2016 SOYBEAN MANAGEMENT FIELD DAYS

RESEARCH UPDATE

Preliminary Report - January 2017 Crop Production Clinic Edition

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Introduction

Keith Glewen, Nebraska Extension Educator

The 2016 growing season represented the sixth year replicated on-farm field research was conducted at the four Soybean Management Field Days locations. Why the need for conducting on-farm research at multiple locations? I'm sure you have driven across the Nebraska and if you're like me, my eyes are focused on production agriculture. What I see and I'm sure you will agree is the variability of the land, which includes the soil, topography, and water resources. This coupled with diversity of production culture which we have learned from experience and to some extent our predecessors, leads us to grow soybeans so differently from East to West and North to South. Production practices discovered and tested at Mead, Nebraska may not perform equally at Orchard, Nebraska. Our attempt is to generate new discovery and validate current production practices.

As growers you are increasingly challenged to grow soybeans more responsibly and to document sustainability. Faculty and staff representing the University of Nebraska-Lincoln greatly appreciate the financial investment you the soybean growers of Nebraska have made through your Checkoff contribution in supporting the research undertaken in this project. We would also like to thank the Nebraska Soybean Board for their part in support and management of this effort. Their input into the selection of research topics and in some cases treatments was extremely valuable.

We would also like to thank each of the four collaborating soybean growers who provided their farm as a research location.

After reviewing the report, if you have additional questions, we encourage you to contact researchers associated with the study. Their names appear in the write up of each study and their contact information is listed on the back cover. We are committed to working for you, the soybean growers of Nebraska.

	Plant	Harvest	Soil	Herbicide		Site Average Yield
	5/5/2016	10/5/2016	Sandy Loam	Date	Chem/Rate	65 bu/ac
CHAPMAN	Pre	All except PPO*		5/5/2016	Roundup 33oz AMS 12 lb/100 Prowl H20 2pt Fierce 3oz	
	Post	All except Conv. & PPO		6/27/2016	Roundup 28oz AMS 17lb/100 Cobra 12.5oz Intensity 6oz Herbimax 1qt	
		Conventional		6/21/2016	+/-Pusuit 4oz +/-Cobra 12.5oz Outlook 12oz NIS 0.25%v/v AMS 12lbs/100	
		PPO		6/24/2016	Roundup 28oz AMS 17lb/100	
	5/13/2016	10/18/2016	Sand	4/16/2015		75 bu/ac
CLEARWATER	Pre	All except PPO		5/17/2016	Roundup 33oz AMS 12 lb/100 Prowl H20 2pt Fierce 3oz	
	Post	All except Conv. & PPO		6/27/2016	Roundup 28oz AMS 17lb/100 Cobra 12.5oz Intensity 6oz Herbimax 1qt	
		Conventional		6/20/2016	+/-Pusuit 4oz +/-Cobra 12.5oz Outlook 12oz NIS 0.25%v/v AMS 12lbs/100	
		PPO		6/24/2016	Roundup 28oz AMS 17lb/100	
	5/6/2016	10/9/2015	Clay Loam			69 bu/ac
CORDOVA	Pre	All except Conv. & PPO		5/10/2016	Roundup 33oz AMS 12 lb/100 Prowl H20 2pt Fierce 3oz	
	Post	All except Conv. & PPO		6/27/2016	Roundup 28oz AMS 17lb/100 Cobra 12.5oz Intensity 6oz Herbimax 1qt	
		Conventional		6/20/2016	+/-Pusuit 4oz +/-Cobra 12.5oz Outlook 12oz NIS 0.25%v/v AMS 12lbs/100	
		PPO		6/24/2016	Roundup 28oz AMS 17lb/100	
	5/19/2016	10/21/2016	Clay Loam			77 bu/ac
SCHUYLER	Pre	All except PPO		5/19/2016	Roundup 33oz AMS 12 lb/100 Prowl H20 2pt Fierce 3oz Outlook 21 oz	
	Post	All except Conv. & PPO		6/27/2016	Roundup 28oz AMS 17lb/100 Cobra 12.5oz Intensity 6oz Herbimax 1qt	
		Conventional		6/20/2016	+/-Pusuit 4oz +/-Cobra 12.5oz Outlook 12oz NIS 0.25%v/v AMS 12lbs/100	
		PPO		NA	None	

* Pre Emergent program for PPO trial listed in PPO section

**For more information,
contact the Nebraska Soybean Checkoff Board
at (800)852-BEAN
or Nebraska Extension at (800)529-8030.**

Conventional Soybean Variety Production Study

- Authors: Rodrigo Werle (Cropping Systems Specialist), Nicholas J. Arneson (Plant Pathology Research Technologist), Joshua Miller (Plant Pathology Graduate Student), and Loren J. Giesler (Extension Plant Pathologist)

- Researchers: Steven Spicka (Agronomy Research Technician III) and Keith Glewen (Extension Educator).

TAKE HOME POINTS:

- Weed density in 15-inch and 30-inch row spacing soybean was similar across locations. Late season weed suppression was not observed in narrow row spacing in this study perhaps because a soil residual product (Outlook) was sprayed POST-emergence to reduce weed infestations at each cooperator's field.
- At Orchard and Cordova, 15-inch row spacing had significantly higher yields than 30-inch row spacing soybeans. At Chapman and Schuyler, soybean yields were similar for 15-inch and 30-inch row spacing.
- There were no yield differences between herbicide programs; however, PRE-emergence followed by POST-emergence herbicides resulted in significantly lower weed density when compared to PRE-emergence only program.
- Overall, narrow row spacing combined with a PRE-emergence followed by a POST-emergence herbicide program resulted in higher yields and better weed control in conventional soybeans.

INTRODUCTION

Because of the higher seed prices of glyphosate-resistant (GR) soybean varieties when compared to conventional (non-GR) varieties, widespread occurrence of GR weeds in Nebraska (e.g., common waterhemp, Palmer amaranth, marestail/horseweed, giant ragweed, and common ragweed), and premiums for non-GMO soybeans, some growers have considered including conventional soybean varieties as part of their cropping systems. Some of the challenges associated with growing conventional soybeans are: i) seed availability and variety selection, ii) misapplication and drift of glyphosate to non-GR varieties, iii) managing weeds without using glyphosate post-emergence (which most of us have become accustomed to), and iv) continual scouting and spraying fields in a timely manner (keeping in mind that weed identification for proper herbicide selection and weed size for proper herbicide efficacy becomes more critical than when using glyphosate post-emergence).

Current weed management strategies in conventional soybeans should not differ much than in GR soybeans where GR resistant weeds are present or a concern. The major difference is that glyphosate is still an extremely effective post-emergence tool for managing grasses and some of the glyphosate-susceptible broadleaf species that are commonly present in row crop production in Nebraska (e.g., velvetleaf, common sunflowers, cocklebur, nightshades, common lambsquarters, etc.). Our recommendation to farmers willing to grow conventional and even GR soybeans is to "START CLEAN, STAY CLEAN". A herbicide program consisting of burndown plus soil residual activity at planting allows growers to "START CLEAN". Continual scouting and respray programs that contain a post-emergence plus soil residual activity herbicides should control weeds until canopy closure, helping growers to "STAY CLEAN". Several herbicide options are available for weed management in conventional soybeans; however, different herbicide options control different spectrum of weeds and sometimes can cause cosmetic injury to the crop.

Herbicide resistance is also a concern in conventional soybean production. For instance, several weeds have evolved resistance to ALS-inhibiting herbicides in Nebraska (e.g., common waterhemp, Palmer amaranth, shattercane, johnsongrass, kochia, and marestail). Overreliance on a single herbicide program within and across growing seasons will eventually lead to resistance. Therefore, growers should consider using herbicides from multiple effective modes of action at each application to slow the evolution of herbicide resistance. Moreover, growers should consider incorporating mechanical (e.g., pre-plant tillage, in crop cultivation, post-harvest tillage) and cultural strategies (e.g., crop rotation, plant population, row spacing, planting date, and cover crops) as part of their weed management program. 30-inch row spacing has been the standard for most growers across Nebraska; however; research has shown a yield increase when soybeans were planted at 15-inch row spacing. Moreover, narrow-row spacing has been reported to reduce the likelihood of weed resurgence in soybeans due to the faster rate of canopy closure (Section 1/Figure 1). Smaller yield losses have been detected in narrow- compared to wide-row soybean systems when herbicide applications were delayed (due to environmental conditions or operational issues). Therefore, row spacing is a cultural strategy that could be better explored by growers in order to increase yield potential and assist with weed management.

Over the past years, trials have been conducted to evaluate if the practice of using fungicide and insecticide application at R3 (pod set) could increase soybean yields. These trials have used GR soybeans and the response on conventional soybeans has not been evaluated. Thus, the objective of the conventional soybean production study was to explore the impact of crop row-spacing, fungicide and insecticide application at pod set (R3), and PRE, and PRE followed by (*fb*) a conventional POST herbicide program on weed management and crop productivity.

Section 1/Figure 1. **15-inch versus 30-inch row spacing. Pictures taken on August 10, 2016 at the location near Chapman, NE. Note the faster canopy closure and higher light interception under 15-inch when compared to 30-inch row spacing.**

METHODS

Experiments were conducted at all four locations of the 2016 Soybean Management Field Days. These locations were near Chapman, Orchard, Cordova, and Schuyler, NE. The study was conducted as a 2x2x2 factorial with a total of 8 treatments and 4 replications on a randomized complete block design. Treatments consisted of: i) two row spacings, ii) two herbicide programs, and iii) two pod set treatments applied at the R3 growth stage (Section 1/Table 1). A robust pre-emergence herbicide program that included Fierce (3 oz/A), Prowl H_2O (2 pt/A), Roundup Power Maxx (33 oz/A) and AMS (12 lb/100 gal), was applied to all treatments at planting. Additionally, Outlook (12 oz/A) was applied to the entire plot area to reduce weed infestation at each cooperator's field at the same time the post-emergence treatment was applied. The two herbicide programs were designed to help growers visualize the importance of soil applied herbicides at planting, as well as reinforce University recommendations for growers to scout fields and apply post-emergence along with soil residual herbicides before canopy closure. Information on the soybean varieties planted and treatment application time for each location can be found in Section 1/Table 2.

Section 1/Table 1. **Treatment list for the conventional soybean variety production study.**

Row Spacings:	POST Herbicide Programs:	Pod Set Treatments:
15 inch	***Pre only***: No POST treatment[1]	***None:*** No treatment
30 inch	***PRE fb POST***: Pursuit (4 oz/A) + Cobra (12.5 oz/A) + NIS (0.25% v/v) + AMS (12 lbs/A)[1]	***F&I***[2]: Stratego YLD (4 oz/A) + Leverage 360 (2.8 oz/A)

[1]Outlook (12 oz/A) was applied to all plots to help prevent late season weed resurgence at all locations.

[2] F&I = fungicide and insecticide at pod set.

Section 1/Table 2. **Soybean variety planted, and planting date, PRE-herbicide, POST herbicide, and pod set treatment (fungicide and insecticide) application time at each location[1].**

Site	Variety	Planting	PRE-Herbicide	POST-herbicide	Pod set
Chapman	U11 – 911079	5/5/16	5/5/16	6/21/16 (V4)	7/21/2016 (R3)
Orchard	U09 -312115	5/13/16	5/17/16	6/20/16 (V4)	7/21/2016 (R3)
Cordova	U11 – 911079	5/6/16	5/10/16	6/20/16 (V7/R1)	7/21/2016 (R3)
Schuyler	U11 – 911079	5/19/16	5/19/16	6/20/16 (V4/V5)	7/21/2016 (R3)

[1]Before planting seeds were treated with Apron XL (7.5 g/100 kg seed) + Maxim 4FS (2.5 g/100 kg seed) + Vibrance (2.5 g/100 kg seed). Seeding rate = 125,000 seeds per acre.
Varieties included in this study were all UNL conventional varieties.

Data collection

Weed density. Weed density reported as plants per acre was determined by counting the total number of weeds in the center 5 ft across of each plot (30 ft long). Weed counts were conducted at the end of the season at soybean physiological maturity.

Grain yield. Yields in bushels per acre were determined with a small plot combine by harvesting two center rows of each plot after they were cut to a standard length of 30 ft. Yields were adjusted to 13% grain moisture for final reported values.

Statistical analysis. The experimental data were analyzed to evaluate interaction and main treatment effects on weed density and yield. Significant differences were determined based on a probability of 0.95. Section 1/Tables include the average and standard error value for each treatment as well as the treatments where statistical differences (P-value<0.05) were detected.

