IRRIGATED SOYBEANS IN WESTERN NEBRASKA

- Planting dates
- Row spacing
- Seeding rates
- Fertility programs

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RESEARCH REPORT

EXTENSION REPORT

How Row Spacng Affects Irrigated Soybean in Southwest Nebraska

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Keith Glewen - Extension Educator

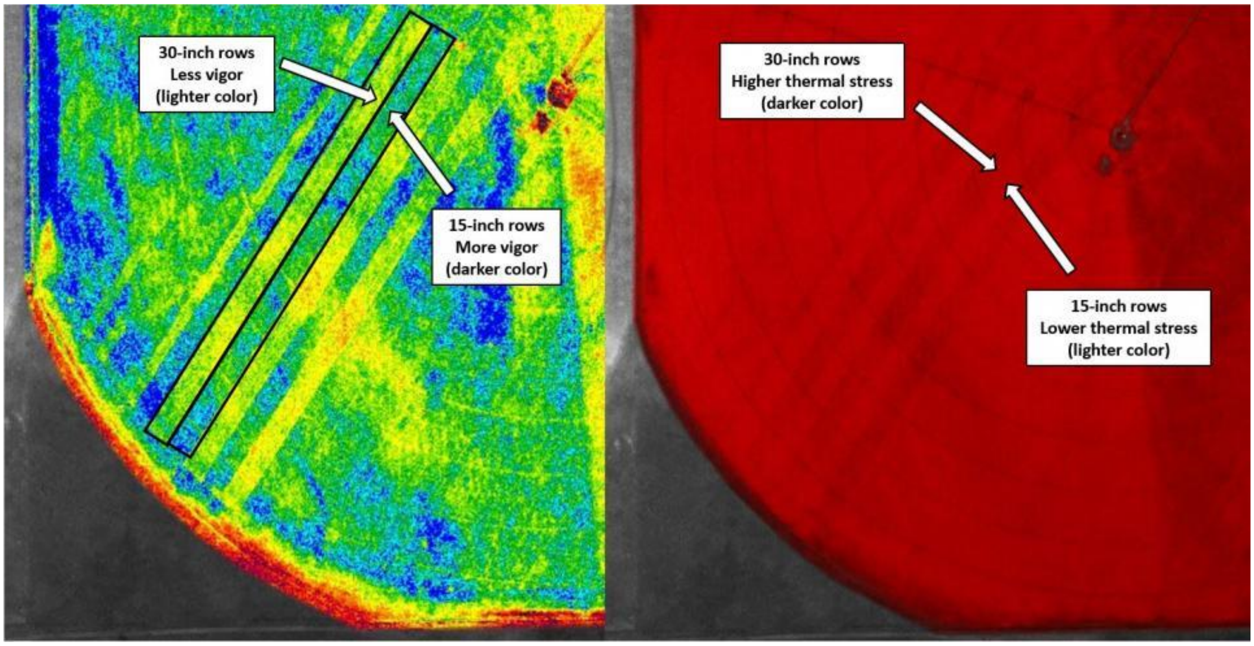

Figure 1. TerrAvion aerial imagery taken on Aug 4, 2017 at Chase County site showing less vigor and higher thermal stress in 30-inch row soybeans than in 15-inch row soybeans.

Continuous corn has been the most common and in many cases the most profitable irrigated crop sequence in southwest Nebraska. However, difficulties in managing resistant pests (Western corn rootworm, western bean cutworm) and bacterial disease outbreaks (Goss's wilt, Bacterial leaf streak) have triggered the need for adding other crops, such as soybean, to irrigated crop rotations in southwest Nebraska.

Larger adoption of soybean, however, has not readily occurred in this area. For example, planted soybean acres in southwest Nebraska were 153,000 acres and 151,500 acres and average soybean yield was 55.8 bu/ac and 61.5 bu/ac for 2010 and 2017, respectively (USDA National agricultural statistics service).

On-Farm Research Study: 15-inch Versus 30-inch Rows

Soybean row spacing research in eastern and central Nebraska often has shown a potential to increase soybean yield with narrower rows (15-inch or drilled). In addition, many farmers from western Nebraska have reported superior soybean yield with 15-inch rows due to the faster rate of canopy closure, better weed suppression, and reduced evaporative loss early in the season (*Figure 1*); but limited data is available on what those yield differences may be.

In 2017, the Nebraska Soybean board funded an on-farm research initiative to quantify the yield differences between irrigated soybeans planted in 15-inch versus 30-inch rows in southwest Nebraska. We conducted three replicated on-farm studies comparing soybean yields in 15-inch vs 30-inch rows. Field experiments were carried out at one location in 2015 and two locations in 2017. Site descriptions, agronomic information, and data on percent grain moisture at harvest, yield (bu/ac), and marginal net return in dollars/acre ($/ac) for these studies is summarized in *Table 1* (below).

For more information about soybean row spacing view the on-farm research results (PDF publication) or search the results database. If you're interested in evaluating the impact of soybean row spacing on your farm in southwest Nebraska, contact Strahinja Stepanovic at 308-352-4340 or email sstepanovic2@unl.edu.

Also check the latest UNL recommendations on soybean planting dates and seeding rates.

Results

When averaged across site-years, soybean planted in 15-inch rows yielded 67 bu/ac which was 7 bu/ac more than soybeans planted in 30-inch rows (60 bu/ac). Yield differences ranged from 4 bu/ac in Chase County (2015, 2017) to 12 bu/ac in Perkins County (2017). Soybeans planted in 15-inch rows also had lower grain moisture at harvest (up to 0.9% less) and significantly greater marginal net return ($25-$128 per ac) than soybeans planted in 30-inch rows.

Aerial imagery at the Chase County site in 2017 showed less vigor and higher thermal stress in 30-inch row soybeans during the early reproductive growth. The on-farm research cooperator at the site also observed better suppression of volunteer corn with 15-inch rows.

Recommendations

- Planting irrigated soybeans in 15-inch rather than 30-inch rows definitely showed a potential for southwest Nebraska farmers to increase soybean yield and profit.
- Aerial imagery showed less thermal stress in 15-inch row spacing soybeans, which suggests that in cases where water may be limiting, such as in sandy soil with low water holding capacity and higher evaporative losses, there may be an even greater benefit to 15-inch row spacing. More research is needed to evaluate soybean yield response to narrower rows in heavier soils compared to sandier soils.

Notes

- Although we have not observed differences in disease pressure in our studies, it has been reported that planting soybean in 15-inch rows may increase the occurrence of white mold disease.
- Finally, switching from 30-inch to 15-inch rows would require either double planting or buying a 15-inch row planter.

Acknowledgements

Thank you to the Nebraska Soybean Board for funding row spacing and late season N-management research in southwest Nebraska. Also, thank you to our collaborators Leon Regier of Perkins County and Tim Varilek from Chase County for their time and effort to conduct row spacing studies in soybean and generate research-based information that could benefit many farmers in southwest Nebraska.

Table 1. Site description, agronomic information and data on grain moisture at harvest (%), yield (bu/ac) and marginal net return ($/ac) for irrigated soybeans grown in 15-inch and 30-inch row spacings at three site-years in SW NE.

	Research site (year)					
Site description	**Perkins County (2017)**		**Chase County (2017)**		**Chase County (2015)**	
Soil type	Valent Loamy sand		Valent loamy sand		Valent loamy sand	
Planting date	May 25		May 17		May 26	
Harvest date	Oct 28		Oct 14		Oct 12	
Previous crop	corn		corn		corn	
Rainfall (inches)	12		15		11	
Irrigation (inches)	13		13		13	
Agronomic information						
Tillage	no-till		conventional		no-till	
Variety	Curry® 1264		Asgrow® 2733		Asgrow® 2733	
Maturity	2.6		2.6		2.6	
Population (plants/ac)	120,000		145,000		160,000	
Study results						
Row spacing	**15-inch**	**30-inch**	**15-inch**	**30-inch**	**15-inch**	**30-inch**
Moisture at harvest (%)	12.6 B*	13.5 A	10.4 A	10.3 B	10.1 A	10.7 B
Yield (bu/acre)†	61 A	49 B	62 A	58 B	78 A	74 B
Marginal Net Return‡ ($/ac)	553 A	425 B	545 A	520 B	694 A	659 B

*Values with the same letter are not significantly different at a 90% confidence level.

†Bushels per acre corrected to 13% moisture.

‡Marginal net return based on $8.90/bu soybean.

Is Late Season N Fertilization Warranted for Irrigated Soybean in SW Nebraska?

Strahinja Stepanovic, Nemanja Arsenijevic, Zaim Ugljic

Soybeans absorb 60% of nitrogen (N) after R3 (beginning of pod setting). Is N supply from soil N and biological fixation sufficient to meet this demand, or should this be interpreted as period in growth when soybeans need supplemental N to reach its full yield potential? As many soybean farmers are undecided as to whether they should adopt or abandon this practice, we tried to find answers by conducting three on-farm research studies in three SW NE counties Perkins, Chase and Lincoln County.

The article, "Is Soybean Yield Limited by Nitrogen Supply," reports on field experiments in eastern Nebraska and Argentina. The authors' findings indicate soybean yield was limited by N supply, especially in high-yield environments, and that N supplementation slightly increased yield and seed protein content. An article from retired University of Nebraska-Lincoln Soil Scientist Charles Shapiro titled "Nitrogen on Soybeans – the Hope Never Dies" searches for the answer to the lack of response by soybeans to N in cases when N balance (supply vs. demand) clearly suggests that supplementation is needed.

