Fertilizer and Ag Lime Grants
Final Report on:

Soil pH effects on atrazine carryover damage to no-till soybean

Peter Scharf, Reid Smeda, and Kevin Bradley
Agronomy Department, University of Missouri

Accomplishments for 2004:

- Soybeans were grown in 160 plots with:
  - a wide range of soil pH values and
  - four atrazine treatments applied to the 2003 corn crop:
    - Atrazine 1.25 lb a.i./acre preplant
    - Atrazine 2.5 lb a.i./acre preplant
    - Atrazine 1.25 lb a.i./acre preplant followed by 1.25 lb a.i./acre post
    - Untreated check
  - Weeds in both 2003 corn and 2004 soybean crops were controlled with glyphosate, so that atrazine effectiveness was not a factor

Results for 2004:

- **Soybean yields were excellent**, with an average yield in this experiment of 69.1 bu/acre.
- **Yield loss associated with atrazine carryover was minimal in 2004.**
  - High-pH plots (salt pH of 6.5 to 7.0 in the top inch of soil) that had received atrazine yielded on average 1.4 bu/acre less than medium-pH plots (see Table 1). Statistics indicate 82% confidence that this is a true yield difference.
  - High-pH plots that had not received atrazine yielded 0.6 bu/acre less than medium-pH plots, with little or no statistical evidence that this difference was real.
  - Thus we would conclude, but not with great confidence, that it appears that atrazine carryover at high soil pH resulted in a 0.8 bu/acre yield loss in these plots.
  - We saw larger yield loss associated with low pH, but it was the same regardless of previous atrazine treatment (see below).
- **Soil pH had a substantial effect on yield, regardless of last year's herbicide treatment.** This is the first time (in three two-year cycles) that soil pH has influenced yield of plots that had not received atrazine the previous year.
  - Plots that had received one of the acidifying treatments (either 2 or 4 tons/acre of ferrous sulfate applied over the six-year study period) yielded 3.6 bu/acre less than plots that had not received either lime or ferrous sulfate. Statistics indicate 99% confidence in this conclusion. Yields were numerically, but not statistically, 1.4 bu/acre lower for the 4-ton ferrous sulfate treatment than for the 2-ton treatment.
  - The yield decline for the low-pH plots was the same for plots that had not received any atrazine in 2003 as for the average of all atrazine treatments (see table). This means that there was no yield loss due to atrazine carryover at low

soil pH this year (as had been seen in both the 2000 and the 2002 soybean crops).

  - Acidifying treatments had, by the sixth year of the study, affected the soil pH to a greater depth than during the early years of the study. Soil pH values were lower at the 0-1" depth than in previous cycles, but more notably they were lower at the 0-6" depth. In 2004, for the first time, we saw plots with the 0-6" salt pH below 5. The movement of the acidity down into a greater proportion of the root zone probably was responsible for the negative effect on soybean yield. It is well known that soybean yields drop off in acid soil conditions, but we had not seen any yield loss associated with acidity alone in the previous years of the study.
  - There was also a possible small yield decrease associated with the liming treatments. Average yield for all plots receiving lime was 1.2 bu/acre less than unlimed plots, with 81% confidence that this difference was real. It is likely that this was due mainly to yield loss on plots that had received both lime and atrazine (see above).
- Plots that had received the split atrazine treatment in 2003 yielded 2.4 bu/acre more than plots that had received no atrazine in 2003 (95% confidence). The reason for this is not clear.

Table 1. Yield loss of low and high pH plots (compared with medium-pH plots) for various atrazine treatments applied to the 2003 corn crop. Yield loss was the same, 3.6 bu/acre (99% confidence), with highly acid surface soil for plots that had received no atrazine in 2003 and for the average of all plots receiving atrazine in 2003, indicating no yield loss due to atrazine carryover at low pH. A small yield loss appeared to occur due to atrazine carryover at high pH, where plots with atrazine yielded 1.4 bu/acre less (82% confidence) than plots with atrazine at medium pH. Soil pH was measured in the top inch, where atrazine is mainly active, and where pH extremes can occur in no-till. Nitrogen fertilizer had been surface-applied to the corn about a month before measuring pH, resulting in acidification of the top inch. Soil pH values had gone up by about 0.2 units by May 2004 as this acidity spread farther into the soil.

