Foliar fertilization of soybean: Is it useful to supplement primary fertilization?

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Abstract
Many Iowa fields require phosphorus (P) and potassium (K) fertilization for optimum soybean production. Suggested application rates, when required and based on soil testing, are fairly large amounts. Fertilizer application methods and equipment commonly used to supply these nutrients are adapted to apply these large fertilizer rates to the soil before planting. Foliar fertilization, on the other hand, can be used to apply only small amounts of nitrogen (N), P and K, and also to apply sulfur (S) and micronutrients.

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Hundreds of field experiments during the 1970s and 1980s in Iowa and other regions of the United States investigated foliar fertilization of soybeans at late reproductive stages. The soybean plant's nutrient use is characterized by a sharp decline of root activity during seed development stages and increased translocation of nutrients from leaves and pods into the seeds. Researchers theorized that if nutrients were applied directly to the foliage at this time, grain yield might be increased.

A few Iowa experiments during the early to mid-1970s seemed to confirm this hypothesis by suggesting that spraying soybeans with a 10-1-3-0.5 N-P-K-S nutrient mixture between the R4 and R6 growth stages could increase yield up to 8 bu/acre. However, numerous follow-up trials did not confirm these results. Additional work in Kansas during the mid-1990s suggested significant yield response of high-yielding, irrigated soybeans to foliar application of N. However, more recent trials in Kansas, Iowa, and other Midwestern states showed no consistent yield increases from spraying N at R2 to R6 growth stages, and sometimes yield decreases when rates were higher than 20 to 30 lb N/acre.

Field observations in Iowa during the early 1990s suggested that poor growth perhaps due to nutrient deficiencies may occur during early growth of soybeans. This was observed in fields where producers applied P and K before planting corn at the fertilization rate for the two-year corn-soybean rotation (as most producers do). Deficiencies were even observed in some fields where broadcast fertilizer was applied before the soybean crop. Deficiencies have been partly explained by inhibited activity of roots when the topsoil is dry, reduced nutrient uptake because of excessively wet and cold soil, and other factors resulting in slow early root growth. In these conditions, small amounts of N, P, or K sprayed at early critical periods could be effective to supplement soil P and K fertilization and symbiotic atmospheric N fixation. Therefore, approximately 100 replicated field trials were conducted in Iowa producers' fields since 1994 to evaluate this possibility. The fields were managed with no-till, ridge-till, or chisel-plow tillage. Because the majority of Iowa fields test optimum or higher in soil-test P or K, only a handful of fields tested below optimum levels. Treatments changed over time, and the mixtures used (N-P-K-S) included 3-18-18-0, 3-18-18-1, 10-10-10-0, 10-
10-10-1, 8-0-8-0. In some instances, mixtures included various micronutrients. Treatments involved single or double applications (spaced about 10 days) of 2 to 6 gal/acre sprayed during the V5 to V7 growth stages.

This early-season foliar fertilization resulted in statistically significant yield increases (usually more than 2 bu/acre) in about 15 percent of the fields, with frequency depending on the year. However, average yield increase across all sites was about 0.5 bu/acre. Application rates higher than 3 or 4 gal/acre of formulations with a higher proportion of N reduced yield in a few fields (and leaf burn sometimes was observed). Differences between treatments in increasing yield were not consistent across fields and could not be explained with certainty, but yield responses were more consistent for a rate of 3 gal/acre of 3-18-18. Addition of S or micronutrients to the mixtures or double applications seldom produced higher yield. It is important to remember that most fields tested optimum or higher in P and K, and that responses were observed in low-testing fields and also in high-testing fields. More detailed results of this research were published in the 2003 Iowa State University ICM Conference proceedings ("Starter and foliar fertilization: Are they needed to supplement primary fertilization? [1]).

Study of relationships between yield response and various field or crop characteristics indicated that the conditions in which foliar fertilization would increase yield are difficult to predict. However, the research did indicate conditions in which a response might be more likely. In some years, responses were higher and more frequent in ridge-till and no-till fields compared with chisel-plow tillage, which is reasonable because foliar fertilization could alleviate early nutrient deficiencies sometimes occurring with these systems. Yield responses also were higher and more frequent when early plant growth and P or K uptake were limited by a variety of conditions (such as nutrient deficiency, cool temperatures, and either too low or excessive rainfall).

Although the research suggests that foliar fertilization can sometimes be effective to supplement the primary fertilization program for soybeans, spraying across all production conditions will not be economically effective because the expected probability of a positive yield response is only 15 percent and the average expected yield increase across all fields is 0.5 bu/acre or less. For suspected problem fields, a single application of N-P-K fluid fertilizers having a low proportion of N and a low-salt K source should be safe (to minimize leaf burning and yield decrease) and may produce economical yield responses when these problem fields are targeted for application. Addition of micronutrients will seldom increase yield unless early deficiency symptoms are observed (such as iron chlorosis in Iowa). The research on foliar fertilization continues this year by evaluating several treatments, including combined application of foliar fertilizer and fungicides.

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