RESULTS AND DISCUSSION

Treatment effect on weed density. Site and herbicide program had an impact on the weed density. Chapman and Orchard had the highest weed pressure followed by Cordova and Schuyler, respectively (Section 1/Table 3). At Chapman, common waterhemp was the predominant weed. At Orchard, common lambsquarters was the predominant weed. At Cordova, common waterhemp and velvetleaf were present. At Schuyler, common waterhemp, common lambsquarters, marestail and velvetleaf were the weeds present. As expected, the *PRE fb POST* program had lower weed density at soybean maturity than the *PRE only* program across all locations combined. The use of PRE-emergence herbicides is an effective strategy for weed control, however, a subsequent POST-emergence application is often necessary for proper weed management. Row spacing and pod set treatment with a fungicide and insecticide had no impact on weed density. Narrow-row spacing has been reported to reduce the likelihood of weed resurgence in soybeans due to the faster rate of canopy closure. Perhaps this was not observed in this study because a soil residual herbicide (Outlook) was sprayed across the entire experimental area to reduce weed infestation at each cooperator's field at the time the POST-emergence treatment was applied. At Orchard and Chapman, weed density was still high when compared to Cordova and Schuyler, even after the POST-emergence application. Thus, a second POST-emergence application would have been necessary to further reduce weed density at these locations. Growers should constantly scout their fields and spray in a timely manner when weeds are resurging. Growers should use multiple effective herbicides at each application to enhance weed control and slow the evolution of herbicide resistance.

Section 1/Table 3. **Weed density (average plants per acre ± standard error) in response to row spacing, herbicide program and foliar fungicide and insecticide application at reproductive stage. All treatment averages are included at the top part of the table. The combined averages for the significant treatment effects are shown at the bottom part of the table.**

Row spacing	Herbicide	Foliar	Chapman	Orchard	Cordova	Schuyler
15-inch	PRE only	NONE	37,031±8,803	18,152±5,221	1,743±795	436±241
30-inch	PRE only	NONE	19,604±1,830	24,832±2,148	3,050±629	1,307±519
15-inch	PRE *fb* POST	NONE	6,970±1,927	6,390±2,023	0±0	290±145
30-inch	PRE *fb* POST	NONE	6,825±4,037	10,165±2,069	0±0	145±126
15-inch	PRE only	F&I	28,027±6,156	22,073±4,400	3,921±1,169	145±126
30-inch	PRE only	F&I	19,750±8,324	23,235±2,590	2,759±519	1,597±904
15-inch	PRE *fb* POST	F&I	4,357±633	9,730±4,635	581±503	145±126
30-inch	PRE *fb* POST	F&I	5,809±1,882	13,070±4,296	0±0	0±0
Significant effects:						
			Chapman	**Orchard**	**Cordova**	**Schuyler**
		Site (P<0.001)[1]	16,047±4199 a	15,956±3423 a	1,507±452 b	508± 273 c
			All locations combined			
		Herbicide (P<0.001) [1]	**Pre only**	12979±2773 a		
			Pre *fb* Post	4030 ± 1785 b		

[1]Groups that do not share the same letter are significantly different (P<0.05). Letters, in alphabetic order, represent weed densities from highest to lowest.

Treatment effect on grain yield. There was a significant row spacing by site interaction. The average yield for the 15-inch row spacing was higher across all locations when compared to the 30-inch row spacing, with the yield difference of 2, 11, 23, and 7 bushels per acre at Chapman, Orchard, Cordova and Schuyler, respectively (Section 1/Table 4). At Orchard and Cordova, 15-inch row spacing had significantly higher yield than 30-inch row spacing. At Chapman and Schuyler, the yields were not statistically different. These results corroborate the studies conducted during the 2014 and 2015 Soybean Management Field Days, where 15-inch row spacing tended to result in higher yields when compared to 30-inch row spacing. In this study, herbicide program had no effect on yield. Even though the POST-emergence program significantly reduced weed density (Section 1/Table 3), the weed pressure left after the PRE-emergence program was apparently not high enough to significantly reduce yields. From a herbicide resistance management perspective, weeds should not be allowed to seed; therefore, the POST-emergence treatment along with a residual product can assist growers with reducing weed seedbank, thus, reducing yield infestations in subsequent years. Fungicide and insecticide treatment at pod set had no effect on yield. That can be explained by the absent or low disease and insect pressure across locations (data not shown).

Section 1/Table 4. **Conventional soybean yield (average in bushels per acre ± standard error) in response to row spacing, herbicide program and foliar fungicide and insecticide application at reproductive stage. All treatment averages are included at the top part of the table. The combined averages for the significant treatment effects are shown at the bottom part of the table.**

Row spacing	Herbicide	Foliar	Chapman	Orchard	Cordova	Schuyler
15-inch	PRE only	NONE	50±5	65±5	89±3	79±2
30-inch	PRE only	NONE	48±4	60±5	63±11	73±1
15-inch	PRE *fb* POST	NONE	53±8	76±6	72±13	76±7
30-inch	PRE *fb* POST	NONE	53±2	66±4	63±12	69±1
15-inch	PRE only	F&I	53±3	72±9	94±3	76±1
30-inch	PRE only	F&I	49±2	54±2	63±11	73±1
15-inch	PRE *fb* POST	F&I	54±2	80±2	93±2	82±2
30-inch	PRE *fb* POST	F&I	52±2	66±1	66±11	72±3
Significant effects:						
		Row spacing*site (P<0.001)[1]	**Chapman**	**Orchard**	**Cordova**	**Schuyler**
		15-inch	53 ± 5 d	73 ± 3 b	87 ± 5 a	79 ± 3 b
		30-inch	51 ± 3 d	62 ± 3 c	64 ± 11 c	72 ± 1 b

[1]Groups that do not share the same letter across locations and between row spacings are significantly different (P<0.05). Letters, in alphabetic order, represent yields from highest to lowest.

CONCLUSIONS

By switching from 30-inch to 15-inch row spacing, growers are likely to increase the yield potential of their soybeans. For proper weed control in conventional soybeans, growers should use an effective PRE-emergence program followed by a POST-emergence program along with a residual product. Depending upon the weed pressure at their farms, growers should constantly scout their field and apply a second POST-emergence program in case of weed resurgence prior to canopy closure. Given the lack of new herbicide sites of action and the alarming increase in the number of herbicide resistant weeds, growers should adopt a “Zero-Tolerance” program, where weeds should not be allowed to produce seeds. “START CLEAN, STAY CLEAN” is a key strategy for successful weed management program in any cropping system.

The overall average soybean yield across all trials at each site was 65 bu/A at Chapman, 75 bu/A at Orchard, 69 bu/A at Cordova, and 77 bu/A at Schuyler. Other than lower than average yield at Chapman, the yield of the conventional study was similar to the overall average at all sites.

Effect of Soil Applied Protoporphyrinogen Oxidase (PPO) Inhibitor Herbicides on Soybean Yield and Seedling Disease Severity

- Authors: Nicholas J. Arneson (UNL Graduate Research Assistant), Loren J. Giesler (Nebraska Extension Plant Pathologist) and Rodrigo Werle (UNL Cropping Systems Specialist)

- Researchers: Steven Spicka (Agronomy Research Tech III), Joshua Miller (UNL Graduate Research Assistant), Keith Glewen (Nebraska Extension Educator), and Kyle Broderick (Research Technologist-Plant Pathology)

TAKE HOME POINTS:

- PPO herbicides can result in seedling injury and reduced stand when environmental conditions are not favorable for crop establishment
- Results suggest that soil applied PPO applications can increase seedling disease severity
- Although root rot severity was increased by PPO applications, there was no significant correlation to a decrease in yield
- The use of the fungicide seed treatment reduced seedling disease at one of the four locations
- There were differences between varieties in yield production at two of the four locations. At Chapman, the difference was attributed to a difference in genetic resistance to Sudden Death Syndrome

INTRODUCTION

There has been increased reliance on soil applied herbicides with residual activity to control weed species that have evolved resistance to glyphosate. Protoporphyrinogen oxidase inhibitor (PPOs, Group 14) herbicides are common components of these preemergence programs in Nebraska. However, soil applied PPO herbicides can result in seedling injury if environmental conditions are not favorable for crop establishment (Section 2/Figure 1). Soybean seedling diseases caused by fungi and fungal-like organisms such as *Fusarium* spp., *Rhizoctonia solani*, and *Pythium* spp. can have significant impacts on crop stand and yield. Some of the same environmental conditions that favor PPO injury, such as saturated soils, heavy rains near emergence and cool soil temperatures also favor infection of common seedling pathogens. Section 2/Figure 2 features a comparison of two soybean root systems from the trial area, one with low and one with high amounts of disease. It has been shown in previous literature that seedling damage may allow infection by soilborne plant pathogens. It is of great importance to determine if PPO herbicides affect soybean root rot severity and whether that has an impact on yield. This study was designed to investigate interactions between soil applied PPO herbicides and common soybean seedling diseases.

METHODS

Experiments were conducted at all four locations of the 2016 Soybean Management Field Days. These locations were near Chapman, Orchard, Cordova, and Schuyler, Nebraska. There were 12 treatments (two varieties x two seed treatments x three herbicide programs) (Section 2/Table 1). The experimental design was a randomized complete block design with four replications. Each experimental unit (plot) was 10 ft wide (4 rows x 30 in rows) by 30 ft long.

Variety: Two varieties were selected based on sensitivity ratings to sulfentrazone provided by Pioneer Hybrids®. P22T41R2 was listed as sensitive to sulfentrazone while P28T08R was rated as tolerant.

Seed treatments: A base fungicide seed treatment was included and compared to no treatment. The fungicide selected represented several different modes of action designed to protect against multiple common fungal pathogens in Nebraska.

Herbicide programs: There were three herbicide programs evaluated, a glyphosate alone treatment, a glyphosate + sulfentrazone tank mix, and a glyphosate + flumioxazin tank mix, all sprayed 2-5 days after planting. The selection of the chemistry tested in this study is not an indication that these are the best products; instead, it was intended to be representative of common PPO herbicides used in Nebraska. For example, we have selected Spartan and Valor as these are commonly used soil applied herbicides. These products could be comparable to other herbicides which have sulfentrazone or flumioxazin, respectively, as their active ingredient.

***Section 2/Figure 1.* Damage on soybean cotyledon and lower stem resulting from soil applied PPO herbicides.**

Section 2/Figure 2: Root rot symptom severity comparison (left: 2.5%, right: 60%).

***Section 2/Table 1.* Specific treatments tested in the 2016 SMFD PPO experiment. All seed treatments were applied to the seed prior to planting and all herbicide applications were soil-applied at 15 gal/ac.**

Varieties	Seed Treatment (ST)	Herbicide Program[z]
P22T41R2 Sensitive to PPO[y]	No Treatment	Roundup (glyphosate, 32 oz/ac + 17 lb/100 gal AMS)
P28T08R Tolerant to PPO	Fungicide (Apron XL 7.5 g/100 kg seed + Maxim 4FS 2.5 g/100 kg seed + Vibrance 2.5 g/100 kg seed)	Roundup (glyphosate, 32 oz/ac + 17 lb/100 gal AMS) + Spartan (sulfentrazone, 8 oz/ac)
		Roundup (glyphosate, 32 oz/ac + 17 lb/100 gal AMS) + Valor (flumioxazin, 2.5 oz/ac)

[z] Herbicides were soil applied 2-5 days after planting, before emergence
[y] Variety designation based on Pioneer Hybrids ratings of sulfentrazone sensitivity

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[z] Herbicides were soil applied 2-5 days after planting, before emergence
[y] Variety designation based on Pioneer Hybrids ratings of sulfentrazone sensitivity

Data Collection

Plant populations: Plant populations were assessed by counting the total number of plants from the middle two rows in a 10 ft section of row for each plot. There were two early season plant population evaluations done at 12 – 21 days after planting (DAP) and 26–35 DAP. Populations were converted to populations per acre based on the representative sample counts.

PPO injury incidence: Incidence of injury caused by PPO application was assessed at the time of the first plant population assessment. Injury on the cotyledon was observed and rated on 0-100% scale of amount of the entire plot area exhibiting symptoms (Section 2/Figure 1).

Root rot assessment: At V3-V5 growth stage, roots were dug from each plot and rated for root rot severity on 0-100% scale of total root area rotted. Section 2/Figure 2 displays examples of soybean root systems from the trial area with root rot symptoms.

Disease and Insect Assessments: During the season, plots were evaluated for foliar diseases and insect defoliation on a linear percentage scale of 0-100 for disease incidence and severity. *Disease incidence* represents the total percentage of canopy in which damage or injury is present. *Disease severity* represents the overall intensity of injury or damage caused by the disease activity typically represented as necrotic plant tissue on the plants within the plot.

