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Foliar Fertilization of Roundup Ready Soybeans

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Abstract

Roundup Ready (RR) soybeans (*Glycine max*) have become the dominant type of soybean grown throughout most soybean growing areas. This RR soybean technology allows the opportunity to add foliar fertilizers to glyphosate. This opportunity is attractive to growers because it eliminates the cost of application associated with foliar fertilization. Nonetheless, if this application of fertilizer results in no yield increases, the purchase of the fertilizer would decrease overall profitability. We evaluated soybean yield response to several foliar fertilizers on Coastal Plain soils over eight site-years. Norcop, Nutrition Plus, Ele-Max (Mn), and 8-0-0-9 were applied with glyphosate on RR soybean. Nitrogen containing products (CoRon) were also evaluated for potential yield responses when applied during early reproductive growth. With the exception of the 8-0-0-9, our results showed no injury to soybean foliage when these products were used at recommended rates. The 8-0-0-9 caused serious foliar injury when applied at a rate of N at 25 lb/acre. The effectiveness of glyphosate herbicide was not affected by the foliar fertilizers. Overall, our results indicated that there was no yield increase from adding these foliar fertilizers to glyphosate, and there was no yield increase from the application of N fertilizers during early reproductive growth.

Introduction

With the advent of Roundup Ready (RR) soybeans, foliar fertilization of soybean has become more popular among soybean growers in the Mid-Atlantic region. This increased usage of foliar fertilizers has occurred because the fertilizer is applied with the glyphosate, thereby eliminating the application costs of the foliar fertilizers. Although some growers are considering this option of adding fertilizers to the glyphosate, they are seeking information on the value of this practice in the Mid-Atlantic region on sandy Coastal Plain soils. Currently, we can find no information that addresses this important question.

Roundup Ready soybeans have been widely adopted and are planted on the majority of soybean acres in the US (10). This method of weed control has been adopted because it is simple, relatively inexpensive, and effective. Generally, glyphosate herbicide is applied about three to five weeks after planting depending on weed pressure.

Foliar fertilization has been widely studied with soybean, and these studies have shown varied results. An Iowa study (4) in the mid-1970s found significant yield increases at several sites when foliar fertilizers were applied during early seed development stages. A Kansas study in the late 1990s (12) found that six of eight sites had significant increases in irrigated-soybean grain yield from N applied during early reproductive growth [i.e., R3 stage (2)]. Several other studies, however, found no response to foliar fertilization (1,3,8,9). Most foliar fertilization studies in soybean have evaluated fertilizer applications made during reproductive growth. Recent Iowa studies (5,6,7), however, did evaluate foliar fertilizer applications made during early vegetative growth and found that responses were small and infrequent across numerous locations.

The primary objective of the study reported here was to evaluate the yield response of RR soybeans to foliar fertilizers that were applied with standard glyphosate applications. In addition, we evaluated soybean yield response to foliar applications of some commonly promoted N products that are applied during the early reproductive growth stages of the soybean.

Foliar Fertilization Evaluation

A total of eight field trials were conducted at various locations at the University of Delaware's Research and Education Center near Georgetown, DE during 2000, 2001, and 2002. Each trial involved the application of several types and rates of foliar fertilizers that are described in Table 1. We evaluated the following foliar fertilization products: (i) Norcop applied at 1 and 2 qt/acre, (ii) Nutrition Plus applied at 1 and 1.5 qt/acre, (iii) Ele-Max (Mn) applied at 1 pt/acre, (iv) CoRon 28-0-0 at 2 gal/acre, and (v) CoRon 12-0-0 at 3 qt/acre. For the 2001 and 2002 seasons, another treatment was added that included a mix of both CoRon products (CoRon 28-0-0 at 1 gal/acre and CoRon 12-0-0 at 2 qt/acre). In 2002, an additional treatment of liquid ammonium sulfate (8-0-0-9) was applied at a rate of N at 25 lb/acre. This treatment of 8-0-0-9 was added because of an advertisement received by a local soybean grower stating that applying 8-0-0-9 at a rate of N at 25 to 30 lb/acre with the glyphosate on RR soybeans would be beneficial. We were concerned that this rate of 8-0-0-9 would cause serious plant injury; therefore, we added this treatment to this study for evaluation. The Norcop, Nutrition Plus, Ele-Max (Mn), and 8-0-0-9 were all applied at growth stage V3 (2) with 1 qt/acre of glyphosate (RoundUp Ultra). The CoRon treatments were applied at growth stage R3 (2), which is the recommended time of application by the manufacturer of the products. All foliar treatments were applied with a CO₂-powered backpack sprayer equipped with a six-nozzle boom calibrated to deliver 25 gal/acre at 30 PSI. The rate was adjusted for the 8-0-0-9 treatment to deliver N at 25 lb/acre.

