IS IN-SEASON FERTILIZATION FOR SOYBEAN EFFECTIVE?

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Questions often arise in June about "emergency or catch-up" fertilization for soybean. Most producers are not worried about this because they typically apply adequate amounts of phosphorus (P) and potassium (K) fertilizers before planting soybean or apply sufficiently large amounts before the previous year corn for both the corn and soybean crops. Those producers asking these questions, however, wonder if fertilizer rates were inadequate or if late planting dates, replanting, and cold or excessively wet conditions have altered the crop nutrient uptake and fertilization need. Others may wonder if the soil nutrient levels might limit high yield potential when growing conditions are exceptionally good.

Is applying dry, granulated fertilizer a viable post-emerge option?

The short answer to this question is no. Typically this is not a good option for two main reasons. One, both P and K nutrients, but especially P, are needed at early growth stages to enhance plant cell multiplication when the number of nodes, leaves, and potential seed numbers are largely determined. Both nutrients also are needed at later growth stages, especially K. Two, the application of fertilizer to the soil surface or banded/injected between the rows will be of low efficiency, mainly due to the common low or infrequent summer rainfall (perhaps not the case this year). There is only one situation in which an in-season application of granulated P and K fertilizer might be considered. That is when the soil tests are very low, and for certain the producer will have to apply a high fertilizer rate for next year corn crop to assure adequate P and K levels. Also, perhaps if the plan is apply a greater than optimum rate to quickly buildup soil P and K test levels. In this scenario, an in-season application when the soybean plant is still small (only three or four leaves) may not be very efficient at increasing grain yield but will increase soil P and K levels and decrease the rate needed before the next corn crop.

What about foliar fertilization?

Some producers wonder if foliar fertilization could help improve soybean growth and grain yield. It may, but the potential is quite low in fields that have been well fertilized or where growth is limited by factors other than nutrient supply.

Prior to the 1990s hundreds of field experiments conducted across de Midwest focused on foliar fertilization at late soybean reproductive stages (R4 to R7) using fertilizers that included nitrogen (N), P, K, sulfur (S), and other nutrients. Researchers theorized that if nutrients were applied to the foliage at this time, leaf senescence and “seed starving” could be alleviated and grain yields increased. A few early Iowa trials suggested that spraying a nutrient mixture in a ratio 10-2.3-3.6-0.5 N-P2O5-K2O-S between the R5 and R6 growth stages could increase yield by 7 to 8 bu/acre. However, many subsequent trials in Iowa, and across the Midwest and Southern states from the late 1970s to the early 2000s, showed inconsistent results, with an equal frequency of yield increases and decreases. More recent work in the Midwest under rain-fed conditions showed similar results, and often yield decreases when N sources were sprayed alone or in a mixture. The more positive results were observed under very high yield conditions with

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irrigation in Kansas. Therefore, these results have discouraged further research and adoption of foliar fertilization of soybean at late reproductive stages.

Other researchers thought that small amounts of nutrients sprayed onto soybean foliage at early growth stages could supplement inadequate pre-plant fertilization, increase nutrient supply even with presumably adequate pre-plant fertilization, and especially when soil conditions limit nutrient uptake when soil levels are adequate. About 100 replicated field trials were conducted in Iowa from 1994 until the early 2000s to evaluate these possibilities. Applications included spraying foliar fertilizers with or without mixing with glyphosate herbicide at the V5 to R3 growth stages. The products tested (not all products were included in all trials) included the low-salt fluid fertilizer 3-18-18 (N-P2O5-K2O) and 10-10-10 (N-P2O5-K2O) both with or without S and with or without the micronutrients boron (B), iron (Fe), and zinc (Zn); and also 8-0-8 (N-P2O5-K2O). Product rates ranged from 2 to 6 gal/acre applied once or twice (spaced 8 to 10 days). The fields were managed with no-till, ridge-till, or chisel-plow tillage. These results were summarized before and are not shown here (see, for example, http://www.extension.iastate.edu/CropNews/2008/0703Mallarino.htm).

Briefly, results showed that foliar fertilization increased yield in 15 to 30 percent of fields depending on the trial set and year, and about 15 percent of fields on average. The average response to the best treatment (3 gal/acre of 3-18-18) across all trials was 0.7 bu/acre but the average response across the responsive trials was 4.1 bu/acre. Differences between treatments were not consistent across fields, but responses tended to be higher for the 3 gal/acre rate of 3-18-18. Adding S or micronutrients did not produce higher yield. The highest rate of 10-10-10 (with or without S) and 8-0-8 fertilizers reduced yield in a few fields (some leaf burn was observed). Yield with the double applications were the same as single applications.