Yield: Yield was determined with a small plot combine by harvesting the two center rows of each plot after they were cut to standard length of 30 ft. Yields were adjusted to 13% grain moisture for final reported values.

Statistical analysis. The experimental data was analyzed by individual sites and as a combined experiment using a randomized complete block design. All treatments were considered across all locations. Significant differences were determined based on a probability of 0.90. Additionally, treatment effects varied by location, so for most treatment comparisons the results will be presented by location and for the average responses across all four locations. Some Section 2/Tables do not include average responses since certain foliar diseases were present only at some sites and not others.

RESULTS

Depending on the location there were differences in response for each factor being evaluated (variety, seed treatment and herbicide program). The response variable used to determine the effects of these inputs were established stand (Section 2/Table 3), root rot severity (Section 2/Table 5) and yield (Section 2/Table 7).

PPO injury occurred at all locations except Cordova, with incidences ranging from 2% to 30% of plants displaying symptoms. No apparent injury occurred in the glyphosate alone treated plots. The highest occurrence of PPO injury was at Chapman with Orchard and Schuyler having lower overall incidences of PPO injury present (Section 2/Table 2).

Section 2/Table 2. **PPO injury incidence ratings for the variety comparison at each 2016 SMFD location and overall average incidence.**

Variety	Location and PPO Injury Incidence (0-100%)				
	Chapman	**Orchard**	**Cordova**	**Schuyler**	**Average**
Sensitive	11.9	3.3	0	9.3	8.2
Tolerant	**23.3**[y]	**5.9**	0	8.0	**12.4**
Prob>F	0.0031	0.07	NA[z]	0.56	0.04

[z] No apparent PPO injury occurred throughout trial area at Cordova

[y] BOLD = values in bold represent significant increases ($p<0.10$)

Variety Response to PPO Herbicides. PPO injury incidence was higher in the tolerant variety at Chapman, Orchard and when averaged across all locations (Section 2/Table 2). This is unexpected, however tolerant varieties can still be injured by PPO application and ratings are related to specific environmental conditions in which they are developed. It was expected to see this amount of damage in the sensitive variety. If environmental conditions were even less favorable at emergence, we would have expected more damage and even greater stand loss overall.

Seed Treatment Effect on PPO Injury. Fungicide seed treatment resulted in lower PPO injury at Orchard and Schuyler (data not shown). Through providing protection against infection, the fungicide seed treatment would increase root establishment and growth which could accelerate emergence and potentially result in less PPO injury.

Herbicide Effect on PPO Injury. Sulfentrazone resulted in higher PPO injury at Chapman, Orchard and when averaged over all locations. Injury levels between sulfentrazone and flumioxazin were similar at the Schuyler location (data not shown).

Effects on Plant Population.

Section 2/Table 3. **Treatment factors and level of significance for a treatment effect or interaction with treatments on plant population. Note that for a factor to be considered significant or to have an effect the value would need to be less than 0.10 at a 90% confidence level.**

Treatment Factor and Interaction	**Probability > F** for Treatment Factors Affecting Plant Population									
	Chapman		**Orchard**		**Cordova**		**Schuyler**		**All**	
	14 DAP[z]	**26 DAP**	**21 DAP**	**35 DAP**	**12 DAP**	**25 DAP**	**15 DAP**	**29 DAP**	**First**	**Second**
Variety	**0.0002**	**0.0003**	**<0.0001**	**0.0001**	**0.0001**	**0.0010**	**<0.0001**	**0.0007**	**<0.0001**	**<0.0001**
Seed Treatment	0.8843	0.7662	0.7025	0.6575	0.6721	0.6269	0.3330	0.9187	0.7076	0.7771
Herbicide	**0.0143**	**0.0731**	**0.0403**	0.5046	0.4764	0.2302	0.9457	0.4988	0.1885	0.6814
Variety X Seed Treatment	0.1959	0.1005	0.4576	**0.0109**	0.3439	0.3516	0.1084	0.9187	**<0.0001**	0.1058
Variety X Herbicide	**0.0722**	0.2465	0.6633	0.9926	0.3906	0.6447	0.2028	0.7194	0.6056	0.7951
Herbicide X Seed Treatment	0.6053	0.2912	0.9101	0.9060	0.1239	0.6613	0.9815	0.4977	0.8955	0.7589

Section 2/Table 4. **Soybean populations for all treatment factor comparisons at each 2016 SMFD location and overall average populations.**

Treatment Factor Comparisons	Location and Population (plants/ac)									
	Chapman		**Orchard**		**Cordova**		**Schuyler**		**Average**	
	14 DAP[z]	**26 DAP**	**21 DAP**	**35 DAP**	**12 DAP**	**25 DAP**	**15 DAP**	**29 DAP**	**First**	**Second**
Variety										
Sensitive	**67,228[y]**	**65,667**	**93,924**	**82,581**	**64,472**	**95,788**	**89,588**	**75,539**	**78,704**	**79,767**
Tolerant	54,813	54,849	81,623	72,492	53,751	85,757	77,283	67,082	67,043	69,896
Prob>F	0.0002	0.0003	<0.0001	0.0001	0.0001	0.0010	<0.0001	0.0007	<0.0001	<0.0001
Seed Treatment										
No Treatment	60,803	60,657	88,282	78,045	58,588	90,097	82,316	71,426	72,422	75,133
Fungicide	61,238	59,859	87,265	77,029	59,635	91,449	84,555	71,196	73,326	74,530
Prob>F	0.88	0.77	0.70	0.66	0.67	0.63	0.33	0.92	0.71	0.78
Herbicide Program										
Glyphosate	67,246y	64,741	92,728	79,061	60,499	89,069	83,599	72,762	75,984	76,120
Glyphosate + Sulfentrazone	59,623	58,153	84,996	77,755	56,996	89,105	83,799	71,656	71,615	73,926
Glyphosate + Flumioxazin	56,192	57,880	85,595	75,794	59,841	94,144	82,909	69,513	71,022	74,448
Prob>F	0.01	0.07	0.04	0.50	0.48	0.23	0.95	0.50	0.19	0.68

[z] DAP = number of days after planting

[y] BOLD = values in bold represent significant increases (p<0.10)

Variety Effect on Plant Population. Overall, plant populations were lower than expected. Populations ranged from 40 – 75% of the initial seeding rate of 125,000 seed/acre. At all locations the sensitive variety resulted in significantly higher plant populations for both assessments (Section 2/Table 4). This could be explained by the difference in field emergence ratings for each variety. The tolerant variety had a score of 7, while the sensitive had a score of 8. The rating score of 9 on this scale was rated “excellent”.

Seed Treatment Effect on Plant Population. There were no significant differences in plant populations between fungicide and no seed treatment across all herbicide treatments.

Herbicide Program Effect on Plant Population. In general, there was a trend in which the glyphosate alone herbicide program resulted in higher plant populations than the two PPO tank mix programs. At Chapman and Orchard, glyphosate resulted in higher plant populations for the first assessment (Section 2/Table 4). This is likely due to poor environmental conditions during crop emergence including cool wet soils with rainfall.

Effects on Root Rot Severity.

When plant root systems were evaluated for root rot the factor which most consistently affected root rot severity was herbicide treatment (Section 2/Table 5). The specific seedling disease pathogens that were most commonly isolated were *Fusarium* spp. at Orchard, *Pythium* spp. at Cordova, and *Rhizoctonia solani* at Chapman and Schuyler.

Section 2/Table 5. **Treatment factors and level of significance for a treatment effect or interaction with a treatment on root rot severity. Note that for a factor to be considered significant or to have an effect the value would need to be less than 0.10 at a 90% confidence level.**

Treatment Factor and Interaction	**Probability > F** for Treatment Factors Affecting Root Rot Severity				
	Chapman	**Orchard**	**Cordova**	**Schuyler**	**All**
Variety	0.2474	0.1665	**0.0205**	**0.0660**	0.8437
Seed Treatment	0.7387	0.1717	**0.0007**	0.1601	**0.0109**
Herbicide	**0.0080**	0.1805	**0.0006**	**0.0279**	**<0.0001**
Variety X Seed Treatment	0.7387	0.8191	0.8522	0.6019	0.9784
Variety X Herbicide	0.3551	0.6484	**0.0347**	0.6749	**0.0671**
Herbicide X Seed Treatment	0.2395	0.6853	**0.0030**	0.2522	0.1507

Section 2/Table 6. **Root rot severity ratings for all treatment factor comparisons at each 2016 SMFD location and overall average severity.**

Treatment Factor Comparisons	Location and Root Rot Severity (0-100%)				
	Chapman	**Orchard**	**Cordova**	**Schuyler**	**Average**
			Variety		
Sensitive	18.8	8.4	**33.6**[y]	8.5	17.3
Tolerant	21.7	10.3	25.5	**11.1**	17.1
Prob>F	0.25	0.17	0.02	0.07	0.84
			Seed Treatment		
No Treatment	19.8	10.3	35.8	8.8	18.7
Fungicide	20.6	8.4	**23.3**	10.8	**15.8**
Prob>F	0.74	0.17	0.0007	0.16	0.01
			Herbicide Program		
Glyphosate	14.7	7.6	19.5	7.6	12.3
Glyphosate + Sulfentrazone	**24.7**	10.6	**32.6**	9.5	**19.3**
Glyphosate + Flumioxazin	**21.3**	9.8	**36.6**	**12.4**	**20.0**
Prob>F	0.008	0.18	0.0006	0.03	<0.0001

[y] BOLD = values in bold represent significant increases (p<0.10)

Variety Effect on Root Rot Severity: There were differing results between the varieties for root rot severity across the locations (Section 2/Table 6). The tolerant variety had higher root rot severity than the sensitive at three of the four locations. However, only at Schuyler the difference was significant. At Cordova, the sensitive variety resulted in significantly higher root rot severity than the tolerant.

Seed Treatment Effect on Root Rot Severity: Root rot severity was lower for fungicide compared to no treatment at Cordova as well as when averaged across locations. The fungicide seed treatment reduced root rot severity by 12.5% and 3%, respectively (Section 2/Table 6).

Herbicide Program Effect on Root Rot Severity: Root rot severity was 2-17% higher in the sulfentrazone and flumioxazin treatments compared to glyphosate at all four locations. Three of the four locations resulted in significantly higher amounts of root rot in plots treated with sulfentrazone or flumioxazin compared to the glyphosate treatment (Section 2/Table 6). At Chapman, where there was the most frequent occurrence of PPO injury, root rot was increased by 7-10% with a PPO application. However, at Cordova where there was no visible PPO injury, PPO application resulted in 12-17%. It does not appear that soybeans needed to be visually injured by the PPO herbicides in order for them to have an impact on seedling disease severity.

***Section 2/Table 7.* Treatment factors and level of significance for a treatment effect or interaction with an early season treatment on yield. Note that for a factor to be considered significant or to have an effect the value would need to be less than 0.10 at a 90% confidence level.**

Treatment Factor and Interaction	**Probability > F** for Treatment Factors Affection Yield				
	Chapman	**Orchard**	**Cordova**	**Schuyler**	**All**
Variety	**0.0015**	0.8312	0.2451	**0.0142**	0.0920
Seed Treatment	0.6802	0.6229	0.9928	0.5447	0.8395
Herbicide	0.5392	**0.0589**	**0.0722**	0.9393	0.6044
Variety X Seed Treatment	0.5463	0.5159	0.8261	0.3210	0.4357
Variety X Herbicide	0.5104	0.7710	0.5673	0.4531	0.5863
Herbicide X Seed Treatment	0.8806	0.7723	0.7909	0.1139	0.5399

Section 2/Table 8. **Yield results for all treatment factor comparisons at each 2016 SMFD location and overall average yields.**

Treatment Factor Comparisons	Location and Yield (bu/ac)				
	Chapman	Orchard	Cordova	Schuyler	Average
			Variety		
Sensitive	57.3	73.6	65.5	**78.3**	68.6
Tolerant	**63.4**[y]	73.8	67.3	75.9	**70.0**
Prob>F	0.0015	0.83	0.25	0.01	0.09
			Seed Treatment		
No Treatment	60.0	73.9	66.4	76.8	69.3
Fungicide	60.7	73.5	66.4	77.4	69.4
Prob>F	0.68	0.62	0.99	0.54	0.84
			Herbicide Program		
Glyphosate	59.6	**74.4**	63.8	77.3	68.8
Glyphosate + Sulfentrazone	61.7	72.3	**68.3**	76.9	69.7
Glyphosate + Flumioxazin	59.7	**74.3**	67.0	77.1	69.5
Prob>F	0.54	0.06	0.07	0.94	0.60

[y] BOLD = values in bold represent significant increases ($p<0.10$)

Variety Effect on Yield. There was no consistent trend of yield difference between the two varieties across all locations. At Chapman, the tolerant variety yielded 6 bu/ac higher than the sensitive. This difference in yield is likely attributed to differing resistance scores to Sudden Death Syndrome (Section 2/Figure 3). While at Schuyler, the sensitive variety yielded 2.4 bu/ac higher than the tolerant (Section 2/Table 8).