Table 1. Foliar fertilizer analyses and the company that markets the product.

Product	Company	Labeled percent nutrient analysis							
		N	P	K	B	Zn	Mn	Fe	Mo
Norcop	Notrace	4	2	12	0.5	0.05	2	0	0.0005
Nutrition Plus	Law EL	0	0	0	0.2	2.1	3.2	0.3	0.01
Ele-Max (Mn)	Helena Chem.	3	0	0	0	0	27	0	0
CoRon 28	Helena Chem.	28	0	0	0	0	0	0	0
CoRon 12	Helena Chem.	12	0	0	5	0	0	0	0

The soil and cropping information for each site are shown in Tables 2 and 3. The soil texture was classified as loamy sand for all sites. A randomized complete block design with eight replications was used at each site. Individual plots were 10 ft wide and 25 ft long. Soybeans were planted in 15-inch rows with a Kinze planter at all sites except Site 8, which was planted in 7-inch rows with a Great Plains drill. All plots were harvested with a small-plot combine by harvesting an area that was 25 ft long and 6.5 ft wide (i.e., header size) within each plot.

Table 2. Soil properties for the 0- to 8-inch soil layer at each site.

Site	Year	Soil series ^a	O.M. (%)	pH	Mehlich III soil analyses (ppm)						
					P	K	Ca	Mg	Mn	Zn	B ^b
1	2000	Woodstown	0.9	5.9	282	136	462	65	20.1	5.2	ND
2	2000	Woodstown	1.0	5.8	343	92	430	92	8.9	6.6	ND
3	2001	Woodstown	1.2	6.1	338	151	497	78	22.0	2.4	ND
4	2001	Rumford	1.1	6.3	112	63	381	93	11.5	1.1	ND
5	2001	Woodstown	1.4	5.8	192	116	501	57	39.0	5.3	ND
6	2002	Evesboro	1.2	5.7	330	65	450	75	6.2	3.4	1.0
7	2002	Woodstown	1.6	5.6	154	82	350	68	2.5	2.5	0.7
8	2002	Kalmia	1.3	5.8	108	95	260	75	12.3	2.4	0.5

^a Woodstown is an Aquic Hapludult, Rumford is a Typic Humaquept, Evesboro is a Typic Quartzipsamment, and Kalmia is a Typic Hapludult.

^b ND = Not Determined.

Table 3. Cropping information for each site.

Site	Soybean variety	Planting date	Cropping system ^a	Previous year's crop	First crop this year	Tillage ^b	Irrigated
1	SS-446-RT	26-Jun	DC	Sweet Corn	Peas	NT	Yes
2	SS-446-RT	26-Jun	DC	Sweet Corn	Peas	NT	No
3	SS-4495N-RT	22-Jun	DC	Soybean	Barley	NT	No
4	SS-4495N-RT	30-May	FS	Soybean	NA	NT	No
5	SS-4495N-RT	12-Jun	FS	Peas	NA	CT	Yes
6	SS-446-RT	28-May	FS	Soybean	NA	NT	No
7	SS-446-RT	28-May	FS	Soybean	NA	NT	No
8	SS-446-RT	16-Jul	DC	Field Corn	Peas	NT	Yes

^a Cropping systems are: DC = double-crop soybean; FS = full-season soybean.