Yield increases were observed in fields testing low in P and K, but sometimes also in fields testing Optimum or higher for soybean. Reasons for yield increases in some fields testing Optimum or higher were difficult to identify. Soil-test results, tissue-test results, and climatic conditions did not support strong conclusions, but suggested that conditions in which a response to foliar fertilization was more likely included ridge-till and no-till fields, and slow early plant growth and P or K uptake due to cool early temperatures and excessive rainfall. Therefore, conditions that inhibit root growth and/or nutrient uptake early during the growing season (except drought) increased the likelihood of a yield response.

Five field trials conducted in 2005 and 2006 that studied foliar fertilization and fungicide application alone or in a spray mixture produced even more disappointing results for foliar fertilization. Eight treatments were a non-treated control, four foliar fertilization treatments without fungicide (a single application of 3 gal/acre of 3-18-18 at the V5 and R2 to R3 growth stages, a double 3-18-18 application at V5 and R2 to R3 stages, and 3.3 gal/acre of 28% UAN at the R2 to R3 stages), and three fungicide (Headline®) treatments at the R2 to R3 growth stages (alone and in combination with 3-18-18 or UAN fertilizer). Figure 1 summarizes the results. On average the fungicide increased yield by 2.9 bu/acre, although the responses were statistically significant only at three fields. The fungicide delayed leaf senescence at most fields, although

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disease control by the fungicide was observed only for Brown Spot in three fields. Spraying soybean with 3-18-18 fertilizer did not affect yield at four fields and increased it slightly at one field. Spraying with UAN did not affect yield at two fields, increased it slightly at one field, and decreased it at two fields. The UAN application caused moderate leaf burning and the 3-18-18 application caused no burning. An important result was no interaction between foliar fertilization and fungicide application at any field. Mixing the two fertilizers used in this project with the fungicide did not cause problems or an additional yield response compared to the products alone.

Is tissue testing helpful for identifying fields responsive to foliar fertilization?
Unfortunately there is no simple test or measurement that can be used to identify the conditions that increase the chance of crop response to foliar fertilization with P and K. In spite of many field experiments in Iowa, we have not been able to identify a useful critical or optimal nutrient concentration in young plant tissue. Data shown in Figure 2 for P and Figure 3 for K show a very poor relationship between nutrient concentrations in young plants or mature leaves and crop yield response. These results also have been found in other states, and is the main reason why universities seldom recommend tissue testing for soybean or suggest some high tissue test level at which seldom there is yield response to fertilization. The problem of using a "safe" but high critical nutrient concentration is that such a level may encourage farmers to apply fertilizers when the probability of an economic yield increase is very small or inexistent.

Recommendations
In-season fertilizer application for soybean seldom will be cost-effective in Iowa production systems. The exception might be when soil samples confirm that the soil tests very low and there was no or very insufficient preplant fertilization. A large application of dry, granulated fertilizer to soil during the very early growth stages (younger than V4 or V5) may result in some soybean grain yield increase, and will begin to build up soil test levels that will have to be increased for the next crop anyway. However, the economic benefit for this year's soybean is very doubtful. The probability of an economic response to a small amount of P or K fluid fertilizer sprayed to the soybean canopy (so that it doesn't burn the foliage and decrease yield) is small, but this practice may be justified when nutrient deficiency symptoms are obvious, with confirmed deficient-testing soil, or when soil or climatic factors (other than drought) limit nutrient uptake in late spring and early summer.

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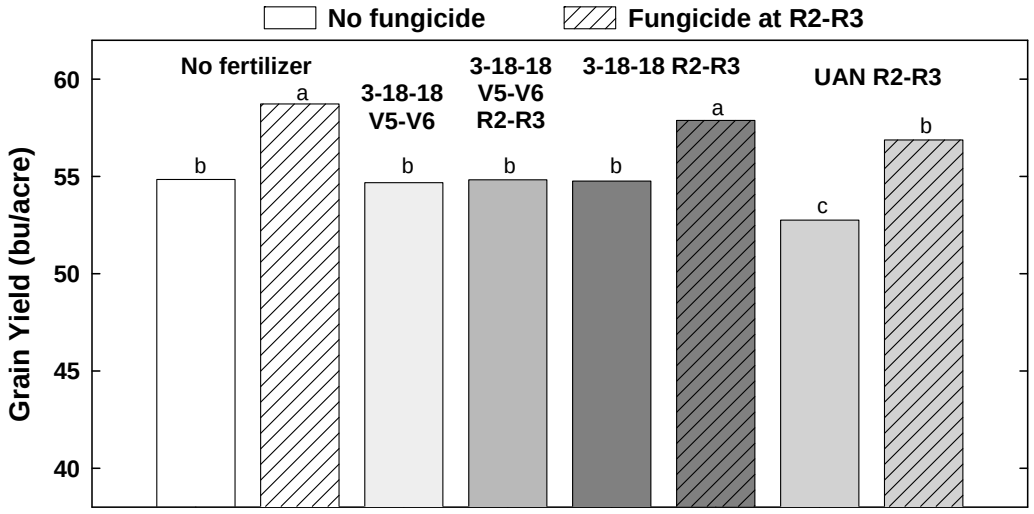

Figure 1. Effects of foliar fertilization and fungicide application on grain yield of soybean (average across five trials in Iowa).