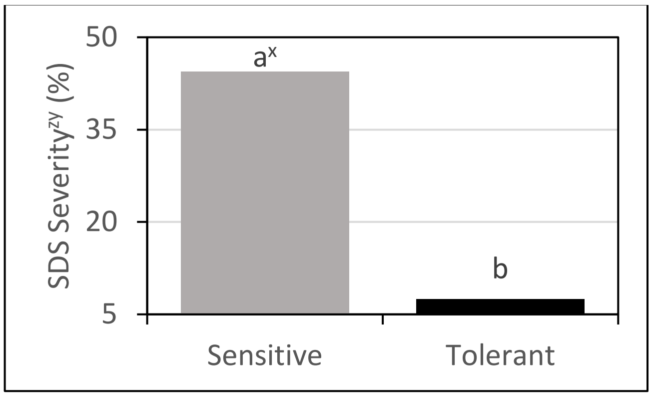
Seed Treatment Effect on Yield. There was no difference in yield between the treatments (Section 2/Table 8).

Herbicide Program Effect on Yield. No consistent trends were observed with yield depending on the herbicide program. The sulfentrazone treatment had significantly lower yield than both the flumioxazin and glyphosate treatments at Orchard. At Cordova, both PPO treatments resulted in higher yield compared to the glyphosate alone treatment. This was likely due to competition with weeds that were not controlled due to the absence of any residual activity.

Disease and Insect Evaluations (Site Specific Factors Affecting Yields):

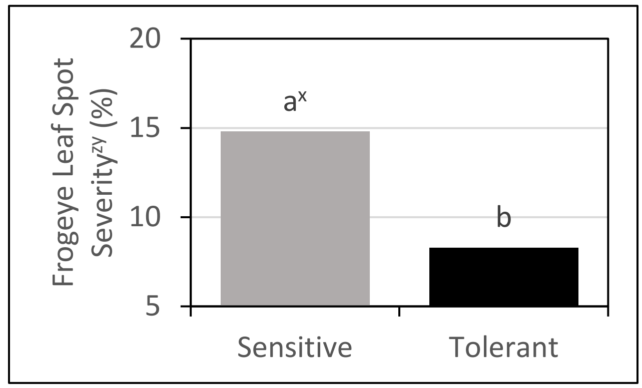
There were a range of diseases observed at low levels throughout the four locations. Frogeye leaf spot (*Cercospora sojina*) was present at Orchard, brown spot (*Septoria glycines*) at Cordova, and Sudden Death Syndrome (SDS, *Fusarium virguliforme*) at Chapman. There was no observable disease present at Schuyler throughout the growing season. There were also no significant insect populations at any of the locations.

Section 2/Figure 3. **Sudden Death Syndrome (SDS, *F. virguliforme*) severity at Chapman for each variety.**



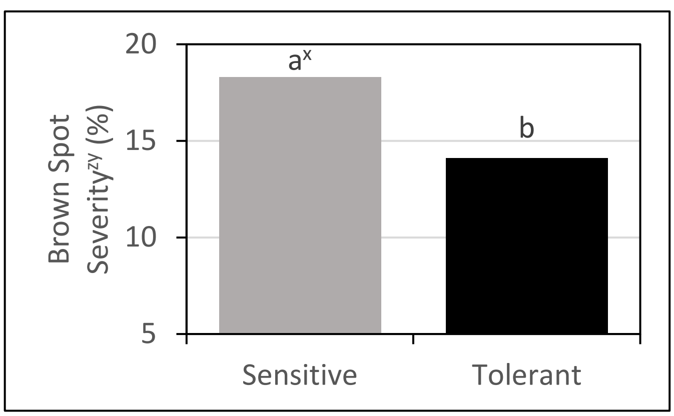
[z] Estimated across the entire plant canopy of the two center rows of each plot on a percentage scale (0-100)
[y] Ratings taken on September 8 (R6 growth stage)
[x] Different letters indicate significant difference

Section 2/Figure 4. **Frogeye leaf spot (*C. sojina*) severity at Orchard for each variety.**



[z] Estimated across the entire plant canopy of the two center rows of each plot on a percentage scale (0-100)
[y] Ratings taken 40 days after R3 application
[x] Different letters indicate significant difference between treatments ($p<0.0001$)

Section 2/Figure 5. **Brown spot (*S. glycines*) severity at Cordova for each variety.**



[z] Estimated across the entire plant canopy of the two center rows of each plot on a percentage scale (0-100)
[y] Ratings taken 42 days after R3 application
[x] Different letters indicate significant difference between treatments ($p<0.01$)

Chapman: The sensitive variety had higher SDS incidence, severity and index for both assessments (Section 2/Figure 3). This variety has a lower score of genetic resistance to Sudden Death Syndrome and subsequently resulted in a higher occurrence of the disease. Herbicide and seed treatment did not affect the amount of SDS.

Orchard: Frogeye leaf spot incidence and severity were lower for the tolerant variety (Section 2/Figure 4). Although the disease pressure was low at Orchard, it appeared that there is varietal difference in terms of resistance to frogeye. There was no difference in frogeye ratings when fungicide see treatment was used. Additionally, there was more frogeye leaf spot disease in the PPO treated plots however not significant.

Cordova: Brown spot incidence and severity were lower for the tolerant variety as well (Section

2/Figure 5). Again, it appeared that there was varietal difference in terms of resistance to brown spot severity even at low densities. There was no difference in brown spot ratings when fungicide seed treatment was used. There were also no differences between herbicide programs.

DISCUSSION

According to the results of our first year, soil applied PPO herbicides, sulfentrazone and flumioxazin, had an effect on root rot severity in soybeans. However, there is still a high level of uncertainty as to the magnitude of these effects and how they can affect yield. At all locations, a soil applied PPO application resulted in higher root rot severity compared to the glyphosate treatment. This increase in root rot severity did not directly correspond to loss of yield in these treatments. Only three of the four locations had observable injury from PPO application. However, the site which had no observable damage had the highest root rot severity and clear separation between PPO treatments and the glyphosate check. This indicates that observable seedling injury from PPO herbicides is not necessary in order to have increases in root rotting disease incidence. Overall, the growing conditions in 2016 were favorable for soybean production and could therefore compensate for any loses that could be attributed to the increased root rot infection. It would be useful to see how the increase in root rotting would affect yield in stressful August environmental conditions. The varieties used in this study were screened for sensitivity to sulfentrazone. At Cordova where there were higher levels of seedling disease pressure, the fungicide seed treatment significantly reduced root rot severity but had no effect on yield. Interactions between herbicides, seed treatment, and varietal sensitivity will be further investigated to better understand the complex relationships among these factors. Additional greenhouse research will be conducted in order to further understand the interaction between PPO herbicide and seedling disease severity.

Evaluation of Fungicide and Insecticide Seed Treatment and Foliar Applications Across Different Varieties and Seeding Rates

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TAKE HOME POINTS:

- Varieties compared in this study resulted in significantly different yields and demonstrated the effect of selecting the correct genetics for your field.
- The higher seeding rates resulted in an increase in yield when compared to the low population rate at two of the four locations. Seeding rates need to be evaluated in all operations for maximizing income.
- The fungicide + insecticide seed treatment increased plant populations at all locations but did not significantly increased yield at any locations over no treatment. All producers will **not** benefit from use of seed treatments.
- Where foliar disease (brown spot and frogeye leaf spot) pressure was present at low levels, the fungicide + insecticide pod set treatment resulted in an increase in yield by 2.0 bu/ac at two locations. Increases in yield observed did not pay for the treatment.

INTRODUCTION

Over the past three years the focus of a large integrated management study at the SMFD sites has been on maximizing yields with at-planting and pod-set (stage R3) inputs. In 2016 we identified specific factors from the past few years of study to further evaluate as a comparison to common production practices in the area of the SMFD locations.

Varieties available to soybean farmers vary in a large array of rated criteria by the companies providing them. Some varieties will be known to have better performance in harsher growing conditions and some will be less ‘defensive’ and be more aggressive on yield production but at the same time not tolerate environmental stress very well. Another criteria that is needed in some fields would be resistance to diseases present in a specific field. Diseases like sudden death syndrome and soybean cyst nematode are two common diseases in Nebraska that varieties will vary in resistance to. Seeding rates are also known to vary greatly in Nebraska and the current UNL recommended rate is typically much lower than common farmer practices.

Inputs of fungicides and insecticides as seed treatments and foliar applications at R3 have had varying response over the past years of study. Overall we have not observed consistent returns with seed treatments unless the soil conditions were cool or a specific disease problem causing stand issues was known to occur in the field. Foliar applications have also not consistently resulted in returns on the investment, but are known to be more consistent if foliar diseases or insects are present at damaging levels.

Therefore, the goal in 2016 was to compare the most common practice in each production area with an opposite approach. This resulted in different varieties, seeding rates, seed treatments, and foliar treatments. In 2014, we noted that narrower row spacing (15 in) yielded significantly more than wider row spacing (30 in) by an average of

4.7 bu/ac (Shapiro et al., 2014). There were no interactions between row spacing and either early season or pod-set treatments, which indicated that the response to any of the treatments we are evaluating would perform similarly on either row spacing. For that reason, all plots in 2016 were planted at 30 in spacing for the ease of data collection and to reduce the space requirements.

While the response of specific inputs is never consistent there were some specific trends observed that may help direct soybean farmers in the local area of the state in which the trials were conducted. With the current agricultural economy, it is critical for producers to invest in treatments that will consistently return. This study was designed to be another source of information to be considered when evaluating the potential for return of these practices.

Overall location parameters for production history, soil type and irrigation can be found on the inside of the front cover.

METHODS

This experiment was conducted at all four locations of the Soybean Management Field Days near Chapman, Clearwater, Cordova, and Schuyler, Nebraska. The experimental design at each location was a randomized complete block with treatments arranged in a 2 x 2 x 3 x 2 factorial structure with four replicates. Treatments consisted of two varieties, two seeding rates, three seed treatments, and two pod-set treatments. Each experimental unit was 10 ft wide (4 x 30 in rows) and 30 ft long. Plots were planted with a research plot planter so that populations and seed treatments could be changed for each plot.

Variety: Two varieties were used at each location: one selected by the grower and the other selected as a competitive comparison. The comparative variety had similar agronomic traits, but differed in how defensive the variety was; for example, in the Pioneer variety comparison there were differences in susceptibility for Sudden Death Syndrome.

Seeding rate: Two seeding rates were used at each location: the current UNL recommended seeding rate of 125,000 seeds/acre and a high population – which varied by location and was decided based on local practices. In all cases, local practices were higher than the UNL recommended rate (Section 3/Table 1).

Seed treatments: Three seed treatments were used at each location: no treatment, a fungicide base, and a fungicide and insecticide combination.

Pod-set treatments: Two pod-set inputs (growth stage R3) were used at each location: no treatment and a fungicide and insecticide (F+I) combination treatment. A complete list of the treatment details for each product and input is in Section 3/Table 1. The selection of the chemistry tested in this study is not an indication that this is the best product; it is intended to be representative of a product group. For example, we have selected Stratego® YLD as a fungicide input at R3. This product is comparable to other fungicides which have a strobilurin and triazole included in their composition.

Section 3/Table 1. **Specific treatments tested in the 2016 SMFD factorial experiment. All seed treatments were applied to the seed prior to planting and all foliar applications were applied at 15 gal. /ac.**

Varieties	Seeding Rate	Seed Treatment (ST)	Pod Set (Stage R3) Inputs
Grower selected Pioneer 31T77 (Chapman + Clearwater) NK 30C1 (Cordova + Schuyler)	High 200,000 (Chapman) 160,000 (Clearwater) 175,000 (Cordova) 165,000 (Schuyler)	No Treatment	No Treatment
Comparison Pioneer 31T11R (Chapman + Clearwater) NK 31F1 (Cordova + Schuyler)	Low 125,000 (all locations)	Fungicide [a] (Apron XL 7.5 g/100 kg seed + Maxim 4FS 2.5 g/100 kg seed + Vibrance 2.5 g/100 kg seed)	Fungicide + Insecticide (Stratego YLD 4.0 fl oz/ac + Leverage 360 2.8 fl oz/ac)
		Fungicide + Insecticide ([a] + Thiamethoxam 50 g/100 kg seed)	

Data Collection

Plant populations: Plant populations were assessed three times by counting the total number of plants from the middle two rows in a 10 ft section of row for each plot at 25 – 35 days after planting (DAP), 42–50 DAP and before harvest. Populations were converted to total plants per acre based on the representative sample counts.