Soil salt pH level in top inch, May 2003	Yield loss with 2003 atrazine treatment:				
	low rate atrazine	high rate atrazine	spllit pre/post atrazine	no atrazine	all atrazine treatments averaged
	----------bu/acre----------				
4.1 to 4.6	5.9	3.5	1.3	3.6	3.6
6.5 to 7.0	1.4	1.9	0.8	0.6	1.4

Overall conclusions

- This two-year study focused on atrazine carryover. It is a follow-up to a prior four-year project that included other potentially pH-sensitive herbicides. Because pH-sensitive carryover damage to soybean yield was seen only with atrazine in the previous project, this study focused on atrazine, and the overall conclusions that we present will relate only to atrazine over the six years of the combined studies.
  - Corn was planted in odd years and received several herbicide treatments including a low (1.25 lb a.i./acre) and high (2.5 lb/acre) atrazine rate in all years, and a split pre/post atrazine treatment in 2003.
  - Soybean was planted in 2000, 2002, and 2004 to study the effects of possible atrazine carryover on soybean yield.
- **Summary of soybean yield losses (see Table 2):**
  - Three-year average yield losses that were apparently due to pH-related atrazine carryover were:
    - **1.3 bu/acre in low-pH plots**
      - Small losses were observed in each of the first two 2-year study cycles. At low pH, atrazine is tightly bound to soil particles and breakdown is slower.
    - **2.3 bu/acre in high-pH plots**
      - This loss came almost entirely in 2000, following a long drought. Normally, degradation of atrazine can proceed at high pH, but water availability may have limited degradation in this season. The remaining atrazine would be extremely soluble at high soil pH, enabling it to cause significant damage to soybeans.
      - Yield loss with atrazine carryover at high pH is consistent with Iowa State research showing low soybean yields in high-pH areas of fields.
  - **In addition, a 3.6 bu yield loss was seen at low pH in 2004 regardless of whether atrazine had been applied the previous year.** This is simply a reflection of the negative effect that low soil pH can have on the soybean plant directly. In the early years of the study, low pH due to the acidifying treatments was probably confined to the top inch or two, but as it spread downward into the root zone, came to influence the crop more negatively.
- In the long term, uncorrected acidity problems will probably reduce soybean yields mainly by their direct influence on the root system.
- However, even in the short term, it appears that, when the soil pH of the top inch gets too high or too low, atrazine carryover can reduce the yield of the following soybean crop.
- Managing the pH of the top inch of soil in no-till can help to prevent this type of yield loss, which appears to be 1 to 2 bushels on average.
  - Smaller, more frequent lime applications can help to prevent wide swings in the surface soil pH in no-till fields.
  - Monitoring the pH of the surface inch of soil can alert the producer to the need to manage soil pH.
  - Subsurface applications of nitrogen fertilizer (anhydrous ammonia or injected UAN solution, for example) help to avoid acidification of the top inch of soil.
  - Variable-rate lime applications may help to avoid problems with atrazine carryover in areas with higher or lower soil pH than the field average. Many fields in Missouri have a pH range of 2 units from one part of the field to another.

Table 2. Estimates of soybean yield loss with or without atrazine at high or low surface soil pH levels, relative to plots with medium pH levels. These results suggest that atrazine carryover causes small yield losses when surface soil pH gets too low or too high. Low pH can also cause direct yield losses, as in 2004, regardless of atrazine use in the previous year.

Year	Herbicide treatment	Yield loss with:	
		low pH (top inch)	high pH (top inch)
		----------bu/acre----------	
2000	no atrazine	0	0
2000	atrazine (ave. low & high)	2.6	6.2
2002	no atrazine	0	0
2002	atrazine (high)	1.2	0
2004	no atrazine	3.6	0.6
2004	atrazine (ave. all)	3.6	1.4
3-year average	no atrazine	1.2	0.2
3-year average	atrazine	2.5	2.5
3-year average	**loss due to atrazine carryover**	**1.3**	**2.3**