On-Farm Research Trials in Southwest Nebraska

Three on-farm studies were conducted in Perkins, Lincoln and Chase counties in 2017 (*Table 1*) to evaluate the effects of applying late season (R3) nitrogen fertilizer to soybeans. The plot layout consisted of alternating pie-shaped sections over an entire pivot, some of which received N through the pivot and some of which were left as untreated checks (*Figure 1*). A foliar application of 65-85 lb/acre of N was made through an irrigation application at the R3 (beginning pod) growth stage.

Surface (0-8 inch depth) and sub-surface (8-24 inch depth) soil samples were collected in each pie at three times: prior to planting, at the R2 growth stage, and after harvest. This was to identify changes in both NO_3-N and NH_4-N soil concentrations throughout the growing season (*Figure 2*). Visual nodulation inspection was conducted at V7 growth stage (*Figure 3*) and plant tissue samples were taken at the R2 and R5-R6 growth stages to monitor nutrient content within the plants (*Figures 4 and 5*). Plant residue was analyzed for residual N content (*Table 1*). In addition to yield, grain samples were analyzed for protein and oil content (*Table 1*).

Main Findings

- Soybean plants at Perkins County and Lincoln County had many active nodules well spread on the roots. Nodulation at Chase County was very poor, possibly due to excessive mineral N in the top 24 inches of soil (*Figure 3*). The amount of soil N available at planting (62-106 lbs/ac) had decreased by more than 50 % when measured at the R2 growth stage (30-40 lbs/ac), suggesting that the plant was taking up soil N as it entered the reproductive stages.
- Nutrient concentrations of both micro- and macronutrients in plant tissue did not differ between the N treatments (*Figures 4-6*). The nutrient levels in plant tissue at all three sites were within the sufficiency range for all macronutrients and micronutrients, except for magnesium (Mg). A positive correlation was found between N supplementation and manganese (Mn) uptake and metabolism.
- Supplementing N to soybeans at R3 did not increase yield, grain protein, oil content, or marginal net return at any of the three locations. A slight yield increase of 2.6 bu/ac was observed at Perkins County, but due to large field variability this increase cannot be attributed to additional N fertilizer. The post-harvest soil N was similar in both N treatments. The only notable difference in end-of-season N balance was N content in plant residue, which was 5, 8, and 14 lbs of N/ac higher in the N treatments at Chase County, Lincoln County, and Perkins County, respectively.

Take-Home Message

- Late season (R3) N fertilization did not increase yield or profit of soybeans grown at three on-farm trials in southwest Nebraska in 2017. Supplementing N to soybeans is more likely to be beneficial in higher yielding environments, perhaps higher than yields achieved in these studies (up to 77 bu/ac).
- More research is needed to fine-tune soybean fertility management and based on our findings, we suggest those areas include:
    - spoon-feeding lighter rates of N to soybean during the reproductive stages (rather than applying one large amount at one time)
    - applying lower rates of N later in the season (R5-R6 growth stages)
    - using manure or compost as a form of slow release N
    - consideration of foliar micro- and macronutrients
    - using fertilizers containing nutrients other than N (e.g., magnesium, sulfur, molybdenum, boron, etc.)

We highly encourage farmers in western Nebraska to test fertilizer practices in their own fields, and more importantly, to consider implementing other practices that are critical in increasing soybean yield potential. These practices include ensuring an adequate water supply and early planting.

For more information on practices recommended for high-yield soybean production, see the Nebraska Extension publication, What Does it Take to Produce 80+ bu/ac Soybean? (EC3000).

Acknowledgment

We would like to thank Nebraska Soybean Board for funding this research project and continuing to support research on soybeans in western Nebraska. We also thank Conrad Nelson of Wallace, Stacy Friesen of Grant, and Dan Reeves of Imperial for collaborating on this research project.

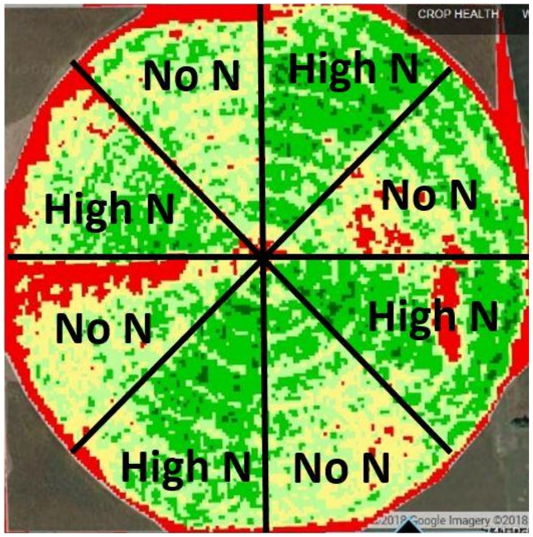

Figure 1. Satellite imagery taken on Aug 23, 2017 at Chase County site showing differences between pie-shaped pivot areas with and without application of 65 lbs of N/ac.

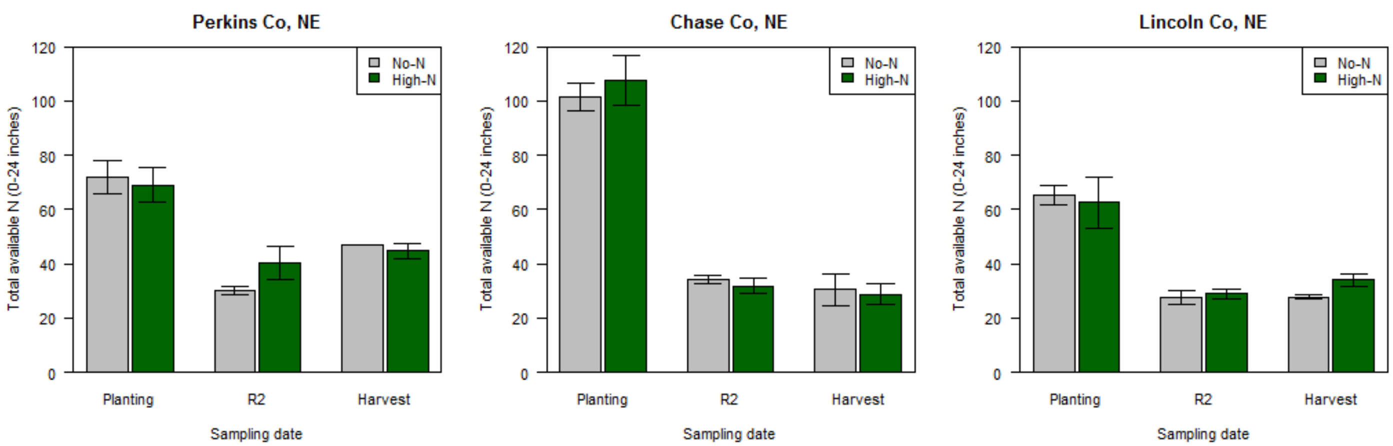

Figure 2. Soil available N (NO_3 + NH_4) from 0-24 inches for two nitrogen treatments (High-N vs No-N) sampled at planting, R2 (prior to N chemigation), and after harvest at on-farm research studies in Perkins, Lincoln, and Chase counties during the 2017 growing season.

Figure 3. Visual soybean nodulation inspection at V7 growth stage in 2017 on-farm research studies in (from left) Perkins County (excellent), Lincoln County (excellent), and Chase County (poor).

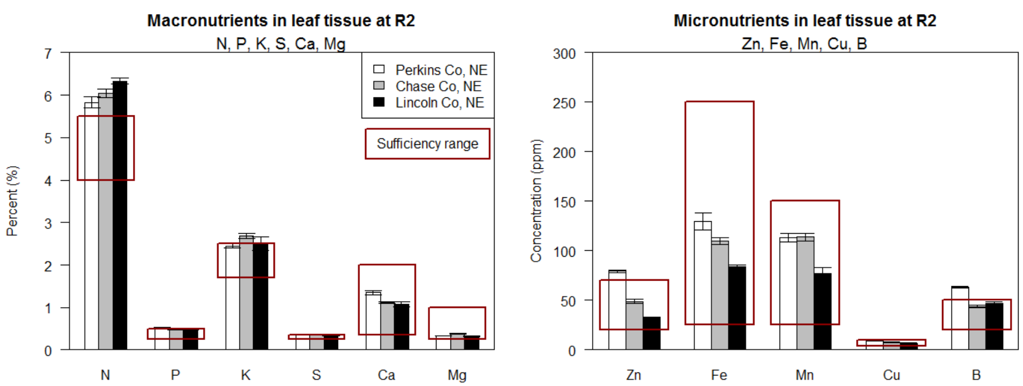

Figure 4. Leaf tissue sample analyses were conducted at R2 stage soybean (prior to chemigation) for macronutrients (N, P, K, S, Ca, Mg) and micronutrients (Zn, Fe, Mn, Cu, B) at on-farm research trials in Perkins, Lincoln, and Chase counties. Red squares represent sufficiency range for nutrients.