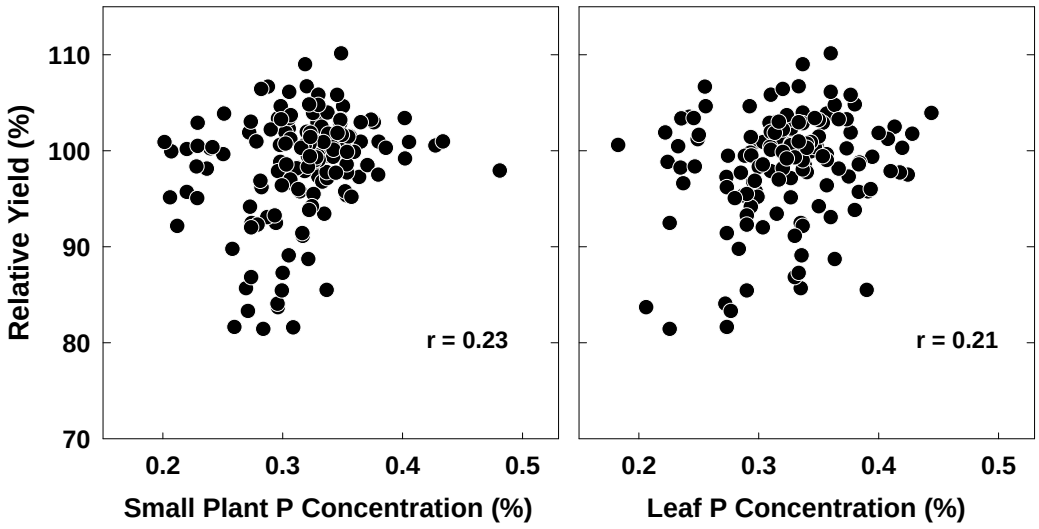

Figure 2. Relationship between relative soybean yield response to P fertilization and the P concentration of small plants and mature leaves (V5-V6 or R2-R3 growth stages) across several Iowa field trials. Relative yield represents the yield without P fertilization expressed as the percentage of the maximum yield achieved with a high and non-limiting P at each site.

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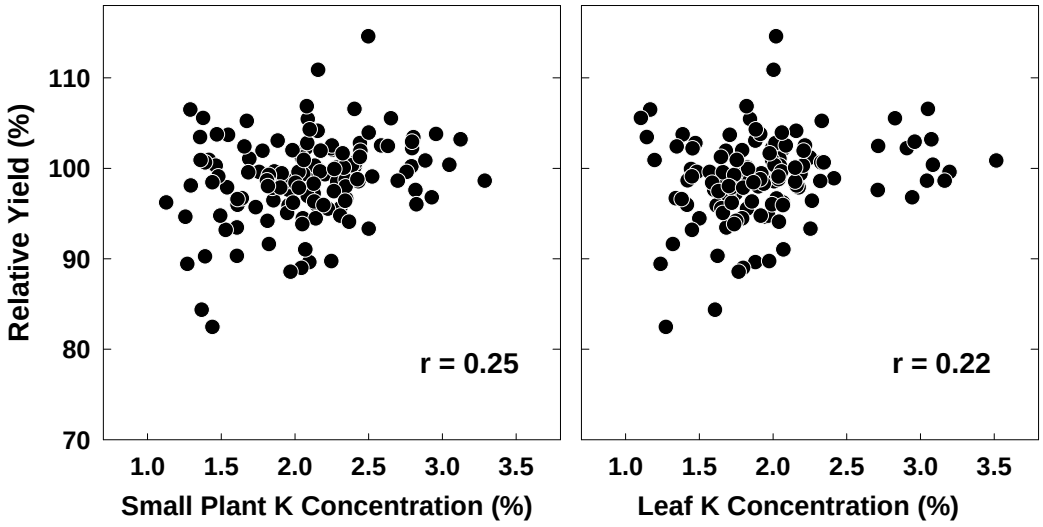

Figure 3. Relationship between relative soybean yield response to K fertilization and the K concentration of small plants and mature leaves (V5-V6 or R2-R3 growth stages) across several Iowa field trials. Relative yield represents the yield without K fertilization expressed as the percentage of the maximum yield achieved with a high and non-limiting K at each site.

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