Disease and Insect Assessments: During the season, plots were evaluated for foliar diseases and insect defoliation on a linear percentage scale of 0-100 for disease incidence and severity. *Disease incidence* represents the total percentage of canopy in which damage or injury is present. *Disease severity* represents the overall intensity of injury or damage caused by the disease activity typically represented as necrotic plant tissue on the plants within the plot.

Yield: Yield was determined with a small plot combine by harvesting the two center rows of each plot after they were cut to standard length of 30 ft. Yields were adjusted to 13% grain moisture for final reported values.

Statistical analysis. The experimental data was analyzed by individual sites and as a combined experiment using SAS Proc Glimmix. Treatments were evaluated across all locations and significant differences were determined based on a probability of 0.90. Because treatment effects varied by location, treatment comparisons are presented by location and for the average response across all four locations. Section 3/Tables that do not include average responses are due to absence of that rating at all locations.

RESULTS

Early Season Inputs Comparison

The early season inputs, including variety, seed treatment and seeding rate, were evaluated based on established stand (Section 3/Table 2) and yield (Section 3/Table 5). Depending on the location there were differences in response for each factor being evaluated. Significant interactions occurred with locations as therefore all sites are being presented separately. The specific conditions at each location and factors that could have affected results (where we can suggest an effect) are discussed.

Section 3/Table 2. **Analysis of Variance for the early season inputs and level of significance for a treatment effect or interaction with an early season treatment on plant population. Note that for a factor to be considered significant or to have an effect the value would need to be less than 0.10 at a 90% confidence level.**

Input Factor and Interaction	**Probability > F** for Early Season Input Factors Affecting Plant Population							
	Chapman		Clearwater		Cordova		Schuyler	
	50 DAP	Harvest	48 DAP	Harvest	49 DAP	Harvest	42 DAP	Harvest
Variety	**<0.0001**	**0.0347**	0.3011	0.1373	**0.0746**	**0.0042**	**<0.0001**	0.6189
Seed Treatment	**<0.0001**	**0.0005**	0.9832	**0.0031**	**0.0616**	0.1719	0.9452	0.6608
Seeding Rate	**<0.0001**	**<0.0001**	**0.0616**	**<0.0001**	**<0.0001**	**<0.0001**	0.2255	0.7598
Variety X Seed Treatment	0.4889	0.1085	0.4439	0.8787	0.4884	0.8177	0.8288	0.6123
Variety X Seeding Rate	**0.0043**	0.3272	**0.0507**	0.4216	0.2895	0.0928	0.4991	0.3069
Seeding Rate X Seed Treatment	0.9036	0.0956	0.2530	0.3911	0.3633	0.9692	0.6461	0.8130
Variety X Seed Treatment X Seeding Rate	**0.0048**	0.6885	0.6200	**0.0864**	0.2861	**0.0397**	0.2276	0.5435

Variety Effect on Plant Population. Variety selection influenced early season plant populations at three of the four locations and harvest populations at two of the four locations (Section 3/Table 2 and 3). At each of these sites, the grower selected variety resulted in higher plant populations. The grower variety averaged approximately 8,000 plants/ac more than the comparative variety during the second early season count (p<0.0001) and 4,000plants/ac more at harvest (p=0.02) (Section 3/Table 3).

Seeding Rate Effect on Plant Population. Soybean populations were significantly different between the high and low seeding rates at all three assessment timings and at all locations except Schuyler (Section 3/Tables 2 and 3). The average populations across all sites were significantly higher for the high population rate versus the low rate.

This would make sense as the relative differences in population rates from high to low ranged from 35,000 – 85,000 additional seeds/ac from site to site (Section 3/Table 1). The average percent establishment, calculated as the actual stand divided by the seeding rate, is provided in Section 3/Table 4. The higher seeding rates consistently had lower percent establishment than the lower seeding rates based on harvest stand counts.

Seed Treatment Effect on Plant Population. When populations were averaged across all locations, the fungicide + insecticide treatment had significantly higher populations compared to fungicide and no treatment at the first and third assessment (Section 3/Table 3). These findings are consistent with results from previous SMFD trials that have shown that the use of seed treatments can significantly increase soybean populations (Miller et al., 2015). At Chapman, the fungicide + insecticide seed treatment had significantly higher populations compared to the fungicide seed treatment and no treatment at all three timings. At Cordova, both the fungicide and fungicide + insecticide had higher populations compared to no treatment at the second assessment. At Clearwater for the second timing, fungicide + insecticide and no treatment had significantly higher populations than the fungicide seed treatment.

***Section 3/Table 4.* Harvest soybean percentage of stand establishment for the planting population comparison at each 2016 SMFD location.**

Seeding Rate	Location and % Establishment of Population			
	Chapman	**Clearwater**	**Cordova**	**Schuyler**
High	48.7%	59.7%	63.3%	48.0%
Low	57.4%	67.5%	73.8%	62.7%

Early Season Input Effect on Yield. Although early season inputs often had an effect on plant populations, this did not necessarily translate to yield. Variety and seeding rate had a significant impact on average yields and seed treatment was significant at Chapman and Schuyler (Section 3/Table 5).

***Section 3/Table 5.* Analysis of Variance for early season inputs and Prob.> F for early season treatments on yield. Note that for a factor to be considered significant or to have an effect the value would need to be less than 0.10 at a 90% confidence level.**

Input Factor and Interaction	**Probability > F** for Input Factors Affecting Yield				
	Chapman	**Clearwater**	**Cordova**	**Schuyler**	**Average**
Variety	**0.0021**	**<0.0001**	**<0.0001**	0.6158	**0.0008**
Seed Treatment	**0.0147**	0.3321	0.8413	**0.0236**	0.2403
Seeding Rate	**0.0369**	0.4147	0.1150	**<0.0001**	**<0.0001**
Variety X Seed Treatment	0.94	0.58	0.53	0.01	0.48
Variety X Seeding Rate	0.88	0.81	0.64	0.83	0.77
Seeding Rate X Seed Treatment	0.8933	0.9770	0.8927	0.4968	0.9795
Variety X Seed Treatment X Seeding Rate	0.9456	**0.0134**	0.5269	0.1765	0.5799
Pod Set	0.4594	**0.0202**	**0.0141**	0.1519	**0.0387**
Pod X Seed Treatment	0.8116	0.2943	0.8205	0.2678	0.2859
Pod X Seeding Rate	0.3187	0.1964	0.7133	0.8928	0.2932
Pod X Variety	0.9356	0.2624	**0.0661**	0.9434	0.7025
Pod Set X Seed Treatment X Seeding Rate	0.7270	**0.0288**	0.7407	0.7173	0.8525
Pod Set X Seed Treatment X Variety	0.6067	0.5720	0.6856	0.6954	0.7085
Pod Set X Seeding Rate X Variety	**0.0126**	0.9346	0.7590	0.7483	0.1046
Pod Set X Seed Treatment X Seeding Rate X Variety	0.4438	0.1810	0.2240	0.7019	0.6969

Section 3/Table 6. **Yield results for all input comparisons at each 2016 SMFD location and overall average yields.**

Input Factor and Interaction	Location and Yield (bu/ac)				
	Chapman	**Clearwater**	**Cordova**	**Schuyler**	**Average**
			Variety		
Grower selected	62.7	71.9	**71.3**	76.8	70.7
Comparative variety	**67.3**[y]	**77.6**	67.3	77.2	**73.4**
Prob>F	0.001	<0.0001	<0.0001	0.61	0.0008
			Seeding Rate		
High	**66.5**	74.4	69.9	**81.3**	**73.0**
Low	63.5	75.1	68.6	72.8	70.0
Prob>F	0.03	0.44	0.10	<0.0001	<0.0001
			Seed Treatment		
No Treatment	63.1	74.7	69.4	**77.7**	71.2
Fungicide	63.9	74.1	69.0	**78.0**	71.2
Fungicide + Insecticide	68.0	75.6	69.6	75.3	72.1
Prob>F	0.39	0.33	0.82	0.02	0.24
			Pod Set Inputs		
No Treatment	65.6	73.8	68.3	77.6	71.0
Fungicide + Insecticide	64.4	**75.8**	**70.3**	76.4	**72.00**
Prob>F	0.3923	0.0202	0.0098	0.1428	0.0387

[y] BOLD = values in bold represent significant increases (p<0.10)

Although the grower variety generally resulted in higher plant populations, it only yielded significantly more at Cordova (4.0 bu/ac). At Chapman and Clearwater, as well as for the average across all sites, the comparative variety yielded significantly more than the grower variety by 4.6, 5.7 and 2.7 bu/ac, respectively (Section 3/Table 6).

The higher seeding rates yielded more than the low seeding rate at Chapman and Schuyler, as well as for the average across all locations, by 3.0, 8.5 and 3.0 bu/A, respectively (Section 3/Table 6). The yield response to seeding rate does not correlate with the plant population response, indicating that plant populations are were not low enough to have a detrimental impact on yield.

An effect of seed treatment was only observed at the Schuyler location and the result was the no treatment having a higher yield than the treatments (Section 3/Table 6). Any effect on plant population did not relate to an impact on yield.

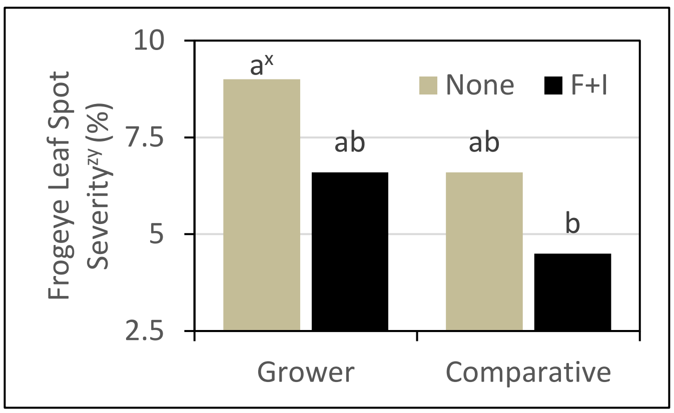
Pod-Set Inputs. Although pod set treatments significantly influenced the average yield across all locations there was a significant interaction with treatments and location. Therefore, we are presenting each locations separately. Only Clearwater and Cordova were significant at the location level (Section 3/Table 5). This is related to disease control, which is discussed for each location in the following section. The fungicide + insecticide pod set treatment resulted in a 2.0 bu/ac increase in yield at both Clearwater and Cordova (Section 3/Table 6).

Disease and Insect Evaluations (Site Specific Factors Affecting Yields):

There were a range of diseases observed at low levels throughout the four locations. Frogeye leaf spot (*Cercospora sojina*) was present at Clearwater, brown spot (*Septoria glycines*) at Cordova, and Sudden Death Syndrome (SDS, *Fusarium virguliforme*) at Chapman. There was no observable disease present at Schuyler throughout the growing season. There were also no significant insect populations at any of the locations.

Chapman: Although SDS was present at the Chapman location, the overall pressure was low with incidence and severity scores less than 2 in all evaluations. At these levels, SDS would not be expected to result in significant yield loss. There were no significant differences between varieties for SDS pressure at Chapman (data not shown). Similarly, there were no significant differences between seeding rates or seed treatments for SDS pressure (data not shown). This is expected as neither of these inputs are known to be helpful in managing the disease.

Section 3/Figure 1. **Frogeye leaf spot (*C. sojina*) severity at Clearwater for pod-set treatments for each variety. Significant variety differences (p<0.10). Significant pod-set treatment differences (p<0.10).**



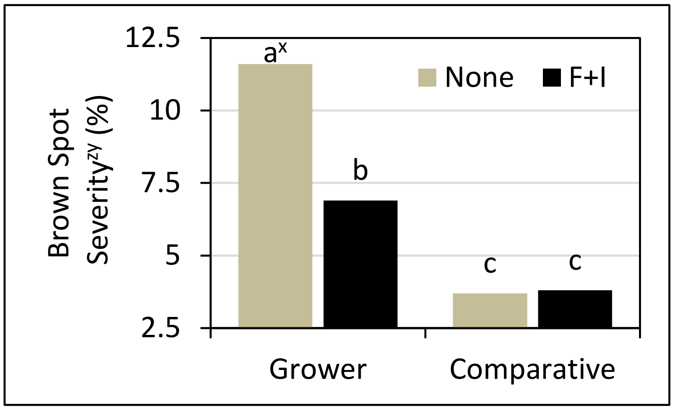
^{z} Estimated across the entire plant canopy of the two center rows of each plot on a percentage scale (0-100)
^{y} Ratings taken 40 days after R3 application
^{x} Different letters indicate significant difference between treatments (p<0.10)

Clearwater: Frogeye leaf spot disease pressure at Clearwater was low with incidences under 12% and severity ratings under 10% (Section 3/Figure 1). Yield loss due to frogeye leaf spot has been limited to less than 20 percent in recent years in Nebraska due to overall low disease pressure. Given the low level of disease pressure at this field, we would not expect to see measurable losses that would justify the additional cost of the fungicide application (Giesler, 2013). The comparative variety had significantly lower frogeye incidence and severity compared to the grower variety; however, only minor effects on yield would be expected at these low levels. Varieties can vary significantly in susceptibility to this disease and would account for the difference in disease ratings and can account for some of the yield differences.