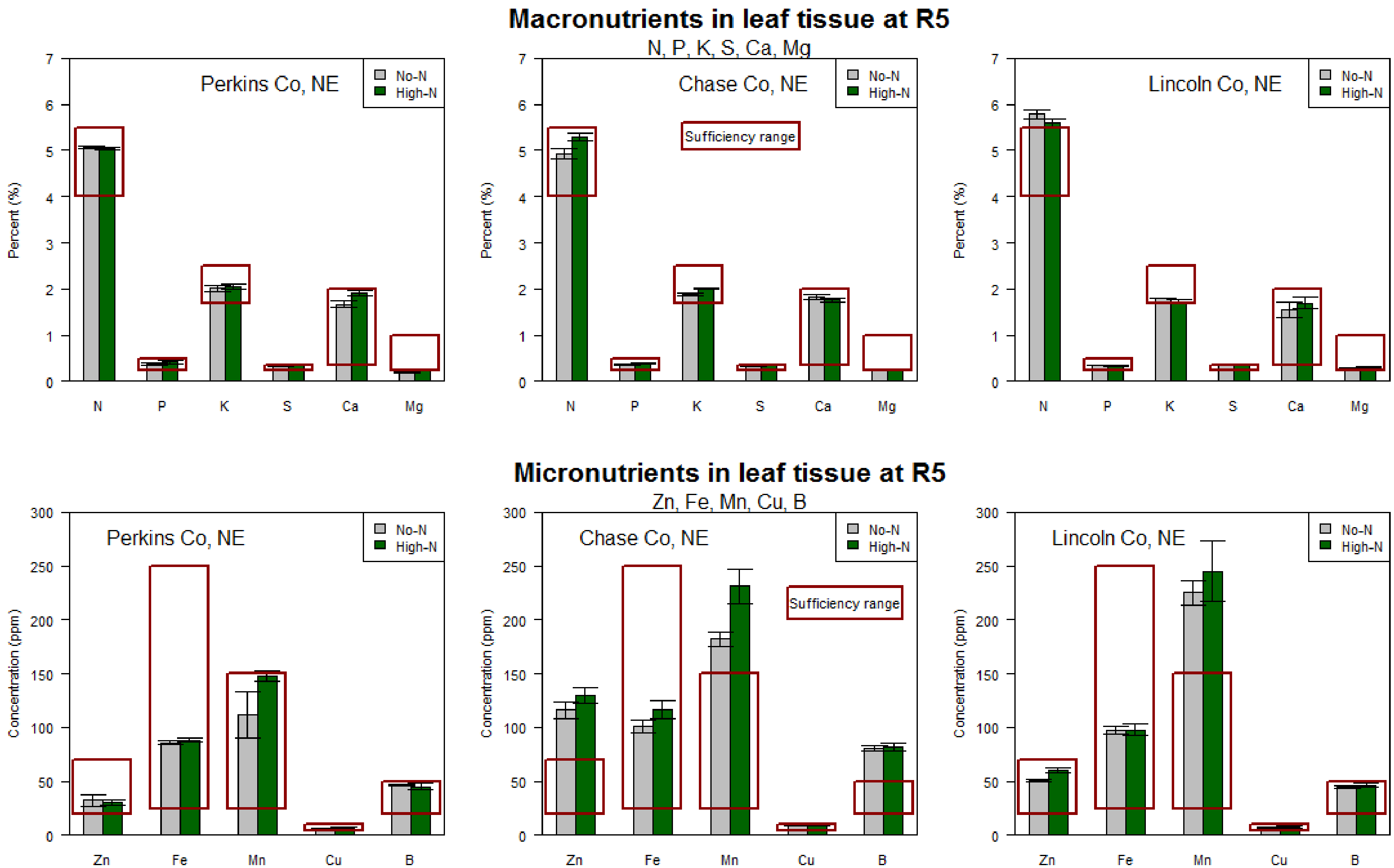

Figure 5. Leaf tissue sample analysis at R5 soybeans (2-3 weeks after chemigation) for macronutrients (Zn, Fe, Mn, Cu, B) and micronutrients (Zn, Fe, Mn, Cu, and B) in Perkins, Lincoln, and Chase counties. Red squares represent sufficiency range for nutrients.

Table 1. Site description, agronomic information and data on grain yield (bu/ac), oil content (%), protein content (%), soil N after harvest, N in the plant residue (lbs/ac), and marginal net return ($/ac) for irrigated soybeans at three western Nebraska sites in 2017.

Site description	**Perkins County - 2017**		**Lincoln County - 2017**		**Chase County - 2017**	
Soil organic material	Keith silt loam		Holdrege fine sandy loam		Valent loamy sand	
Previous crop	corn		corn		corn	
Planting date	May 15		May 25		May 15	
Harvest date	Oct 20		Oct 15		Oct 16	
Rainfall (inches)	12		15		11.5	
Irrigation (inches)	10.5		13.5		11	
Hail	minor injury		no hail		40% damage on 10/01/18	
Agronomic information						
Tillage	Vertical till		No-till		Vertical till	
Row spacing	10-inch		15-inch		10-inch	
Variety	Pioneer 22T41		Chanel 2402		NK S30C1	
Maturity group	2.6		2.4		2.6	
Final stand (plants/ac)	161,000		72,000		168,000	
Nodulation	excellent		excellent		poor	
Nitrogen applied (32-0-0) @ R3	70 lbs N/ac		85 lbs N/ac		65 lbs N/ac	
Study results						
Treatment (N applied at R3)	**High N**	**No N**	**High N**	**No N**	**High N**	**No N**
Yield (bu/acre)†	77.0	74.4	73.0	72.7	65.1	64.4
Oil content (%)	34.5	34.4	36.0	35.9	34.5	34.4
Protein content (%)	20.4	19.9	20.2	19.7	21.7	18.6
Soil N after harvest @ 0-24 in (lbs N/ac)	44.7	47.0	34.0	27.8	28.8	30.5
N in the plant residue (lbs of N/ac)	47.0	39.0	34.0	28.8	52.3	38.0
Marginal net return‡ ($/ac)	656.00	646.00	614.00	646.00	573.00	552.00

*Values with the same letter are not significantly different at a 90% confidence level.

†Bushels per acre corrected to 13% moisture.

‡Marginal net return based on $8.90/bu soybean.

Seeding Practices and Nitrogen Management for Western Nebraska Soybean: What Matters and Why

Strahinja Stepanovic, Justin Richardson, Jovan Radojicic, Ognjen Zivkovic, Milica Bogdanovic

Continuous corn is the most common irrigated crop sequence in southwest Nebraska. Although rotating to other crops, such as soybeans, can mitigate some production issues of continuous corn and often boost the next year's corn yield, larger adoption of soybeans has not readily occurred in this area. According to USDA Farm Service Agency planted acreage data, on average southwest Nebraska farmers plant irrigated soybeans every fifth year.

The culture of farming in southwest Nebraska revolves around corn, which often prevents growers from raising soybeans under more ideal conditions. For example, priority is often given to planting corn first, soybeans fields are often strip-tilled, planted in 30-inch rows, and seeding rates of >160,000 seeds/ac are very common. In addition, late season chemigation with nitrogen (N) is a widespread practice without the full understanding of when and where it's warranted (Stepanovic et al., 2018a).

The objective of this study was to investigate the impact of planting date, row spacing, seeding rates, and N management on yield and yield components of irrigated soybean in southwest Nebraska. *Cover photo: Irrigated soybean in Perkins County, NE (2019).*

Description of the Two Research Sites

The study was conducted at three site-years in Perkins County, Nebraska including Kemling-2018, Stumpf-2018 and Stumpf-2019. The predominant soil type at the Kemling-2018 was Rosebud loam, while the predominant soil type at Stumpf-2018 and Stumpf-2019 was Kuma silt loam. The experimental area at Kemling-2018 was disked to incorporate compost and was planted to AG28X7 variety of soybean (MG 2.8). The experimental area at Stumpf-2018 was planted no-till to AG24X7 soybean variety (MG 2.4), while disk was used to incorporate compost and prepare the site for planting GH2499X soybean variety (MG 2.4) at Stumpf-2019. Aside from the study treatments, soybeans were grown following UNL agronomic and irrigation recommendations.

Weather Conditions in 2018 and 2019

Weather conditions in both 2018 and 2019 were characterized by cool wet springs, with significant crusting issues and hail injury (20%) in late August observed at Stumpf-2018. Direct seeding (no-till) of soybeans at the Stumpf-2018 caused issues with sidewall compaction, soil crusting, and early season growth and development. The disked soil at the Kemling-2018 amd Stumpf-2019 dried out quicker, creating better seeding conditions, less sidewall compaction, and consequently fewer issues with crusting, germination, and early season plant growth (Jasa, 2010). The seasonal temperatures were below the 30-year average in both years, while seasonal precipitation was 7 and 1 inch higher than 30-year average in 2018 and 2019, respectively (*Figure 1*). Total of 13 inches of irrigation water was supplemented throughout the growing season in both 2018 and 2019.

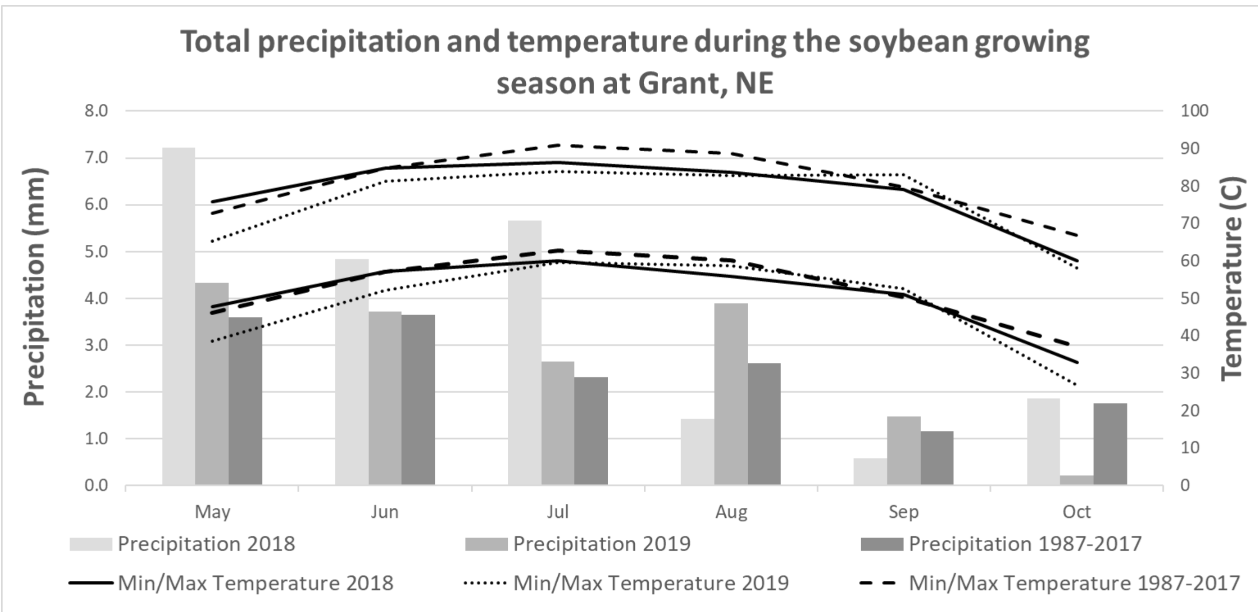

Figure 1. Weather conditions including total monthly precipitation and maximum and minimum temperatures during the 2018 and 2019 soybean growing season near Grant, NE.

