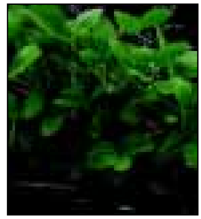

Early Season Foliar Fertilization of Soybeans

By A.P. Mallarino, M.U. Haq, and T.S. Murrell

Based on 74 site-years of investigation of foliar fertilization at early vegetative growth stages, foliar fertilization combinations had relatively low probabilities of increasing soybean yields in Iowa.

Prior to the middle to late 1990s, little research had been conducted on foliar fertilization of soybeans at early vegetative stages. Foliar fertilization at these stages could increase phosphorus (P) and potassium (K) supplies at a time when root systems are not well developed.

This article summarizes work performed across 74 site-years from 1994 to 1998 (Haq and Mallarino, 1998; Haq and Mallarino, 2000; Mallarino et al., 2001). The objective was to evaluate the grain yield response of soybean to early season foliar fertilization. Most soybean varieties used were glyphosate resistant. Products tested include 3-18-18 [nitrogen (N)-P_2O_5-K_2O] and 10-10-10. Additionally, 10-10-10 was examined with the addition of sulfur (S) and S plus the micronutrients boron (B), iron (Fe), and zinc (Zn)…denoted 10-10-10-1S-M. The products used to formulate the 3-18-18 and 10-10-10 were urea, aqueous ammonia, phosphoric acid, and potassium hydroxide. Sulfur was supplied as ammonium sulfate and micronutrients as iron chloride, zinc chloride, and sodium borate. Potassium nitrate was used to formulate the 8-0-8.

Product rates ranged from 2 to 6 gal/A (**Table 1**). Some treatments consisted of a second application, 8 to 10 days after the initial one (denoted by a "+" between rates). The single or first foliar fertilizer applications were made at the V5 to V6 growth stage. For 66 conventional plot trials, the fertilizers were not mixed with

Table 1. Trials, treatment sets, and rates of nutrients applied with foliar fertilization.

Trials and treatment sets	Formulation	Product rate, gal/A	Nutrient rate, lb/A						
			N	P_2O_5	K_2O	S	B	Fe	Zn
3-18-18	3-18-18	2	0.7	4.3	4.2	–	–	–	–
	3-18-18	3	1.1	6.3	6.3	–	–	–	–
	3-18-18	4	1.4	8.6	8.4	–	–	–	–
	3-18-18	2+2	1.4	8.6	8.4	–	–	–	–
	3-18-18	3+3	2.2	12.6	12.6	–	–	–	–
3-18-18 strip trials	3-18-18	3	1.1	6.3	6.3	–	–	–	–
N-P-K various	3-18-18	3	1.1	6.3	6.3	–	–	–	–
	3-18-18	2+2	1.4	8.6	8.4	–	–	–	–
	10-10-10	3	3.1	3.1	3.1	–	–	–	–
	10-10-10	6	6.2	6.2	6.2	–	–	–	–
	8-0-8	4.5	3.4	0.0	3.4	–	–	–	–
N-P-K-S various and micronutrients	3-18-18	3	1.1	6.3	6.3	–	–	–	–
	10-10-10	3	3.1	3.1	3.1	–	–	–	–
	3-18-18-1S	3	1.1	6.3	6.3	0.3	–	–	–
	10-10-10-1S	3	3.1	3.1	3.1	0.3	–	–	–
	10-10-10-1S-M	3	3.1	3.1	3.1	0.3	0.03	0.12	0.02

glyphosate or any other herbicide. The 3-18-18 was mixed with glyphosate in eight replicated strip trials. Some of these strip trials were conducted in the same fields where conventional plots were established. The results suggested no interaction between foliar fertilization with 3-18-18 and glyphosate application, which agrees with industry research and product labels allowing for tank mixtures of these products. Further investigations are needed into yield impacts of possible interactions of other products with glyphosate.

Tillage systems of the studies included no-till, ridge-till, as well as chisel plow tillage. Soybean row spacing of the no-till fields was 7.5 in., while the no-till and ridge-till sites had 30 to 38 in. spacings. Most sites had P and K fertilizer applied in the fall before the previous season's corn crop; however, some sites did have these nutrients applied in the fall before the soybean crop. Soil tests of 0 to 6 in. samples were taken in the spring of the soybean cropping year. Bray P-1 (colorimetric) soil test levels indicated that 1.4, 12.2, 8.1, 18.9, and 59.5% of the fields were very low, low, optimum, high, and very high, respectively. Ammonium acetate extractable soil test K levels indicated that 2.7, 31.1, 24.3, 16.2, and 25.7% of the fields were very low, low, optimum, high, and very high, respectively. Iowa State University does not provide micronutrient soil test interpretations for soybeans, although all the sites where micronutrients were applied had soil test Zn levels considered adequate for corn.

