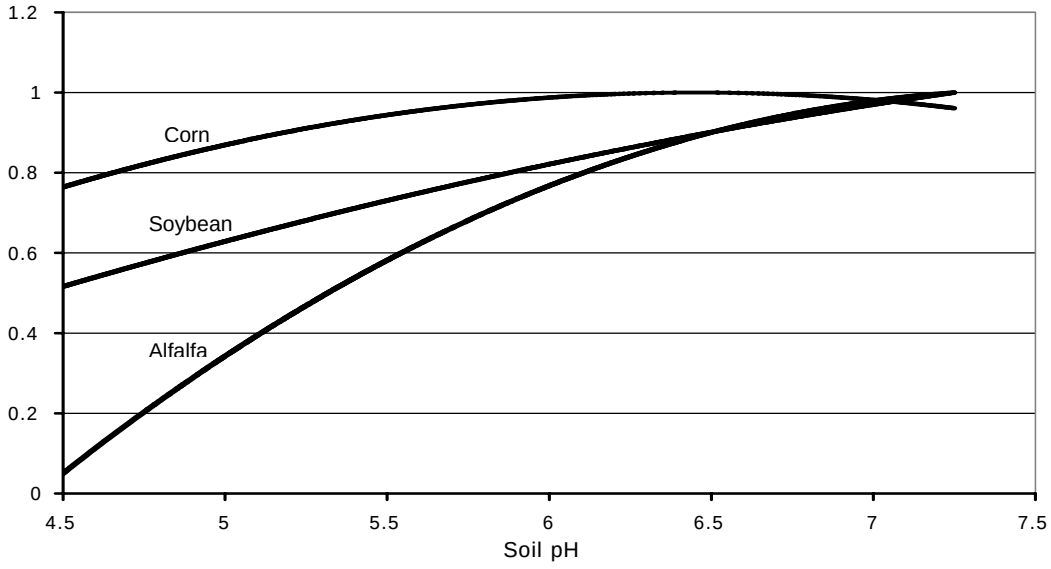
Target pH	Actual pH	Soybean yield bu/acre
4.7	4.5	7.5
5.2	4.9	12.6
5.7	5.4	21.4
6.2	6.1	27.5
6.7	6.6	31.4
Statistical significance Pr>F.		<0.01
$LSD_{0.05}$.		4.95

Table 6. Effect of soil pH on soybean yield, Hancock station site 2004.

Target pH	Actual pH	Soybean yield bu/acre
4.5	4.9	45.7
5.0	5.3	48.9
5.5	5.6	50.0
6.0	6.0	51.3
6.5	6.3	50.3
7.0	6.5	49.3
6.0 [§]	5.9	50.5
7.0 [§]	6.6	49.1
Statistical significance Pr>F.		0.72
$LSD_{0.05}$.		NS[*]

[§] Calcitic lime used
[*] Not significant

Figure 2. Effect of soil pH on crop yield response



Summary

Significant soybean yield responses were seen on the heavy textured silt loams in the Marshfield area and the sandy loam soil at Spooner. Little response was seen in 2004 on the irrigated sands at Hancock. This is comparable to alfalfa, which shows a yield response to liming on virtually all acidic soils in the state, and corn, where yields are often increased by liming on many soils especially those in the central and north central areas of the state. Of the major agronomic crops in Wisconsin, the yield response of soybeans to liming is somewhere in between what is seen with corn and alfalfa. Overall, these results support the current recommendation of liming to a pH of at least 6.3 for soybean production in Wisconsin.

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