^b Tillage systems are: NT = no-till; CT = tilled with disk and field cultivator.

All statistical analyses were performed by using the PROC GLM and PROC ANOVA procedures of SAS Version 8.0 (11). The LSD values were determined by using the PROC GLM procedure of SAS.

Findings from Studies in 2000

There was variation in soybean yield among treatments at both sites in 2000 (Table 4). The 2000 growing season provided good weather conditions for soybean growth; in fact, the average yield for the Site 1 (irrigated) was only 4 bu/acre more than the average yield for Site 2 (not irrigated). At Site 1, the Nutrition Plus at 1.5 qt/acre was the highest yielding treatment and was significantly greater than both CoRon treatments, Norcop at 1 qt/acre, and Nutrition Plus at 1 qt/acre. There was, however, no statistically significant difference between Nutrition Plus at 1.5 qt/acre and the control that received no foliar fertilizer. At Site 2, there were no significant differences among any treatments. The mean yields across both sites indicate that, on average, the control treatment was the highest yielding treatment. Visual evaluations of soybean foliage at one week following application showed no visual differences in growth, color, or damage among any treatments. Visual evaluations of weed control at periodic intervals following herbicide application showed excellent weed control on all treatments.

Table 4. Mean soybean grain yield for each treatment in 2000.

Treatment	Rate (qt/acre)	Mean soybean grain yield (bu/acre)		
		Site 1	Site 2	Mean
Control	none	38.6	33.6	36.1
Norcop	1	33.9	33.8	33.9
Norcop	2	36.8	34.8	35.8
Nutrition Plus	1	35.0	30.2	32.6
Nutrition Plus	1.5	41.4	30.3	35.9
Manganese	0.5	37.2	33.6	35.4
Coron 28	8	36.1	32.1	34.1
Coron 12	3	35.5	31.8	33.7
LSD (0.05)	--	5.3	5.3	--

A single strip trial on a local farm in Sussex County, DE with a loamy sand soil texture was also conducted in 2000. This trial compared seven field-length (approximately 1300-ft) replications of Touchdown herbicide (1 qt/acre) and no foliar fertilizer to Touchdown herbicide (1 qt/acre) mixed with Nutrition Plus at 1.5 pt/acre. The treatments were applied on July 29 to no-till double-crop soybeans planted about July 1 behind winter wheat. The average yield for the Touchdown-only treatment was 38.0 bu/acre, while the average yield for the Touchdown mixed with Nutrition Plus treatment was 37.5 bu/acre. The coefficient of variation (i.e., CV) for this strip trial was 6.4%, and yield difference between these two treatments was not statistically significant ($P = 0.05$).

Findings from Studies in 2001

Soybean yields for the 2001 studies are shown in Table 5. Weather conditions in 2001 were also good for soybean growth. There was some drought stress, however, during the season. In fact, the average yield of Site 5 (irrigated) was 11 bu/acre greater than the average yield at Site 3, even though Site 3 was planted 13 days earlier than Site 5. Statistically, the only site that had significant differences among treatments was Site 3. The highest yielding treatment at Site 3 was the Nutrition Plus treatment at 1 qt/acre, however, this treatment was not significantly greater than the control plot that received no foliar fertilizer. Mean yields for the 2001 studies indicate that the treatment with the highest average yield across all three sites was the Nutrition Plus treatment at 1 qt/acre, however, the lowest yielding treatment across all three sites was the Nutrition Plus treatment at 1.5 qt/acre. Overall, these yield data suggest that there was no consistent trend in fertilizer response among treatments and that foliar fertilization had no measurable impact on soybean yield. Visual evaluations of soybean foliage at one week following application showed no visual differences in growth, color, or damage among any treatments. Visual evaluations of weed control at periodic intervals following herbicide application showed excellent weed control on all treatments.

Table 5. Mean soybean grain yield for each treatment in 2001.