The impact of the foliar fungicide (F+I) resulted in reducing frogeye incidence and severity (Section 3/Figure 1). This is one of the components of yield increase with fungicide + insecticide input at Clearwater.

Cordova: Brown spot disease was present at low levels at Cordova with incidences and severity ratings under 12% (Figure 2). Yield losses due to brown spot can range from 8 to 15 percent when the disease pressure is at a high enough level to defoliate the canopy 25 to 50 percent. The disease pressure at this location was not at this threshold throughout the season at Cordova (Giesler, 2011). The comparative variety had significantly lower brown spot incidence and severity compared to the grower variety. This is a factor not typically considered or rated by industry but will vary with variety. This difference will affect the response with the fungicide + insecticide input.

Section 3/Figure 2. **Brown spot (*S. glycines*) severity at Cordova for pod-set treatments for each variety. Significant variety differences (p<0.0001). Significant pod-set treatment differences (p<0.01).**



^{z} Estimated across the entire plant canopy of the two center rows of each plot on a percentage scale (0-100)
^{y} Ratings taken 42 days after R3 application
^{x} Different letters indicate significant difference between treatments (p<0.10)

The impact of the foliar fungicide (F+I) resulted in reducing brown spot incidence and severity in the grower selected variety (Section 3/Figure 2). This is one of the components of yield increase with fungicide + insecticide input at Cordova.

The lower seeding rate reduced brown spot disease incidence and severity at Cordova (data not shown). This demonstrates the effect of plant density on a disease that initiates in the lower portion of the canopy. More air movement occurs in a less dense canopy reducing humidity and allowing the canopy to dry sooner.

DISCUSSION

In general, the grower selected variety increased soybean populations, but this did not consistently increase yield. In this comparison the grower selected variety was typically one that was a more stable yield producer and would perform well with stress. Only at Cordova did the increased population correlate with an increase in yield. Although the varieties used at each location were comparable in regards to agronomic traits, they differed in disease susceptibility based on the evaluations published in seed catalogues. This demonstrates the importance of selecting varieties for disease resistance and using fungicides when diseases are present, as observed in both the Cordova and Clearwater locations where brown spot or frogeye leaf spot developed. Based on the level of development for foliar disease at these locations we would not have recommended a treatment for controlling the disease.

The higher seeding rates increased the soybean populations at all locations except for Schuyler. The difference in percent establishment was consistently higher for the lower seeding rate in 3 of 4 locations and demonstrated that many seeding rates are in excess as a higher percentage of the higher seeding rate seed did not produce productive plants. While sites will vary in emergence rates and some fields may require higher seeding rates, most growers would benefit from reducing seeding rates to optimize emergence rates for planted seed. At high populations soybeans self-abort to get a population that will allow successful seed set and be in some equilibrium with the environment. With the current agricultural economy, this is a factor that should be considered in all operations. There is a great deal of research that suggests seeding rates lower than 140,000 are optimum (Elmore, 1998). The high seeding rate only contributed to increases in yield at two of the four locations. Depending on seed cost, the increase in yield may not return on the added input cost. At Cordova and Clearwater, the high planting population did not result in significant yield increase and thus would not pay for the additional cost of the seed needed. The phenomenon in which higher stands do not correlate to an increase in yield is due to the ability of soybean plants to compensate for lower plant density by increasing individual plant biomass. Many studies will show no yield differences between 75,000 and 100,000 plants/ac for an ending population (DeBruin and Pederson, 2008; Naeve, 2008).

The fungicide + insecticide seed treatment increased soybean stand population at different timings across several locations, but this did not consistently increase yield. Seed treatments only impacted yield at Schuyler where the fungicide seed treatment and the no treatment both yielded higher than the fungicide + insecticide treatment. It should be noted that fields with a history of stand problems will typically benefit by getting a higher percentage of seed to establish; however, this will not consistently result in higher yield. It should also be noted that maximum yield will not be achieved without having a strong and well established root system, which seed treatments are known to facilitate under stressful environmental conditions. This is another factor that should be carefully considered to determine whether this is an investment that will offer returns in a specific farming system. In general, another criteria for return on a seed treatment is planting into cooler soils. In 2016, soil temperatures were warmer (in general) and at the optimum germination temperature (60^o) or above and, therefore, the potential for return on this investment is much lower. The environmental conditions throughout the summer were very favorable for soybean yield which may have contributed to an overall lack of significant yield impacts from the early season treatments as well. This is also a factor that surely affected the response with the variety comparison as results may have been completely opposite in a year with greater stress. Many growers will select varieties that buffer the effects of a growing season with stress but in years with overall high yielding environments these varieties may not yield as much as less defensive varieties.

Pod-set inputs only resulted in significant yield increases at Cordova and Clearwater where there was disease pressure. Although brown spot and frogeye leaf spot disease incidence and severity was fairly low at Cordova and Clearwater, there were still significant differences between the fungicide + insecticide treatment and no treatment for pod-set applications at both locations. At both locations, the fungicide + insecticide pod-set application resulted in a 2.0 bu/ac increase compared to the no treatment. With current prices this treatment would not have paid for the added input cost.

Overall, there were no clear relationships with any of the treatment strategies which resulted in maximum soybean yield in 2016. While there were effects within the varieties, planting populations, and seed treatments, there were none that consistently increased yield. Similarly, pod-set inputs did not consistently increase yields and there was no association of an early season treatment being related to any late season treatment for maximum yields. Observations related to disease pressure support the idea of using genetics as your first line of management.

Based on this study and the studies conducted in 2013, 2014, and 2015, soybean farmers should continue to use sound agronomic practices to manage their crop based on field history, and it is critical to determine the economic impact of investing in any of the treatments we tested to achieve maximum yields. Location and soil continue to be one of main effects on overall yields as is represented by the overall range in yields (65 to 78 bu/ac) at the four locations.

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Soybean Management Field Day Irrigation Management Trial

- Authors/Researchers: Chuck Burr (Nebraska Extension Educator), Troy Ingram (Nebraska Extension Educator), Aaron Nygren (Nebraska Extension Educator), and Daran Rudnick (Nebraska Extension Irrigation Specialist)

TAKE HOME POINTS:

- Irrigation before the R3 growth stage can result in taller soybean plants that can be prone to lodging
- Starting irrigation at the R3 growth stage is recommended for deep medium or fine textured soils with a full soil water profile at planting
- Irrigation may be required during vegetative growth stages on sandy and sandy loam soils
- Historically, the highest Irrigation Water Use Efficiency was achieved by irrigating at 75% irrigation level

INTRODUCTION

Soybean acreage in Nebraska has increased from 43,000 acres of irrigated production in 1972 to 1.95 million acres in 2013. With rising fuel costs and declining crop prices soybean growers are looking for ways to reduce operating costs. Following two years of severe drought over much of Nebraska, several Natural Resources Districts implemented irrigation water pumping restrictions. Currently, over 1.5 million irrigated acres are under some form of irrigation water allocation.

Proper irrigation management is critical to optimize both grain yields and irrigation water use efficiency. Recent UNL research has shown that the optimal time to begin irrigating soybeans is at the R3 growth stage (Irrigating Soybean, NebGuide G1367). Watering before the R3 growth stage can lead to taller plants which may lodge before harvest. Lodging may impede grain harvesting equipment thus leading to yield reductions. Research has also shown that irrigation during the vegetative growth stage has little impact on soybean yields; whereas, irrigation during the reproductive growth stage has the greatest yield response for a limited water supply.

METHODS

The variety planted at the Chapman and Orchard Soybean Management Field Day (SMFD) locations was Pioneer P31T77 and at the Cordova and Schuyler sites was Northrup King NK30C1. Five irrigation treatments were investigated at each of the SMFD locations with four replications per treatment. The treatment plots were four rows wide and twenty feet long with a 30-inch row spacing. A non-irrigated buffer row separated each plot to reduce the possibility of soybean plants pulling soil water from an adjacent irrigation treatment. Irrigation treatments were watered with drip tape laid on the soil surface next to the soybean row. Plumbing with a main line and valves controlled the water application to the four rows in each treatment plot. The center two rows of each plot were harvested for yield comparisons. Two replications of Watermark soil water sensors (Irrometer Co., Inc., Riverside, CA) were installed at each foot depth down to three feet to monitor changes in soil water storage. The Chapman site was located on a sandy loam soil, Orchard was on a sand, and the Cordova and Schuyler sites were on a clay loam soil. Watermark sensor readings for field capacity and 50% of plant available water are 20 and 200 cb for a clay loam soil, 1 and 30 cb for a fine sand soil, and 1 and 55 cb for a sandy loam soil, respectively (UNL CropWater App). Plant available water is defined as the difference between field capacity and permanent wilting point. Field capacity is the amount of water remaining in the soil profile after water freely drains following a wetting event and permanent wilting point is the amount of water in the soil profile that is unavailable for plant water uptake (Nebraska Extension Circular EC3002: Soil water sensors for irrigation management).

The five irrigation treatments were as follows:

- Full Irrigation: Irrigations were scheduled by monitoring soil water to maintain soil water levels above 50% depletion.
- 75% Irrigation: Irrigation amounts were 75% of the full irrigation treatment for the entire season.
- 125% Irrigation: Irrigation amounts were 125% of the full irrigation treatment for the entire season.
- 50% Early - Full Late: Irrigation amounts were 50% of the full irrigation treatment until the R5 growth stage and thereafter full irrigation.
- Rainfed: No irrigation water was applied to this treatment.

Irrigation Water Use Efficiency (IWUE, bushel per acre inch) was calculated for each treatment (Equation 1). IWUE is a measure of the increase in grain yield of an irrigation treatment (Y_i, bushel per acre) over a rainfed treatment (Y_r, bushel per acre) divided by the irrigation water applied (Irr, inches) to that treatment. In other words, IWUE provides a metric for evaluating the benefit of irrigation for improving grain yield above rainfed production.

Equation 1: $$IWUE = \frac{Y_i - Y_r}{Irr}$$

RESULTS

Chapman Site

The irrigation study was located on a dryland pivot corner on a sandy loam soil. Due to the extreme variation in soils, which is typical for the area, the irrigation plots were abandoned for the growing season and yield results are not available.

Orchard Site

The irrigation study was located on a dryland pivot corner on a fine sand soil. There were no significant differences among yields across irrigation treatments. Yields ranged from 83.3 to 88.5 bu/ac. The full irrigation treatment had the highest yield and the largest IWUE of 0.6 bu/ac-in. The research location experienced lodging; however, there were no significant statistical differences across treatments. The 50% early and full after R5 growth stage treatment had a lower grain yield of 83.3 bu/ac as compared to the rainfed treatment of 85.2 bu/ac, which resulted in a negative IWUE value.

***Section 4/Table 1.* Soybean grain yields (bu/ac), lodging (%), applied irrigation water (in), and irrigation water use efficiency (IWUE, bu/ac-in) for the five irrigation treatments at the Orchard site.**

Treatment	Yield, bu/ac	Lodge, %	Irrigation, inches	IWUE, bu/ac-in
125% Full Irrigation	84.2 a	11.3 a	7.5	-0.1
Full Irrigation	88.5 a	5.0 a	6.0	0.6
75% Full Irrigation	85.9 a	15.0 a	4.8	0.1
50% Early, Full after R5	83.3 a	15.0 a	4.5	-0.4
Rainfed	85.2 a	2.5 a	0	

Cordova Site

The irrigation study was located on a dryland pivot corner on a clay loam soil. Yield results for the five treatments ranged from 50.7 to 59.0 bu/ac with no significant differences among irrigation treatments. The rainfed treatment yielded 53.4 bu/ac which resulted in several treatments having a negative IWUE value. The subtle differences in grain yield across treatments at this site suggests that both water and energy could have been conserved by withholding irrigation under the experienced rainfall pattern.

