Foliar fertilisation of soya bean:
Is it useful to supplement primary fertilisation?

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Many Iowa fields require phosphorus (P) and potassium (K) fertilisation for optimum soya bean production. Suggested application rates, when required and based on soil testing, are fairly large amounts. Fertiliser application methods and equipment commonly used to supply these nutrients, are adapted to apply these large fertiliser rates to the soil before planting.

Foliar fertilisation, on the other hand, can be used to apply only small amounts of nitrogen (N), phosphorus (P) and potassium (K), and also to apply sulphur (S) and micronutrients.

Nutrient use of the soya bean plant

Hundreds of field experiments during the 1970s and 1980s in Iowa and other regions of the United States (US) investigated foliar fertilisation of soya beans at late reproductive stages. The soya bean plant's nutrient use is characterised by a sharp decline of root activity during seed development stages, and increased translocation of nutrients from leaves and pods into the seeds. Researchers theorised 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 soya beans 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 0,54t/ha. 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 soya beans 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 22,4 to 33,6kg N/ha.

Deficiencies during early growth

Field observations in Iowa during the early 1990s suggested that poor growth, perhaps due to nutrient deficiencies, may occur during early growth of soya beans. This was observed in fields where producers applied P and K before planting corn at the fertilisation rate for the two-year corn/soya bean rotation (as most producers do). Deficiencies were even observed in some fields where broadcast fertiliser was applied before the soya bean 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 fertilisation and symbiotic atmospheric N fixation. Therefore, approximately 100 replicated field trials were conducted in Iowa producers' fields since 1994 to evaluate this possibility.

Mixtures used in Iowa trials

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 ten days) of 18,7 to 56,1 litre/ha sprayed during the V5 to V7 growth stages.

This early-season foliar fertilisation resulted in statistically significant yield increases (usually more than 0,14t/ha) in about 15% of the fields, with frequency depending on the year. However, average yield increase across all sites was about 0,034t/ha. Application rates

higher than 11,3 or 15,1 litre/ha of formulations with a higher proportion of N, reduced yield in a few fields (and at times leaf burn 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 11,3 litre/ha 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 as well as in high-testing fields.

Yield responses and field characteristics

A study of relationships between yield response and various field or crop characteristics, indicated that the conditions in which foliar fertilisation 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 fertilisation could alleviate early nutrient deficiencies often 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 little or excessive rainfall).

Research conclusions

Although the research suggests that foliar fertilisation can sometimes be effective to supplement the primary fertilisation programme for soya beans, spraying across all production conditions will not be economically effective, because the expected probability of a positive yield response is only 15% and the average expected yield increase across all fields is 0,034t/ha or less.

For suspected problem fields, a single application of N-P-K fluid fertilisers having a low proportion of N and a low-salt K source should be safe (to minimise 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 fertilisation continues by evaluating several treatments, including combined application of foliar fertiliser and fungicides.

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