Treatment	Rate (qt/acre)	Mean soybean grain yield (bu/acre)			
		Site 3	Site 4	Site 5	Mean
Control	none	41.4	34.0	47.3	40.9
Norcop	1	42.4	37.3	47.6	42.4
Norcop	2	41.5	35.7	46.8	41.3
Nutrition Plus	1	44.5	37.0	47.7	43.1
Nutrition Plus	1.5	40.3	34.2	47.7	40.7
Manganese	0.5	40.2	33.0	50.2	41.1
Coron 28	8	41.9	37.6	46.6	42.0
Coron 12	3	42.3	37.7	44.6	41.5
Coron Mix	6	43.3	38.4	45.0	42.2
LSD (0.05)	--	3.9	6.2	6.3	--

Findings from Studies in 2002

Soybean yields in 2002 were markedly below normal under non-irrigated conditions (Table 6). These low yields occurred because the 2002 growing season was one of the driest on record in Delaware. These yield data indicate that foliar fertilizer did not improve yields of soybean under extremely dry conditions. At the irrigated site in 2002 (Site 8), the highest yielding treatment was the control, which received no foliar fertilizer. As expected, there was a severe yield penalty from applying 8-0-0-9 at a rate of N at 25 lb/acre. In fact, visual evaluations of the foliar fertilizer treatments one week after application showed severe leaf damage to all plots receiving the 8-0-0-9. Visual ratings indicated that about 75% of the leaf area was destroyed by the application of 8-0-0-9 at all three sites. The yield reduction from the 8-0-0-9 was 39% at Site 8 and 36% at Site 7. Severe leaf damage was also present at Site 6; however, there was not a significant reduction in yield. This lack of yield reduction at Site 6 was likely because the drought stress was more severe than the stress from the fertilizer damage. As in the previous two years, there was no visual leaf damage from the foliar fertilizers, other than the 8-0-0-9. Weed control was excellent for all treatments, except the 8-0-0-9, which had several weed escapes due to the lack of canopy that occurred after the leaves were destroyed from the fertilizer burn.

Table 6. Mean soybean grain yield for each treatment in 2002.

Treatment	Rate (qt/acre)	Mean soybean grain yield (bu/acre)			
		Site 6	Site 7	Site 8	Mean
Control	None	7.5	7.0	35.7	16.7
Norcop	1	8.4	7.2	34.3	16.6
Norcop	2	9.2	7.6	34.2	17.0
Nutrition Plus	1	6.9	8.6	30.7	15.4
Nutrition Plus	1.5	8.1	8.2	34.3	16.9
Manganese	0.5	6.9	7.8	33.3	16.0
Coron 28	8	8.2	6.8	34.0	16.3
Coron 12	3	9.4	6.3	32.7	16.1
Coron Mix	6	8.7	8.3	32.3	16.4
8-0-0-9	125	7.9	4.8	20.5	11.1
LSD (0.05)	--	2.9	2.4	6.2	--

Summary

These studies showed few significant yield increases from the application of foliar fertilizers that were applied with glyphosate to RR soybeans or to the application of N fertilizers applied during early reproductive growth. In fact, there were no consistent trends among any treatments. In several cases, the control plot (i.e., received no foliar fertilizer) was the highest yielding treatment within a site. A pooled analysis of variance (ANOVA) across all eight sites (using the same treatments) showed no statistically significant differences among any treatments; in fact, the mean differences among treatment yields were less than 0.8 bu/acre across all eight sites. With the exception of the 8-0-0-9 treatment, there was no visual foliar burn caused by any treatments. The 8-0-0-9 treatment caused severe foliar burn and loss of soybean leaves. There were no visual indications of increased leaf area or improved leaf color from the application of any foliar fertilizer treatments. Weed control was excellent for all treatments, except the 8-0-0-9 treatment.

Recommendations Based on this Work

This research shows no benefit from mixing foliar fertilizers with glyphosate during application to RR soybeans on Coastal Plain soils in the Mid-Atlantic Region. In addition, the application of N fertilizers during early reproductive growth results in no yield benefit within the yield range and growing conditions observed in this study.

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