Section 4/Table 2. **Soybean grain yields (bu/ac), lodging, (%), applied irrigation water (in), and irrigation water use efficiency (IWUE, bu/ac-in) for the five irrigation treatments at the Cordova site.**

Treatment	Yield, bu/ac	Lodge, %	Irrigation, inches	IWUE, bu/ac-in
125% Full Irrigation	59.0 a	26.7 b	9.1	0.6
Full Irrigation	52.3 a	11.7 a	7.3	-0.2
75% Full Irrigation	54.0 a	7.5 a	5.4	0.1
50% Early, Full after R5	50.7 a	21.3 ab	6.3	-0.4
Rainfed	53.4 a	15.0 ab	0	

Schuyler Site

The irrigation study was located on a dryland pivot corner on a clay loam soil. Yield results for the five treatments ranged from 77.3 to 89.7 bu/ac. Only the 75% irrigation treatment was significantly higher than the other 4 treatments and had the highest IWUE of 3.3 bu/ac-in.

Section 4/Table 3. **Soybean grain yields (bu/ac), lodging (%), applied irrigation water (in), and irrigation water use efficiency (IWUE, bu/ac-in) for the five irrigation treatments at the Schuyler site.**

Treatment	Yield, bu/ac	Lodge, %	Irrigation, inches	IWUE, bu/ac-in
125% Full Irrigation	81.4 a	0	6.3	0.7
Full Irrigation	78.3 a	0	5.0	0.2
75% Full Irrigation	89.7 b	0	3.8	3.3
50% Early, Full after R5	80.3 a	0	4.0	0.8
Rainfed	77.3 a	0	0	

DISCUSSION

With the exception of the 75% irrigation treatment at Schuyler, all other treatments at the individual sites were not statistically different than the rainfed treatments. A systematic response to irrigation (i.e., continued increase in grain yield to irrigation) was not observed at any location, which was most likely due to nearly adequate rainfall during the growing season coupled with variability in soil type. Although, irrigation was not supporting statistically greater grain yields, irrigation can enhance grain yield when soil water status is adequately determined. The investigated irrigation treatments this year at all locations started prior to the R3 growth stage which most likely resulted in minor to no increase in grain yield production. The overall results support that monitoring soil water status and targeting the most sensitive growth stages (i.e., post R3 growth stages) should be adopted to maximize the use of irrigation water.

Section 4/Table 4. **Average Soybean Yield and Irrigation Water Use Efficiency for three sites (Orchard, Cordova, and Schuyler) in 2016.**

Treatment	Soybean Yield, bu/ac	Irrigation, inches	Irrigation Water Use Efficiency, bu/ac-inch
125% of Full Irrigation	74.9	7.6	0.4
Full Irrigation	73.0	6.1	0.2
75% of Full Irrigation	76.5	4.7	1.0
50% Early, Full after R5	71.4	4.9	-0.1
Rainfed	72.0	0.0	

Thanks to Nebraska Extension Educators Troy Ingram, Jenny Rees, Aaron Nygren, Amy Timmerman, and Mara Zelt as well as the summer intern for taking weekly readings and managing the irrigation systems.

Testing Phosphorus, Sulfur, and Inoculants on Soybean Growth and Yield

- Authors/Researchers: Brian Krienke (Soils Extension Educator) and Charles Shapiro (Soil Scientist – Crop Nutrition)

TAKE HOME POINTS:

- Soil tests at the phosphorus sites ranged from low to very high with one site having a slight phosphorus response of about 2 bu at the site with a high soil test phosphorus level.
- Average response to phosphorus was less than a bushel.
- Sulfur increased yields at the same site as phosphorus did with an average increase to 20 lbs S of 2.5 bu/ac.
- Average response to sulfur was 1.6 bu/ac.
- Innoculant at the high fertility site, without recent history of soybeans did not increase yields.

INTRODUCTION

The idea of continual improvement in soybean yields is accepted as necessary and probable over time. The challenge for soil nutrient management is to determine what is the cause and what is the effect when it comes to choosing fertilizer rates for high yields. Some say that one can push soybean yields by over fertilizing and others say that yield is mostly determined by genetics and the role of soil nutrient management is to provide an environment around the roots that is non-limiting so the full genetic potential will be expressed. Our research this summer was to test two ideas that we have had about soybean growth and yield in Nebraska.

The main emphasis is on determining when phosphorus fertilization is needed. Our soybean recommendations as articulated in our Nutrient Management for Agronomic Crops in Nebraska EC155 (revised December 2014) http://extensionpublications.unl.edu/assets/pdf/ec155.pdf stops recommending phosphorus for soybeans when the soil test level using the Bray 1P test is greater than 10 ppm and does not recommend sulfur under most circumstances. Given that these recommendations were developed in the 1970s, many people think they may limit yields. Those who think they need revision do so from a theoretical perspective since soybeans remove about 0.80 lbs P_2O_5 per bushel and with a typical soybean yield of 75 bu/ac that makes annual soybean removal about 60 lbs P_2O_5/acre.

Over the past few years the Soybean Management Field Days (SMFD) have included P treatments in their treatment set several times. The most recent was in 2015 when at four locations there was a 40 lbs P_2O_5 treatment and a 40 P_2O_5 plus gypsum and potassium chloride treatment. At the four locations only one site had a significant yield increase and that was a site with a soil test of a 7 ppm Mehlich III (Bray P1 equivalent is 85% of Mehlich III value). The yield increase at this site over the control was an average of 9 bu/acre. The other three sites had soil tests of 42, 82, and 108 ppm Mehlich III (0-8" samples) with yield differences of none, none, and -2 bu/acre. Hardly any evidence that at greater soiltest levels applying added P is beneficial. However, the soils were buildt much greater than the critical level of 10, so this was not a fair test of the idea that maybe the critical level needs to be greater than 10 ppm.

Usually the SMFD sites are not picked with soil fertility interests as priority. We work with the sites we get. In 2016 the four sites had Mehlich III P levels of 23, 89, 31, and 18 (Section 5/Table 1). Since three of the four sites had soil test P levels at typical levels where a producer might consider phosphorus application they were chosen for a phosphorus study.

The one site that was greater than the critical level by a factor of almost 9 (Orchard) was chosen for another study. It happened that at this site soybeans had not been grown for more than 8 years. One concern producers have is whether soybeans need to be inoculated periodically, especially when soybeans are not grown often in the rotation. So at this site (Orchard) a different study was conducted that examined the question of whether inoculant was needed, and if it was not used how much nitrogen would be needed to substitute for the inoculation deficiet.

Methods

In 2016, there were four locations: Chapman, Cordova, Schuyler, and Orchard. Table 46 lists soil fertility and production factors for each site. Three of the locations (Chapman, Cordova, and Schuyler) contained a fertility study that examined the combination of differing phosphorus (P) and sulfur (S) rates. The Orchard site was considered highly fertile, and a response to P or S was considered highly unlikely. The site had not had soybean planted for over 9 years. It was determined that a study that evaluated response to inoculant was more appropriate for Orchard. Orchard, in addition to use of inoculant had differing nitrogen (N) rates. Section 5/Table 2 lists cultural information for each site.

Section 5/Table 1: **Soil analysis results from spring soil samples (0-8") averaged over the fertility study. Information in ppm unless indicated. (Spring, 2016)**

Soil Nutrient and Production Factors	----------------------------------Site----------------------------------			
	Chapman	**Cordova**	**Schuyler**	**Orchard**
Soil pH	7.9	6.1	7.0	6.9
Buffer pH	7.2	6.7	7.2	7.2
Soluble Salts mmho/cm	0.2	0.2	0.48	0.1
Excess Lime	NONE	NONE	NONE	NONE
Organic Matter LOI %	1.2	1.2	2.9	1.2
Lbs./acre Nitrates	9	11	50	15
Phosphorus Mehlich III ppm	23	31	18	89
Potassium ppm	169	324	281	144
Sulfate-S ppm S	11	13	19	11
Zinc ppm	2.18	1.21	1.25	1.86
Iron ppm	12.3	80.6	60.4	31.7
Manganese ppm	2.7	16.2	11.4	1.3
Copper ppm	0.41	0.82	1.16	0.26
Boron ppm	0.34	0.49	0.41	0.27
CEC/Sum of Cations me/100g	10.8	16.8	21.4	6.4
Irrigation nitrate (ppm)	N/A	N/A	N/A	13

N/A = Not available

Section 5/Table 2**: Cultural practices at the 2016 general fertility soybean study.**

Item	Chapman	Cordova	Schuyler	Orchard
Previous crop	Corn			
Tillage	Tilled prior to planting			
Planting date	May 5, 2016	May 6, 2016	May 19, 2016	May 13, 2016
Variety	Pioneer P31T77	NK 30C1	NK 30C1	Pioneer P31T77
Soil Series	Alda sandy loam	Hastings silt loam	Shell silt loam	Shell silt loam
P and S applied with N Offset	Jun 9, 2016	Jun 8, 2016	Jun 8, 2016	-
N applied	-	-	-	May 24, 2016
Plant samples	Aug 30, 2016	Aug 30, 2016	Sep 2, 2016	Not taken
Harvest date	Oct 5, 2016	Oct 9, 2016	Oct 21, 2016	Oct 18, 2016
Seasonal Rainfall (inches)	14.5	18.5	23.5	15.2

Phosphorus x Sulfur Study

The Phosphorus x Sulfur (PxS) study consisted of three rates of P and two rates of S. Treatments were established close to a month after planting. Phosphorus was applied via sidedress knife in the form of ammonium polyphosphate with the analysis of 10% N, 34% P_2O_5. Sulfur was applied via broadcast application in the form of Gypsum or ($CaSO_4$) with the analysis of 17% S. To offset the confounding rates of N used from the P source, the balance of N applied for each treatment as urea ammonium nitrate (28% N) via sidedress knife.

Whole plant sampes were taken at the R5 growth stage at each site. From each experimental unit, plants in 0.5 m of row were counted and cut. Fresh weight was taken, six plants were ground fresh, subsampled and weighed, dried to constant weight in an oven at 60 degrees C. Dry weight was taken. A sub sample was sent to Ward Laboratory, Kearney, NE for elemental analysis. At the same time as the whole plant samples were taken soil samples were taken from treatments 1 and 3.

Grain yields were taken with a plot combine from the center two rows. Grain yields were adjusted to 13% based on the plot combine, on-board moisture tester. Phosphorus and sulfur were determined by Ward Lab for the soybean grain.

Section 5/Table 3: **Treatments listed for Phosphorus x Sulfur fertility study with respective rates of each nutrient listed.**

Trt	P_2O_5 (lbs/ac)	Sulfur (lbs/ac)
1	0	0
2	50	0
3	100	0
4	0	20
5	50	20
6	100	20

Inoculation Study

The inoculation study consisted of with or without inoculant and one of three N rates. Treatments are listed along with the respective N rates in Section 5/Table 4. The inoculant used was N Dure (Verdesian Life Sciences, Cary, NC, USA)**.** It was applied dry with the seed at the label instructed rate of 2.5 oz/50 lb of seed with the seed at planting time. Nitrogen was applied two weeks after planting via broadcast in the form of ammonium nitrate (NH_4NO_3) 34%. The design of this study was a split plot with inoculant as the whole plot, and nitrogen rate randomized within each inoculant strip.

Section 5/Table 4: **Treatments for the inoculation study. Inoculated treatments are coded as Y (Yes), and without inoculation is coded as N (No). Respective rates of N applied to each treatment are also listed.**

Trt	Inoculant (Y/N)	Nitrogen (lbs/ac)
1	Y	0
2	Y	50
3	Y	100
4	N	0
5	N	50
6	N	100

Results

Phosphorus x Sulfur Study

All sites were considered above the critical level for P and S fertility, which means there is a low probability of response to fertilizer application. Section 5/Table 5 contains the treatment means and summary statistics for yield. At the Chapman site, yield was not different no matter the fertility rate or treatment. At Schuyler there were no significant effects across all P rates or S rates, but there was a significant difference between the check treatment (no fertilizer) and treatment 6, which received the highest rate of P and S. At Cordova, there were significant differences in yield across S rates, but not P rates. There was not a significant interaction between (PxS), which means that yield would respond differently to additional inputs of P and S. However, the P value was approaching significance. Several treatments were significantly different with the highest yielding treatment receiving 50 lbs P_2O_5 and 20 lbs of S per acre. The only consistent trend was a higher yield with applied Sulfur. Chapman and Cordova had similar soil fertility values for organic matter and soil test S. Cordova had higher yielding soybean over Chapman, but numerous other growing conditions were different for the Chapman site, including a higher pH and different soybean variety.