Data We Collected

The study evaluated four soybean management practices, each at two different levels, for a total of 16 treatments:

- Planting dates (early May vs early June)
- Row spacing (15 inch vs 30 inch rows; 7.5 inch rows treatment added at Stumpf-2019)
- Seeding rates (90,000 vs 140,000 live seeds/ac)
- N management – two fertility regimes (low and high):
    - Stumpf-2018 – control vs chemigation 50 lbs of N/ac @ R5 (beginning seed)
    - Kemling-2018/Stumpf-2019 – control vs pre-plant compost @ 5 tons/ac

Each treatment was replicated four times and each replication was divided into blocks by fertility regime. Seeding practices (planting date, row spacing, and seeding rates) were randomized within each fertility block. The study treatments were planted into strips 40 ft by 180 ft. The middle 30 ft of each strip was harvested for yield using a John Deere 9650 STS combine.

In addition, at-harvest plant population (plants/ac) was counted in each strip and ten-plant subsamples were taken to evaluate yield components, including nodes/plant, branches/plant, pods/plant, seeds/pod, and seed weight.

Soybean Yield and Yield Quality

Generally, soybeans had the best yield at the early planting date (early May) and in narrower row spacing (e.g. 15 inches), while soybean yield was not significantly increased with higher seeding rates (*Figure 3*).

At the Kemling-2018, early planted soybeans benefited from pre-plant application of compost at 5 ton/ac (107 bu/ac), especially at low populations (*Figure 2 and 3*). At the Stumpf-2018, chemigating 50 lbs of N/ac at R5 (beginning seed) did not result in a yield increase (*Figure 2 and 3*). Small yield increase of 2 bu/ac was observed at Stumpf-2019 following a compost application at both early and late planting dates (*Figure 2 and 3*).

Grain protein at Kemling-2018, Stumpf-2018 and Stumf-2019 was 32, 33, and 37, respectively (*Table 1*) suggesting strong interaction between the environment and genetics (variety) planted at specific site. Slight increase in grain protein (1.4%) was observed with late planting at Stumpf-2018 (*Table 1*). Grain oil averaged 20% over three site-years (*Table 1*).

Early planted soybeans had slightly higher post-harvest N in the soil (23 lbs N/ac) and plant residue (12 lbs N/ac) than later planted soybeans. For more information on soybean response to different fertility programs click here (Stepanovic et al. 2020b).

Table 1. Impact of planting date and fertility regimes on soybean yield, grain protein (%), grain oil (%), post-harvest soil N (NO_3-N + NH_4-N) in top 24 inches (lbs N/ac), and post-harvest N in plant residue (lbs of N/ac) in field experiments conducted at the Kemling and Stumpf Farm during 2018 and 2019 growing season near Grant, NE.

Site-Year (variety)	Planting date	Fertility regimes	Yield (bu/ac)	Grain protein (%)	Grain oil (%)	Soil N (lbs N/ac)	N in residue (lbs N/ac)
Kemling-2018 (AG28X7)	May 1	no-compost	81 b	32 a	21 a	84 a	49 a
	May 1	compost @ 5 ton/ac	90 a	31 a	21 a	76 a	44 ab
	Jun 5	no-compost	38 c	31 a	20 a	63 a	42 ab
	Jun 5	compost @ 5 ton/ac	35 c	31 a	20 a	51 b	30 b
Stumpf-2018 (AG24X7)	May 1	no chemigation	61 a	33 ab	19 a	77 b	45 a
	May 1	50 lbs N/ac @ R5	56 b	32 b	19 a	95 a	55 a
	Jun 5	no chemigation	36 c	34 a	19 a	57 c	34 a
	Jun 5	50 lbs N/ac @ R5	36 c	34 a	19 a	62 c	43 a
Stumpf-2019 (GH2499X)	May 3	no-compost	66 ab	34 a	21 a	49 a	47 a
	May 3	compost @ 5 ton/ac	68 a	36 a	21 a	51 a	46 a
	Jun 3	no-compost	62 c	36 a	21 a	29 b	33 a
	Jun 3	compost @ 5 ton/ac	64 bc	37 a	21 a	29 b	32 a

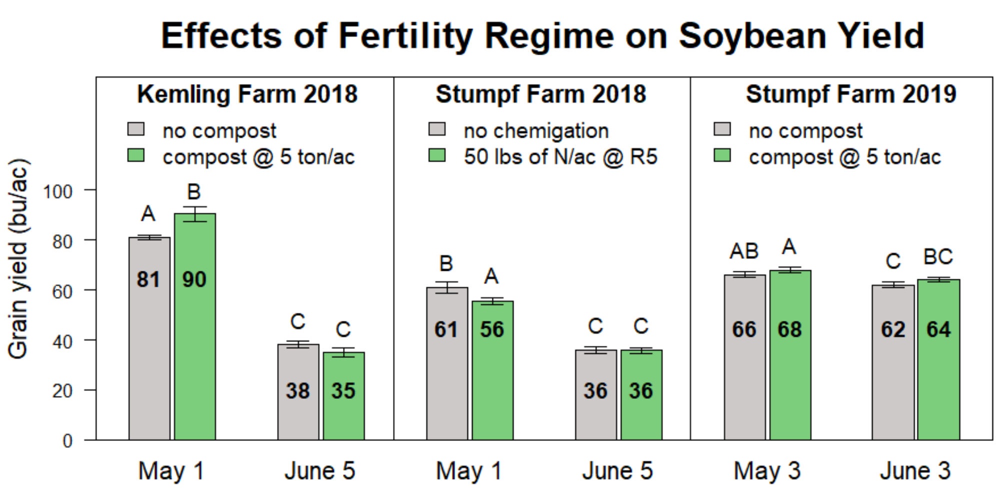

Figure 2. The impact of fertility regimes on soybean yield (bu/ac) in field experiments conducted at the Kemling Farm and Stumpf Farm during the 2018 and 2019 soybean growing seasons near Grant, NE.

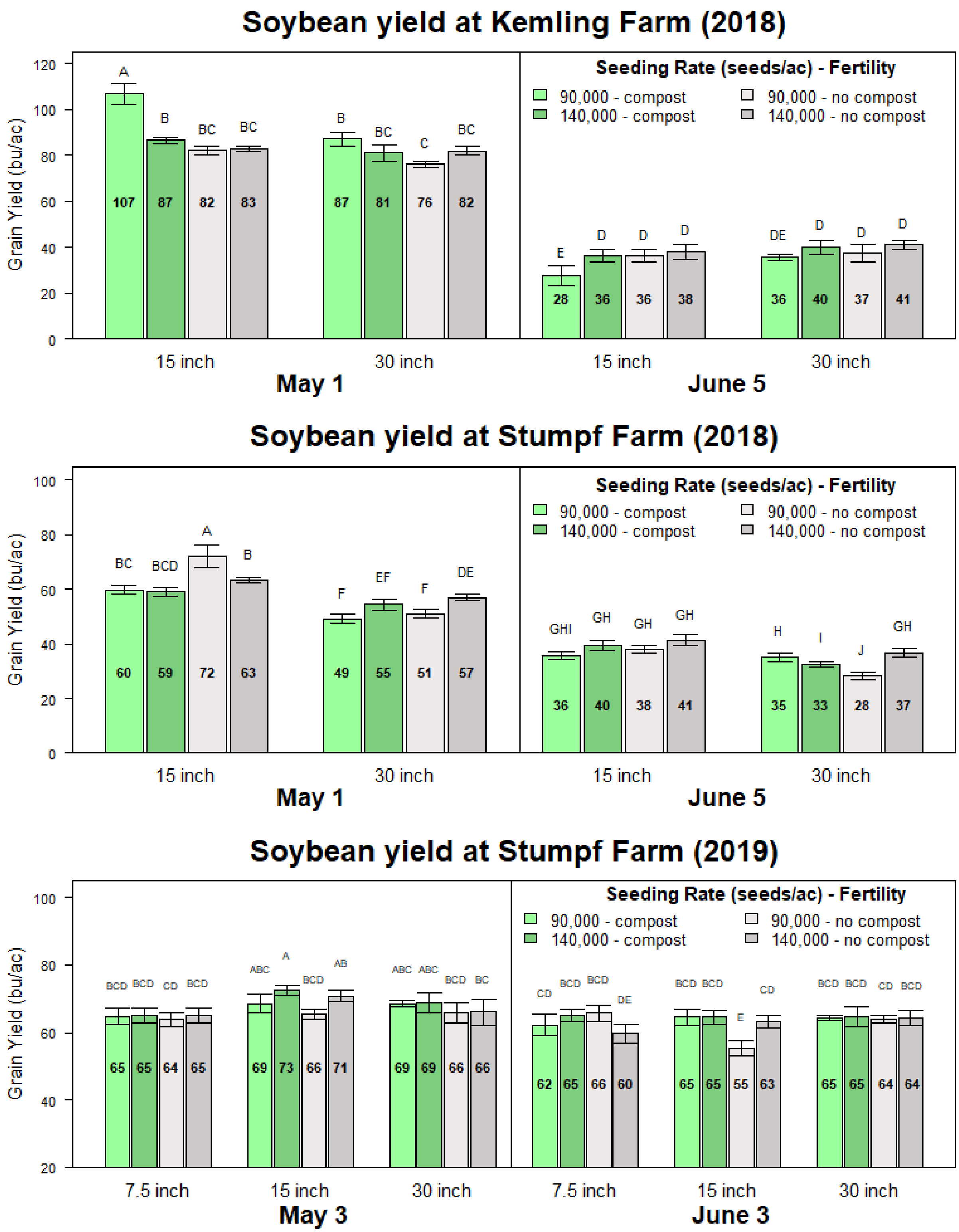

Figure 3. Impact of planting date (early May vs early June), row spacing (7.5 inch, 15 inch, 30 inch), seeding rates (90,000 vs 140,000 live seeds/ac) and fertility regimes (low and high) in field experiments conducted at the Kemling Farm and Stumpf Farm during the 2018 and 2019 soybean growing season near Grant, NE.