Leaf injury from foliar applications sometimes occurred with applications of 10-10-10-1S and 10-10-10-1S-M (at 3 gal/A) or when 10-10-10 was applied at the higher rate of 6 gal/A. Injury usually affected 5% or less of the leaf area; however, up to 10% of the leaf area was affected at two sites where 6 gal/A of 10-10-10 had been applied. Injury to the leaves did not result in statistically significant yield decreases. Treatments that did not produce significant foliar injury sometimes decreased yields. Consequently, leaf injury was not related to soybean yield response.

Table 2 summarizes yield responses from the studies. The same treatments were not evaluated in all 74 trials. The number of site-years in which a specific set of fertilizers and rates were compared to a non-fertilized control ranged from 18 to 74. Across all locations, years, fertilizer products, and application rates, the average relative frequency of positive and negative responses was 16 and 5%, respectively. The increase in yield at the 12 sites with positive responses ranged from 1 to 8% and averaged 6%. At the few sites (4) where yields were significantly decreased with foliar fertilization, yield losses ranged from 6 to 10%, and averaged 9%.

Positive responses to foliar fertilization were more likely with low rainfall in late spring to midsummer and when growing

Table 2. Effects of early season foliar fertilization on grain yield of soybean.

Trial and treatment set	Number of site-years studied	Site-years with statistically significant positive yield responses[1]	Positive response frequency	Avg. positive yield response	Site-years with statistically significant negative yield responses[2]	Negative response frequency	Avg. negative yield response
			--------- % --------			------- % -------	
3-18-18	21	6	29	7	1	5	6
3-18-18 strip trials	8	1	13	1	–	–	–
N-P-K various	27	3	11	8	3	11	10
N-P-K-S various and micronutrients	18	2	11	7	–	–	–
All trials	74	12	16	6	4	5	9

[1] Some or all treatments increased yield compared with the non-fertilized control.
[2] Some or all treatments decreased yield and none increased yield compared with the non-fertilized control.

conditions resulted in low N, P, and K uptake. Across most sites, no significant relationship was seen between yield response and soil nutrient levels, soil pH, or soil series. One site (no-till) did show a significantly positive response to 3-18-18 (3 gal/A) in acidic (pH 5.7-6.0) areas of the field.

However, other sites did not exhibit this relationship. It must be noted that the vast majority of the sites tested optimum or higher according to current P and K soil test interpretations for soybean in Iowa. As a matter of fact, the two largest yield responses were observed in high-testing soils. These two sites were managed with no-tillage or ridge-tillage, but there was no clear overall trend toward higher frequency of responses in these tillage systems compared to a conventional tillage system.

Statistical analyses of specific formulations and rates revealed no consistent trends in yield response (positive or negative) to the different treatments. However, study of yield differences that were statistically significant as well as examination of general agronomic trends across trials indicated a few results of interest. Split applications (V4 toV5 plus another application 8 to 10 days later) increased only slightly the probability of yield response. Inconsistent and small yield responses from one-time (V5-V6 growth stage) foliar applications, combined with application costs, led us to conclude that any economically advantageous yield response was achieved with only a single application. Use of 10-10-10 and 8-0-8 formulations had, on average, a lower probability of producing a positive response than did 3-18-18 at the sites studied. The chance of a statistically significant yield loss from these treatments was nearly the same as the chance of a significant yield gain, and average yield losses were about the same as average yield gains. The inclusion of S provided an advantage at one site. These formulations sometimes resulted in leaf burning, mainly at the high rate of 10-10-10 and 10-10-10-1S, but yield decreases were not clearly related to leaf burning. Adding the mix of the micronutrients B, Fe, and Zn did not provide any additional advantages.

The 3-18-18 formulation at 3 gal/A had the most consistent set of positive responses across all trials in which it was compared to other formulations, although this superiority could not be confirmed at the usual probability level used in research ($p \leq 0.05$). Higher consistency in producing responses combined with no leaf burning and compatibility with glyphosate suggest that 3-18-18 could be the formulation of choice for foliar fertilization of soybeans at early growth stages.

Summary

All foliar fertilization combinations had relatively low probabilities of increasing soybean yields. Of the formulation and rate combinations studied, 3-18-18 had the best chances of increasing yields while minimizing chances of yield losses. Generally in these studies, foliar fertilization has not proven to be a cost-effective management practice when used across all fields and conditions. However, the probability of an economically positive response may be increased by targeting foliar applications to fields in which visual observation of early growth suggests stress. Combining fertilizer with glyphosate applications at the V5 to V6 growth stage may improve the economics of foliar fertilization practices. BC

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