Section 5/Table 5: **Effect of Phosphorus x Sulfur on yield (bu/ac). Within each site, means with the same letter are considered not significantly different (alpha=0.05). SMFD study in 2016.**

----------Treatments----------			---------------Site---------------		
Trt	**P_2O_5 (lbs/ac)**	**Sulfur (lbs/ac)**	**Chapman**	**Cordova**	**Schuyler**
1	0	0	58.4a	71.5c	74.1b
2	50	0	63.6a	73.4bc	75.4ab
3	100	0	61.9a	74.9ab	76.7ab
4	0	20	65.9a	75.0ab	75.7ab
5	50	20	62.8a	78.1a	75.8ab
6	100	20	57.6a	74.3bc	79.4a
Avg 0 P	0	All	62.2	73.3	74.9
Avg 50 P	50	All	63.2	75.8	75.6
Avg 100 P	100	All	59.8	74.6	78.1
Avg 0 S	All	0	61.3	73.3	75.4
Avg 20 S	All	20	62.1	75.8	77.0
Summary Statistics					
LSD (all trt)			12.8	3.3	4.7
CV % (all trt)			13.8	2.9	15.9
Prob > F					
Across P Rate			0.72	0.10	0.71
Across S Rate			0.90	0.01	0.58
P Rate x S Rate			0.45	0.07	0.50

The values for total accumulation of aboveground biomass and nutrient uptake in that biomass in the form of P and S are below in Section 5/Table 6, Section 5/Table 7, and Section 5/Table 8 respectfully. There were no significant differences in accumulation of total dry matter within each site (Section 5/Table 6) including the Cordova site, which had significant yield differences. There were significant differences in plant uptake of P and S at the Cordova site only. In general there was an increase in uptake of P across P treatments (Section 5/Table 7). Treatment 4 has the lowest uptake of either P or S, yet it was among the highest yielding treatments. This is unexpected considering the same variety is responding to P and S differently both in terms of yield and uptake.

Sulfur uptake tended to increase as well across P containing treatments, but was not considered significant (Section 5/Table 8).

Section 5/Table 6: **Effect of Phosphorus x Sulfur on above group biomass accumulation (lbs/ac) taken at R5 growth stage. Within each site, means with the same letter are considered not significantly different (alpha=0.05). SMFD study in 2016.**

----------Treatments----------			---------------Site---------------		
Trt	**P_2O_5 (lbs/ac)**	**Sulfur (lbs/ac)**	**Chapman**	**Cordova**	**Schuyler**
1	0	0	10942a	9931a	10011a
2	50	0	10889a	11352a	9320a
3	100	0	8972a	10584a	10900a
4	0	20	10753a	10117a	9576a
5	50	20	9540a	11255a	9939a
6	100	20	10105a	11636a	9631a
Summary Statistics					
LSD (all trt)			2034	1705	2372
CV % (all trt)			13.2	10.5	15.9
Prob > F					
Across P Rate			0.19	0.08	0.71
Across S Rate			0.81	0.42	0.58
P Rate x S Rate			0.22	0.58	0.50

Section 5/Table 7: **Effect of Phosphorus x Sulfur on aboveground P_2O_5 uptake (lbs/ac) taken at R5 growth stage. Within each site, means with the same letter are considered not significantly different (alpha=0.05). SMFD study in 2016.**

----------Treatments----------			---------------Site---------------		
Trt	**P_2O_5 (lbs/ac)**	**Sulfur (lbs/ac)**	**Chapman**	**Cordova**	**Schuyler**
1	0	0	81.8a	85.4ab	60.8a
2	50	0	82.0a	99.5a	60.4a
3	100	0	63.5a	95.8ab	74.8a
4	0	20	76.6a	82.1b	63.2a
5	50	20	72.0a	97.1ab	65.4a
6	100	20	77.2a	98.4ab	69.0a
Summary Statistics					
LSD (all trt)			19.1	16.6	19.9
CV % (all trt)			16.7	11.8	20.1
Prob > F					
Across P Rate			0.37	0.03	0.28
Across S Rate			0.93	0.83	0.92
P Rate x S Rate			0.18	0.85	0.70

Section 5/Table 8: **Effect of Phosphorus x Sulfur on aboveground sulfur uptake (lbs/ac) taken at R5 growth stage. Within each site, means with the same letter are considered not significantly different (alpha=0.05). SMFD study in 2016.**

----------Treatments----------			---------------Site---------------		
Trt	**P_2O_5 (lbs/ac)**	**Sulfur (lbs/ac)**	**Chapman**	**Cordova**	**Schuyler**
1	0	0	27.1a	25.6b	24.3a
2	50	0	26.2a	28.1ab	21.5a
3	100	0	22.2a	26.2ab	25.3a
4	0	20	25.9a	25.0b	24.6a
5	50	20	23.9a	30.3a	24.6a
6	100	20	24.5a	28.5ab	23.8a
Summary Statistics					
LSD (all trt)			5.4	4.7	6.0
CV % (all trt)			14.5	11.4	16.5
Prob > F					
Across P Rate			0.25	0.07	0.70
Across S Rate			0.79	0.32	0.68
P Rate x S Rate			0.45	0.58	0.52

Protein and oil content values are reported in Section 5/Table 9 and Section 5/Table 10 respectfully. For both protein and oil content coefficients of variation (CV) values were never greater than 2.5% (54). Low CV's indicate that treatments had very little variability (more uniform), and only a slight difference would be considered significant. Hence, there are significant differences between treatments, but differences represented to not follow any trend depending on treatment, and are likely inconsequential.

Section 5/Table 9: **Effect of Phosphorus x Sulfur on aboveground protein content (%). Within each site, means with the same letter are considered not significantly different (alpha=0.05). SMFD study in 2016**.

----------Treatments----------			---------------Site---------------		
Trt	**P_2O_5 (lbs/ac)**	**Sulfur (lbs/ac)**	**Chapman**	**Cordova**	**Schuyler**
1	0	0	33.6a	33.3ab	34.5ab
2	50	0	32.5c	34.3a	34.8a
3	100	0	32.9bc	32.8b	34.9a
4	0	20	32.4c	33.1ab	33.7b
5	50	20	32.9bc	33.1b	33.6b
6	100	20	33.3ab	32.6b	34.8a
Summary Statistics					
LSD (all trt)			0.65	1.2	3.8
CV % (all trt)			1.3	2.5	1.6
Prob > F					
Across P Rate			0.14	0.08	0.03
Across S Rate			0.48	0.10	0.02
P Rate x S Rate			0.003	0.40	0.23

Section 5/Table 10: **Effect of Phosphorus x Sulfur on aboveground oil content (%). Within each site, means with the same letter are considered not significantly different (alpha=0.05). SMFD study in 2016.**

----------Treatments----------			---------------Site---------------		
Trt	**P_2O_5 (lbs/ac)**	**Sulfur (lbs/ac)**	**Chapman**	**Cordova**	**Schuyler**
1	0	0	19.8b	19.2a	18.9a
2	50	0	20.0ab	19.3a	18.9a
3	100	0	20.1a	19.3a	19.0a
4	0	20	20.1a	19.3a	18.8a
5	50	20	20.0a	19.3a	18.9a
6	100	20	19.8b	19.3a	19.0a
Summary Statistics					
LSD (all trt)			0.2	0.3	0.2
CV % (all trt)			0.6	0.9	0.8
Prob > F					
Across P Rate			0.60	0.55	0.30
Across S Rate			0.87	0.58	0.40
P Rate x S Rate			0.0007	0.99	0.75

Inoculant Study

Yield for the inoculation study is shown below in Section 5/Table 11. Counterintuitively, yield was significantly higher for all treatments that did were not inoculated regardless of N rate applied. Increasing N rate tended to decrease yield regardless of inoculation treatment.

Section 5/Table 11: **Effect of N rate with and without inoculant on yield (bu/ac). Within each site, means with the same letter are considered not significantly different (alpha=0.05). SMFD study in 2016.**

----------Treatments----------			--Site--
Trt	**Inoculant (Y/N)**	**Nitrogen (lbs/ac)**	**Orchard**
1	Y	0	74.4bc
2	Y	50	73.4cd
3	Y	100	69.3d
4	N	0	78.4ab
5	N	50	79.6a
6	N	100	76.1abc
Summary Statistics			
LSD (all trt)			4.5
CV % (all trt)			3.4
Prob > F			
Inoculant			0.05
N Rate			0.02
Inoculant x N Rate			0.54

Protein and oil content are reported in Section 5/Table 12 and Section 5/Table 13 respectfully. There were no significant differences in either measure, and similarly to the PxS study, there was very little variation noted by a low CV and LSD.

Section 5/Table 12: **Effect of N rate with and without inoculant on protein content (%). Within each site, means with the same letter are considered not significantly different (alpha=0.05). SMFD study in 2016.**

----------Treatments----------			--Site--
Trt	**Inoculant (Y/N)**	**Nitrogen (lbs/ac)**	**Orchard**
1	Y	0	34.2a
2	Y	50	34.1a
3	Y	100	34.2a
4	N	0	33.9a
5	N	50	34.3a
6	N	100	34.0a
	Summary Statistics		
	LSD (all trt)		0.6
	CV % (all trt)		1.2
	Prob > F		
	Inoculant		0.71
	N Rate		0.83
	Inoculant x N Rate		0.32

Section 5/Table 13: **Effect of N rate with and without inoculant on oil content (%). Within each site, means with the same letter are considered not significantly different (alpha=0.05). SMFD study in 2016.**

----------Treatments----------			--Site--
Trt	**Inoculant (Y/N)**	**Nitrogen (lbs/ac)**	**Orchard**
1	Y	0	18.9a
2	Y	50	18.9a
3	Y	100	18.9a
4	N	0	18.9a
5	N	50	18.9a
6	N	100	19.0a
	Summary Statistics		
	LSD (all trt)		0.2
	CV % (all trt)		0.9
	Prob > F		
	Inoculant		0.55
	N Rate		0.83
	Inoculant x N Rate		0.94

Discussion

Based on initial soil tests significant, economic response to either phosphorus or sulfur were not expected. As in most field trials, we found variation in the response to phosphorus and sulfur, but no consistent yield increases that were economic. Using price and cost estimates that are current in the fall of 2016, soybeans valued at $6/bu and a lb of phosphorus at $ 0.45, the 50 and 100 lb P treatments, without application costs would be $22.50 and $45/acre, respectively. At $6 soybeans, breakeven yield increases would need to be 3.8 and 7.5 bu/acre, for the 50 and 100 lb P_2O_5 rates, respectively. Section 5/Table 6 shows the yields and when summarized over locations the average yield increase for 50 and 100 lbs P_2O_5 application was 1.4 and 0.7 bu/ac, respectively. With sulfur, only the Cordova site, similar to phosphorus had significant yield increase due to sulfur, of 2.5 bu/acre. Overall, sulfur had 1.6 bu/ac greater yields than no sulfur. Interestingly, adding 20 lbs of sulfur consistently increased yields over the control.

Greater response at Schuyler was expected since it had the lowest soil test phosphorus level (18 ppm Mehlich III) in the spring soil sampling. When sampled in August at the time of whole plant sampling the P levels were even lower averaging 8 ppm. The response to P was not significant, but was the only site that had a consistent 'rate' affect with 75, 76, and 78 bu/ac soybean yield for the 0, 50 and 100 lbs P_2O_5/acre rates, respectively. Also at Schuyler, the 100 lb phosphorus and 30 lb sulfur treatment was the greatest yielding (79 bu/ac) and significantly more than the check (74 bu/ac). This was still not an economic treatment.

Inoculant and nitrogen use actually decreased yields at Orchard. We don't have an explanation that we can back up with data. One idea maybe that since the site was very fertile with high levels of other nutrients and a manure history that the plant did not need the symbioltic nitrogen from the nodules. The energy the plant may have used to create nodules could have been better used in soybean production. We did dig up plants and examine the roots at the SMFD in early August, but took no quantitative measures to determine if they were functioning. We did not take whole plant sample data either, so we can not explain this phenomenon. We did review all our protocols to make sure there were no coding or other method errors. Since it is only one site in one year, we can only speculate on why this occurred.

We should point out that the phosphorus and sulfur study was knife-applied after planting when the soybeans were at the V3-V4 stage. This is not the normal practice, hence the late application in mid row might have influenced yields.

Conclusion

The results in this year's SMFD fertility research are consistent with previous work with phosphorus, sulfur, and inoculation. We do find small increases with applied nutrients, but they sometimes are not significant, and rarely economical. While significant yield increases were not found, maintenance phosphorus application is probably justified when soil tests are in the Mehlich III 20 ppm range. If soybean prices increase and fertilizer decreases, some of these relationships might become economic. Our recommendation that inoculant be used on new soybean ground, and when there is evidence of nitrogen problems is consistent with this year's study.

Soybean Management Field Days

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Soybean Management Field Days

RESEARCH UPDATE

Cumulative Rainfall Totals