What are Soybean Yield Components and Why do They Matter?

Grain yield is comprised of several components that, when analyzed separately, can allow us to better understand their individual contribution to overall grain yield. Despite differences in grain yield, the relationship between grain yield and yield components was similar at the three site-years. *Table 2* summarizes correlation coefficients across three site-years. The sign of correlation coefficient (r) indicates the nature of the relationship (either positive or negative) while the magnitude of coefficient (ranging from 0 to 1) represents the strength of the linear relationship.

Generally, correlation between grain yield and plants/ac and seeds/pod was not significant, except at Stumpf-2018 where issues with crusting caused up to 60% reduction in stand (*Table 2*). These results suggest that: (1) changes in plant population observed in the study had no impact on grain yield, and (2) differences observed in grain yield were not affected by the number of seeds/pod.

Depending on the interaction between site-year and genetic (variety used in the study), significant positive correlation was observed between grain yield and nodes/plant, branches/plant and pods/plant suggesting that the best seeding and N management practices are those that facilitate node, branch, and pod development.

Table 2. Correlation (r) between soybean grain yield, planting date, plants/ac (at harvest), branches/plant, nodes/plant, pods/plant, seeds/pod, seed weight (1000 seeds) in field experiments conducted at the Kemling Farm and Stumpf Farm during 2018 and 2019 soybean growing season at Grant, NE.

Kemling-2018	**Grain yield (bu/ac)**	**Planting date**	**Plants/ acre**	**Nodes/ plant**	**Branches/ plant**	**Pods/ plant**	**Seeds/ pod**
Planting date	-0.95*						
Plants/acre	0.03	0.03					
Nodes/plant	0.71*	-0.73*	-0.26*				
Branches/plant	0.39*	-0.36*	-0.42*	0.47*			
Pods/plant	0.44*	-0.46*	-0.53*	0.65*	0.67*		
Seeds/pod	-0.18	0.17	0.02	-0.09	-0.05	-0.31	
Seed weight	0.01	0.00	-0.13	-0.04	0.18	0.28*	0.11
Stumpf-2018							
Planting date	-0.87*						
Plants/acre	-0.39*	0.59*					
Nodes/plant	0.41*	-0.45*	-0.38*				
Branches/plant	0.96*	-0.74*	-0.51*	0.39*			
Pods/plant	0.72*	-0.75*	-0.51*	0.29*	0.74*		
Seeds/pod	-0.25	0.24	0.00	0.14	-0.08	-0.26	
Seed weight	0.32*	-0.27*	-0.12*	0.05	0.2	0.06	0.04
Stumpf-2019							
Planting date	-0.39*						
Plants/acre	0.06	0.08					
Nodes/plant	-0.04	-0.35*	-0.15				
Branches/plant	-0.02	-0.30*	-0.22*	0.52*			
Pods/plant	-0.27*	-0.41*	-0.36*	0.66*	0.75*		
Seeds/pod	-0.13	0.2	-0.12	-0.05	0.05	0.11	
Seed weight	0.35*	0.06	-0.1	-0.02	-0.12	-0.18	-0.02

* Correlation coefficient significant at 5% level. The sign of coefficient indicates the nature of relationship (either positive + or negative -) while the magnitude of coefficient (ranging from 0 to 1) represents the strength of the linear relationship.

Why Planting Date Matters

Previous UNL research on soybeans in eastern Nebraska has demonstrated that for each day that soybean planting is delayed after May 1, yield penalties of 0.25-0.63 bu/ac can occur, depending on the year. (Elmore et al., 2014; Specht et al., 2012) In our study, there was a wider range of daily yield penalties for late planted soybeans including 0.13, 0.64, and 1.40, bu/ac/day at the Stumpf-2019, Stumpf-2018, and Kemling-2018, respectively (*Figure 4*).

Large variability in yield response to planting dates may be attributed to the variety-specific interactions with weather, soil, and management conditions observed at each site-year. For example, soybeans planted in 2019 at Stumpf-2019 (GH2499X; 2.4 MG) yielded higher at late planting date (early June) than either of the two varieties planted in 2018 at Kemling-2018 (AG28X7; 2.8 MG) and Stumpf-2019 (AG24X7, 2.4 MG)(*Figure 4*). During the 2018 growing season, longer season variety (2.8 MG) planted at Kemlin-2018 (AG28X7) yielded much better at early planting dates than shorter season variety (2.4 MG) planted at Stumpf-2018 (AG24X7) (*Figure 4*). In addition to differences in soybean varieties, weather conditions (e.g. hail events) and management practices (e.g. tillage practices) at Kemling Farm and Stumpf Farm were much different in 2018.

Among yield components, nodes/plant, branches/plant and pods/plant were all negatively correlated with planting date (*Table 2*) suggesting that each soybean plant produced less nodes, branches and pods as planting date was delayed (*Figure 4*).

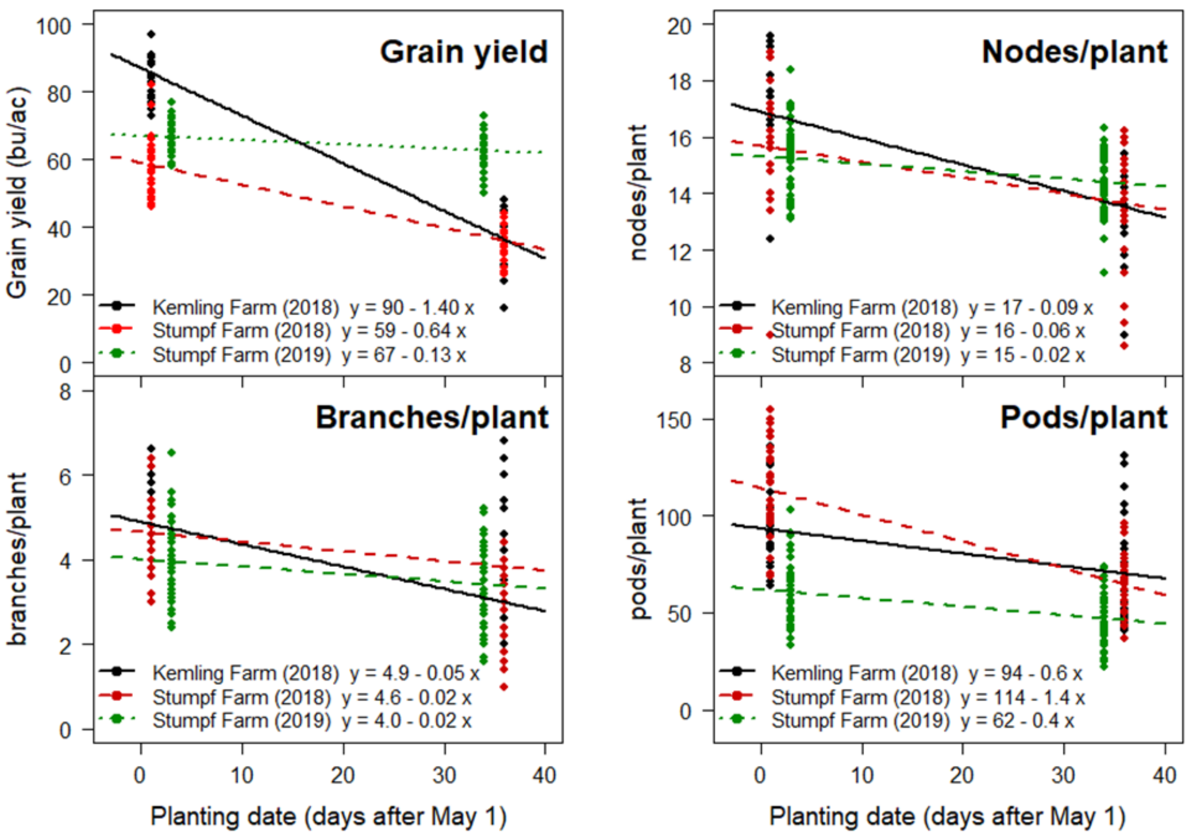

Figure 4. Effects of planting date on soybean grain yield (bu/ac), node development (nodes/plant), branching (branches/plant), and pod development (pods/plant) in field experiments conducted at the Kemling Farm and Stumpf Farm during 2018 and 2019 soybean growing season near Grant, NE.

Why Row Spacing Matters

Overall, soybeans yielded higher when planted in narrower rows. At the Kemling-2018, a yield advantage of 8 bu/ac was observed with 15-inch rows at early planting, while there was no yield advantage with narrower rows at late planting date (*Figure 5*). At the Stumpf-2018, there was a yield advantage of 11 and 6 bu/ac with narrower rows at early and late planting, respectively (*Figure 5*). At the Stumpf-2019, 15 inch rows yielded 2 and 4 bu/ac more than soybeans plant in 30 and 7.5 inch rows, respectively (*Figure 5*). These findings are largely in agreement with our previous on-farm research studies that showed 3-13 bu/ac increases with 15-inch as compared to 30-inch rows (Stepanovic et al., 2018b). More research is needed to evaluate soybean response in 7.5 inch rows.

Seeding in narrow rows did not influence soybean node development; however, we observed enhanced branching and consequently a greater number of pods (and seeds) per plant (*Figure 5*). The additional pods located on the side branches contributed greatly to the yield increase in narrower rows (data not show).

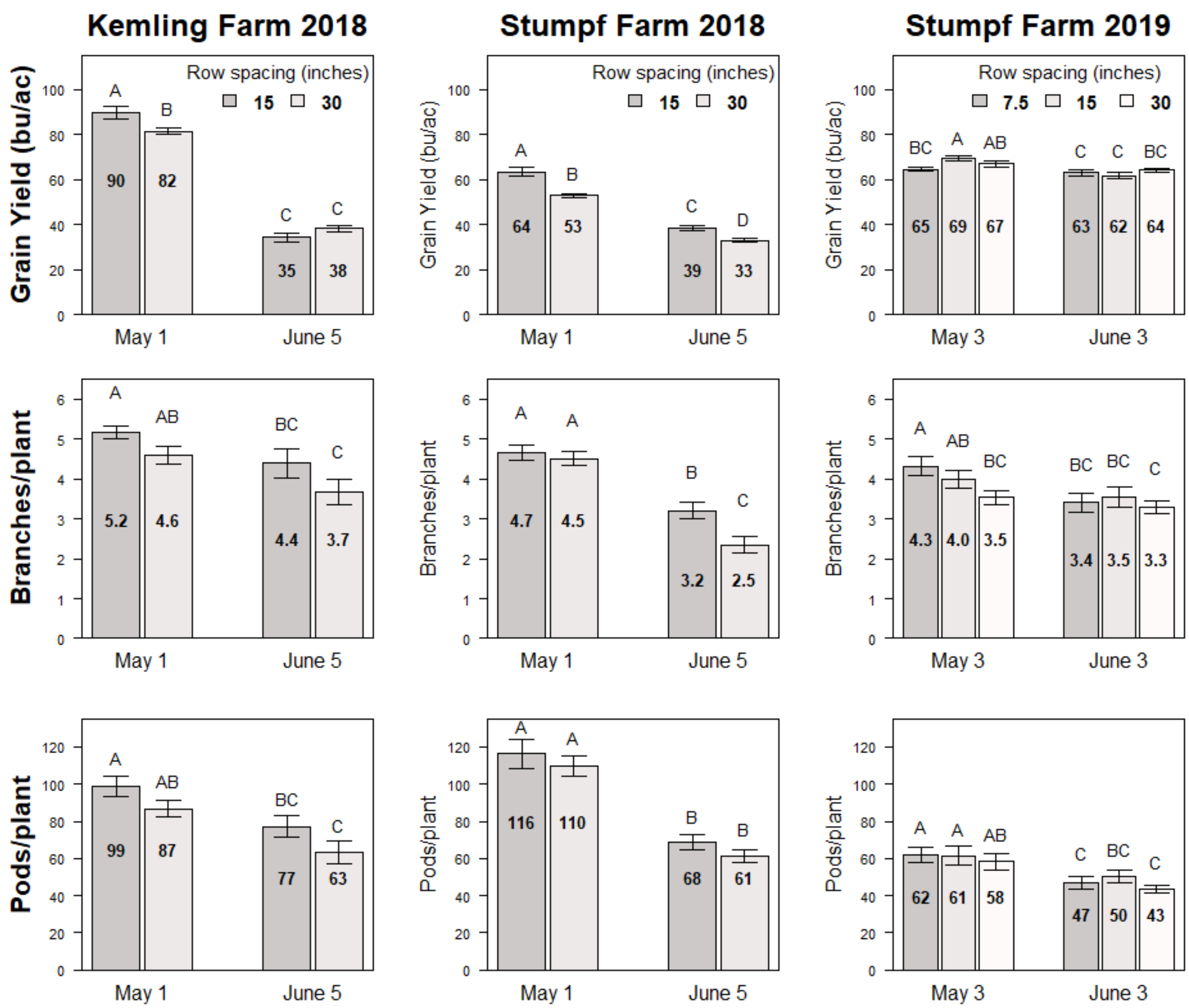

Figure 5. Impact of planting dates (May 1 vs June 5) and row spacing (15 inch vs 30 inch) on grain yield (bu/ac), branching (branches/plant) and pod set (pods/plant) of soybeans in field experiments conducted at the Kemling Farm and Stumpf Farm during the 2018 and 2019 growing seasons near Grant, NE.

Why Seeding Rate Matters Less than Other Factors

Soybean yield at all site-years did not respond to changes in plant populations. Although soybeans were seeded at 90,000 and 140,000 live seeds/ac (i.e. seeding rate after adjusting for germination), actual harvest population (plants/ac) ranged between 30,000 and 160,000 plants/ac depending on the site-year. The stand reduction in 2018 at both sites was due to early season crusting issues and hail injury.

Lack of soybean yield response to increasing populations may be explained by increased competition among the soybean plants themselves. Increasing plant population causes individual soybean plants to produce fewer branches, pods, and seeds, and consequently less yield (*Figure 6*).

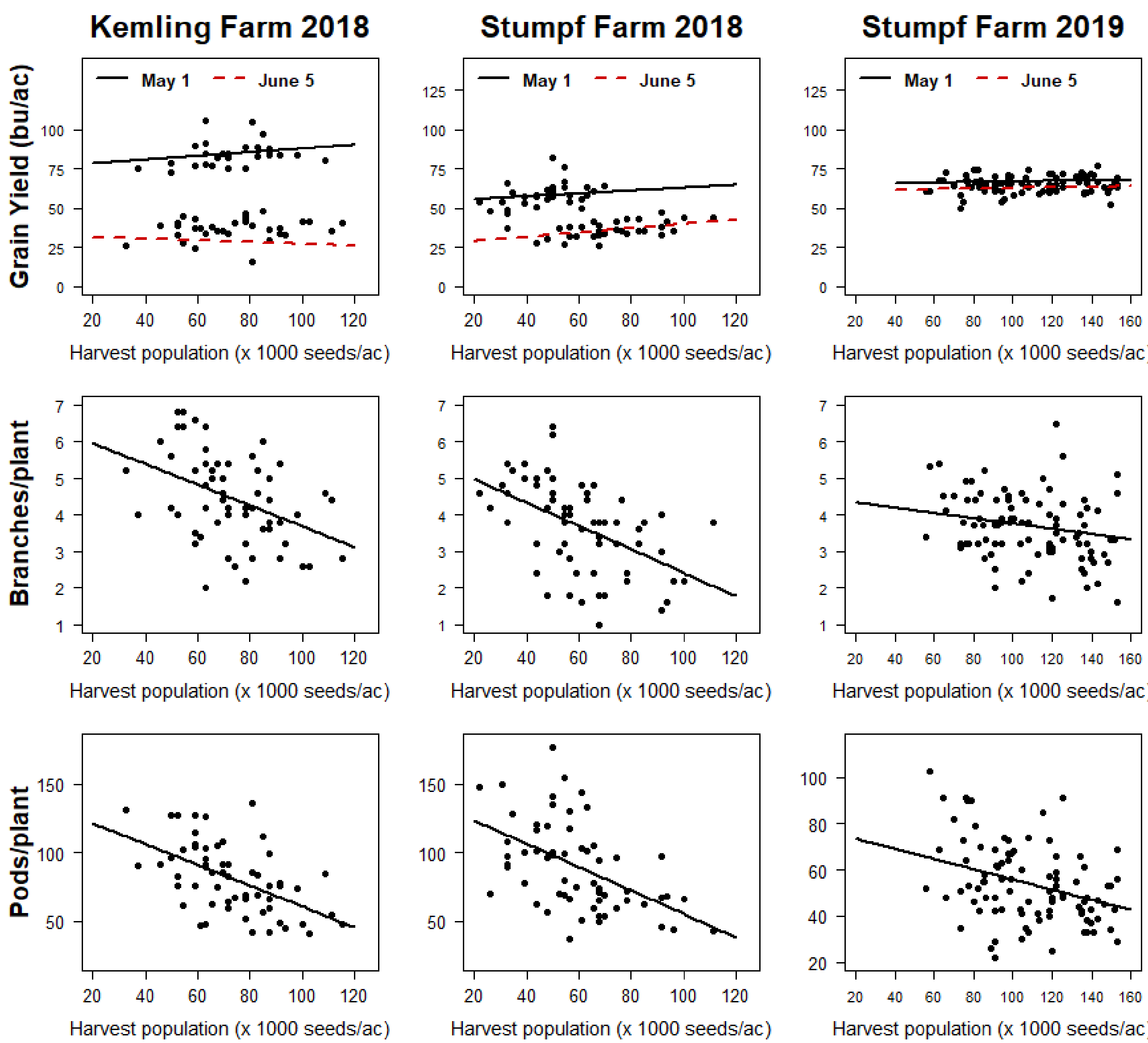

Figure 6. Impact of harvest population (plants/ac) on soybean grain yield (bu/ac), branching (branches/plant), and pod set (pods/plant) in field experiments conducted at the Kemling Farm and Stumpf Farm during 2018 and 2019 growing season near Grant, NE.

It's All About Being More Profitable

In summary, soybean yield potential is increased when the crop is seeded earlier (0.13-1.40 bu/ac/day) and in narrower rows (up to 11 bu/ac yield advantage). This yield potential was achievable at lower seeding rates and without late season N supplementation.

It is not uncommon in western Nebraska to see soybean seeding delayed until after irrigated corn is planted, and to do it in 30-inch rows and at >160,000 seeds/ac. Assuming that yield penalties for late planting are lower for corn than for soybean, that typically there are fewer soybean acres to plant, and that market prices of soybean (~$8.00/bu) are higher than corn (~$3.00/bu), we outline potential savings from incorporating the following practices:

- Seeding soybeans before corn (10 days earlier than traditional) – $20 to $112/ac;
- Seeding soybeans in 15-inch rather than 30-inch rows with modest 3 bu/ac yield increase – $24/ac;
- Reducing seeding rates from 160,000 to 120,000 seeds/acre – $15/ac; and
- Eliminating late season chemigation with 50 lbs of N/ac – $20/ac.

Among these four production factors, early planting is the one factor that soybean growers in the region most often overlook and therefore lose the opportunity to increase their profit margins substantially. Therefore, the real question is what should we plant first in southwest Nebraska: corn or soybeans? The answer is: soybeans.

The real question is what should we plant first to achieve optimal profitability in southwest Nebraska: corn or soybeans?

The answer is soybeans.

We can look to Iowa State University research for supporting data (Klein, 2009). Corn planted between April 20 and May 5 achieved 100% yield potential. Depending on year-to-year variability 99% of yield potential could still be achieved with corn planted before May 20. In the three-year study, significant yield reductions occurred only once and that was when corn planting dates were extended to late May or June. In southwest Nebraska research in 2018/2019, we observed daily yield penalties of 0.2-1.0 bu/ac/day for corn planted after May 1 (Stepanovic, 2020b; two year data).

We strongly recommend soybean farmers in western Nebraska evaluate their seeding and fertility practices and consider implementing changes that could lead to a more profitable crop.

Acknowledgements

I would like to thank my interns Ognjen Zivkovic, Jovan Radojicic, Milica Boganovic as well as our farm technician Justin Richardson for their hard work on this project. We also thank Jim and Troy Kemling who allowed us to do this research on their farm. Lastly, we thank the Nebraska Soybean Board. Without their financial support, this project would not have been possible.

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Soybean Fertility Study in Western NE: What is limiting high yield and protein?

Strahinja Stepanovic, Justin Richardson, Kelly Bruns

Figure 1. Farmers examining different fertility treatments during 2019 August Field Day near Grant, NE.

Background

Is nitrogen (N) limiting high soybean yield?

Based on surveys conducted during seven teaching sessions in 2019 and 2020, 40% of the attendees representing 137,000 acres of irrigated soybean production in western NE reported to chemigate some level of N fertilizer during the soybean reproductive stages (25-50 lbs N /ac most common rate). The main reasons for adopting this practice are based on the notion that biological fixation and residual soil N are often not able to meet N demand of high-yielding soybean (≥70 bu/ac).

Mortzinis et al. (2017) reported a minimal effect of N on soybean yield (0-2 bu/ac increase) in 207 environments (site-years) across the 16 land-grant universities. There are a few studies from eastern parts of Nebraska (Cafaro La Menza et al. 2018, Wortmann et al. 2012) and Kansas (Wesley et al. 2014), where researchers quantified yield responses to fertilizer N sufficient to justify the additional expense associated with the application. In one study, the application of 27 lb/ac N at R3 increased an average yield by 1.1. bu/ac across 44 locations with > 60 bu/ac yield, while no additional yield increase was observed with the application of 54 lbs of N/ac. Variability in yield response to N can depend on differences in soybean cultivars, soil properties, weather conditions, and agronomic practices (Mortzinis et al. 2017).

Soybean response to late-season N in western NE

In 2017, on-farm research studies were conducted in three southwest counties (Perkins, Chase, and Lincoln) with no increase in soybean yield or grain protein with 80 lbs of N/ac at R3 (beginning pod). In addition, low efficiency in fertilizer N utilization (~13%) was observed, with the only notable difference being a 5-14 lbs of N/ac increase in crop residue. The study protocol was changed in 2018 to chemigate less fertilizer (50 lbs of N/ac) at later growth stages (R5-beginning seed) growth stages, and that did not change the outcomes. Leaf tissue analysis in all studies tested low on magnesium (Mg). At the same time, N and all other macronutrients and micronutrients remained within the sufficiency range for most of the soybean growing season.

Will compost and other biological products work?

When Jimmy Frederick from Rulo, NE (eastern NE) raised 138 bu/ac soybeans to win 2017 state and national dryland soybean yield competition, many farmers wanted to learn from his approach. Mr. Frederick did not apply any synthetic fertilizer N and based his entire fertility program on biological products. In our 2018 fertility study in western NE, early planted soybeans in 15-inch rows benefited from pre-plant application of compost at 5 ton/ac, yielding as much as 107 bu/ac (the result of one site-year). Such an outcome initiated a need to repeat the study and look more into the other fertility treatments that might increase soybean yield.

Soybean fertility study in 2019 and 2020

The study was conducted at Henry J. Stumpf International Wheat Center near Grant, NE in 2019 and 2020. In both years, soybean was planted at 30-inch row spacing in early May. Soybean variety GH2499X (Golden Harvest 2.4 maturity) was used in 2019 and AG27X98 (Asgrow Xtend, 2.7 maturity) in 2020.

Total of 12 fertility programs were compared, including inoculant only, high N control (400 lbs of N/ac), cow and chicken manure applied both broadcast and in-furrow, two levels of Mg fertilizer, and four programs based on seed and foliar treatments recommended by our local fertilizer suppliers (Table 1).

Experimental treatments were replicated three times, with individual plots being 20 ft wide by 60 ft long in 2019 and 10 ft wide x 100 ft long in 2020. The following data were collected in each experimental plot: bi-weekly soil and tissue samples, yield, grain quality (protein and oil), and yield components (plants/acre, nodes/plant, branches/plant, pods/plant, seed weight).

The main objective was to identify the nutrients that limit high soybean yield and grain protein.

Key takeaways from the study:

1. Fertility treatments had no impact on soybean. Fertility treatments had minor to no impact on soybean yield, grain protein, seed oil content in both 2019 and 2020 (Table 2). Although broadcasted chicken manure had slightly elevated levels of micro and macro nutrients in 2020 soil and tissue samples, this led to no significant yield increase.

2. N supply was not a yield-limiting factor. Multiple evidence suggest that N supply was sufficient: (1) N levels in tissue samples did not reach the critical level at any point during the growing season, except at crop maturity-R8 (Figure 3 and 4); (2) The High N control, the treatment designed to provide sufficient N supply throughout the growing season, had significantly higher end-of-season residual soil N than any other fertility treatment (N demand did not exceed supply); (3) Yield and grain protein did not differ by fertility treatments (Table 2).

3. Soil pH was the main factor limiting soybean yield and grain protein. Despite the relatively flat topography, uniform soil type, similar soil organic matter (OM), and cation exchange capacity across the study area, soil pH varied significantly from plot to plot. In 2019, 10 bu/ac reduction in yield and 1.5% reduction in grain protein was observed when soil pH > 7.5 (Figure 1). In 2020, soil pH levels throughout the study area were in the optimal level for soybean growth and development (5.6 to 7.3), thus had no impact of soil pH on soybean yield and protein (Figure 1).

4. Magnesium (Mg) deficiency. Magnesium levels in tissue samples were at the lower end of sufficiency range in the early reproductive (R1-R3) and were approaching the critical level during late reproductive stages (R3-R7; Figure 2). The decrease in Mg levels at late reproductive stages (R3-R4) coincided with the sharp increase of Ca concentration in the soybean tissue, suggesting a plausible inhibitory (i.e. unlikely preferential) uptake of Ca over Mg (Figure 2). As soil pH increased, Ca concentration in soil solution increased disproportionally compared to Mg, causing a sharp increase in Ca:Mg saturation ratio (and K:Mg), especially at soil pH levels > 6.7 (Figure 2). We hypothesize that Mg uptake in soybean, especially in late reproductive stages, may be hindered due to soil replenishing with a disproportional amount of Ca into the soil solution.

5. Molybdenum (Mo) levels low at late reproductive stages. Molybdenum levels in soybean tissue were at the lower end of sufficiency range during the seed filling period (Figure 5 and 6). Molybdenum plays an important role in soybean N-fixation, and increasing its availability to the plant at late reproductive stages may help soybean maintain high rates of N-fixation. All other micronutrients were within the sufficiency range throughout the growing season (Figure 5 and 6).

Recommendations

The results of this study validate the current UNL fertilizer recommendations for soybean, especially when it comes to avoiding the routine application of N fertilizer. Soil tests cannot predict the need for N fertilizer; therefore, an in-season tissue sampling as well as inspecting root nodule number, spread and activity are advised before making such a decision. Soybean response to N is, however, more likely to occur in high-yielding environments (> 80 bu/ac) and in certain conditions such as soil pH < 5.5, organic matter < 1.5 %, or poor nodulation (Wortmann et al. 2018). When it comes to applications of compost, manure, and other specialty products (micronutrients, foliar products, etc.), more research is needed to identify specific environmental conditions and soybean varieties where those applications might be warranted.

Soil pH was found to be the main factor influencing soybean yield and grain protein content. Significant decline in soybean yield and grain protein was observed at pH > 7.5., which is outside the optimal soil pH range (5.5-7.0) for soybean nutrient uptake and biological N-fixation. Recent advances in on-the-go field mapping for various soil properties and areal/satellite imagery can help farmers identify areas of the field with high soil pH and treat them as site-specific zones. Improving soybean management when soil is calcareous with pH > 7.5, especially if symptoms of lime induced chlorosis have been previously observed, may include: careful use of herbicides, planting iron-deficiency tolerant varieties at higher seeding rates in 30 inch rows, avoiding high soil nitrate levels, and applying chelated-iron products in the seed furrow at planting.

Tissue analysis in the past few years has consistently showed low/critical levels of magnesium both in our soybean research studies and on-farm samples. Soil analysis, however, always indicated an adequate supply of Mg and a range of Ca:Mg saturation ratio that is considered optimal for soybean production. Significant amounts of Mg are applied in irrigation water. Furthermore, we observed no yield increase (or increase in levels of Mg in tissue) with the application of 140 and 270 lbs of Mg/ac; approximately 30 lbs of Mg/ac was applied through the irrigation water. Although it appears that Mg uptake is somewhat hindered by large amounts of Ca, soybeans had no yield response to applied Mg fertilizer in western NE.

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Table 1. The list of 12 soybean fertility treatments and their application time, product rates, and application method evaluated during the 2019 growing season at Grant, NE.

Trt	Fertility treatment	Application time	Application method	Products and rates used
1	Control - Inoculant	Planting	seed treatment	Inoculant - Verdesian @ 2x rate
2	Control - High N	Pre-plant Planting	broadcast seed treatment	Urea (46-0-0) @ 869 lbs /ac (400 lbs of N/ac) Inoculant - Verdesian @ 2x rate
3	Chicken manure broadcast	Pre-plant Planting	broadcast seed treatment	Beju chicken manure (pelleted) @ 12 ton/ac Inoculant - Verdesian @ 2x rate
4	Cow manure broadcast	Pre-plant Planting	broadcast seed treatment	Beju cow manure (pelleted) @ 12 ton/ac Inoculant - Verdesian @ 2x rate
5	Chicken manure in-furrow	Planting	seed treatment insecticide box	Inoculant - Verdesian @ 2x rate Beju chicken manure (powdered) @ 25 lba/ac
6	Cow manure in-furrow	Planting	seed treatment insecticide box	Inoculant - Verdesian @ 2x rate Beju cow manure (powdered) @ 25 lba/ac
7	Mg High Rate	Pre-plant Planting	broadcast seed treatment	$MgSO_4$ @ 750 lbs/ac (270 lbs Mg/ac) Inoculant - Verdesian @ 2x rate
8	Mg Low Rate	Pre-plant Planting	broadcast seed treatment	$MgSO_4$ @ 388 lbs/ac (140 lbs Mg/ac) Inoculant - Verdesian @ 2x rate
9	Aurora Starter + Foliar	Planting Planting V3 V6 R2 R5	seed treatment seed treatment foliar foliar foliar foliar	Inoculant - Verdesian @ 2x rate Hustle @ 1 gal/ac Heighten @ 8 oz/ac (no product label) + Realize @ 2 oz/ac Heighten @ 8 oz/ac (no product label) + Realize @ 2 oz/ac Realize @ 4 oz/ac + N-cline @ 1 gal/ac + Evito @ 2 oz/ac Boron + Molybdenum (no product label) @ 1 qt/ac
10	Nutrien 1 Starter only	Pre-plant Planting	broadcast seed treatment	Micro Starter @ 0.3 gal/ac (no product label) Inoculant - Verdesian @ 2x rate
11	Nutrien 2 Starter + Foliar	Pre-plant Planting R2	broadcast seed treatment foliar	Micro Starter @ 0.3 gal/ac (no product label) Inoculant - Verdesian @ 2x rate NutriSyncD @ 10 oz/ac
12	Kugler Foliar products	Planting V2 V3 R2 R5	seed treatment foliar foliar foliar foliar	Inoculant - Verdesian @ 2x rate KS178c @ 1 gal/ac + LS624 @ 1 gal/ac + FA20 @ 1 gal/ac KS2075 @ 1.5 gal/ac + LS624 @ 0.5 gal/ac + FA20 @ 1 pt/ac KS2075 @ 2 gal/ac + FA20 @ 1 pt/ac KS2075 @ 1 gal/ac + LS624 @ 1 gal/ac + FA20 @ 1 pt/ac

Table 2. Soil pH, yield (bu/ac), grain protein (%), grain oil (%), N concentration in crop residue (lbs/ac), residual N in top soil 8 inches of soil (lbs/ac), and yield components (plants/ac, nodes/plant, branches/plant, pods/plant, seeds/pod, and 1000 seed weight) for 12 soybean fertility treatments evaluated during 2019 growing season at Grant, NE

Trt	Treatment name	Soil pH	Yield (bu/ac)	Grain Protein (%)	Grain Oil (%)	Plants /ac	Nodes /plant	Branch /plant	Pods/ plant	Seed /pod	1000 Seed weight (g)
1	Control - Inoculant	6.4	77	35.7	21.1	111078	15	3.1	41	2.5	149
2	Control - High N	6.6	74	35.7	21.0	83345	15	3.8	62	2.5	162
3	Chicken manure - broadcast	6.8	78	34.9	20.8	96122	15	3.2	46	2.5	168
4	Cow manure - broadcast	6.4	73	35.5	20.9	102511	15	3.5	50	2.5	154
5	Chicken manure - in-furrow	6.5	74	35.5	21.0	117903	15	3.3	50	2.3	154
6	Cow manure - in furrow	7.2	76	35.3	21.4	114345	15	3.2	45	2.3	160
7	Mg - High rate	6.4	78	35.3	20.9	124582	15	3.1	47	2.4	151
8	Mg - Low rate	6.4	78	35.7	20.7	112965	15	3.3	51	2.5	150
9	Aurora - Starter + Foliar	6.8	74	34.5	20.6	116044	15	3.0	44	2.3	153
10	Nutrien 1 - Starter only	6.2	77	36.0	20.9	121097	14	3.4	47	2.4	155
11	Nutrien 2 - Starter + Foliar	6.1	76	36.0	21.0	111804	15	2.9	43	2.4	162
12	Kugler - Foliar products	6.8	76	35.5	21.0	116450	15	3.0	44	2.4	155
	Average of all treatments	**6.6**	**75.9**	**35.4**	**20.9**	**111057**	**15**	**3.2**	**47**	**2.4**	**155**
	Difference at 5% significance	1.1	12	1.4	0.94	22863	1.5	0.9	11	0.2	7
	Coefficient of variation	10.4	11	2.5	2.83	13	6.6	16.7	15	4.8	18

Table 3. Pearson correlation (r) between soybean grain yield (bu/ac), grain protein (%), grain oil (%), plants/ac, branches/plant, nodes/plant, pods/plant, seeds/pod, seed weight (1000 seeds) in soybean fertility field experiments at Grant, NE (2019)

Parameter	Soil pH	Yield	Grain protein (%)	Grain oil (%)	Plants /ac	Nodes /plant	Branch /plant	Pods/ plant	Seed /pod
Yield	-0.55*								
Grain protein	-0.67*	0.35*							
Grain oil	0.05	0.09	-0.06						
plants/ac	0.24	-0.15	-0.10	-0.04					
nodes/plant	-0.03	0.12	-0.01	-0.15	-0.30				
branches/plant	-0.26	0.07	0.29	-0.28	-0.36*	0.39*			
pods/plant	0.17	-0.06	-0.09	-0.10	-0.42*	0.56*	0.47*		
seeds/pod	-0.22	0.28	0.14	-0.08	-0.21	-0.01	0.21	0.07	
1000 seed weight (g)	-0.16	0.22	0.26	-0.02	-0.39*	-0.04	-0.09	0.08	0.03

* Correlation coefficient significant at 5% level. The sign of coefficient indicates the nature of relationship (either positive + or negative -) while the magnitude of coefficient (ranging from 0 to 1) represents the strength of the linear relationship.

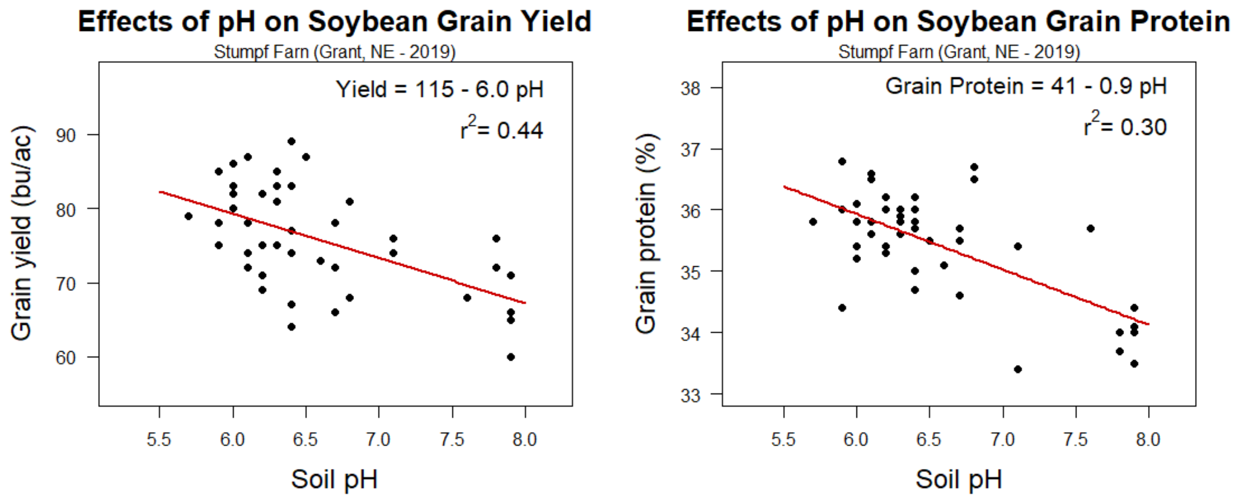

Figure 2. Effects of soil pH on soybean grain yield (bu/ac) and protein content (%) averaged over 12 soybean fertility treatments; study conducted during 2019 growing season at Grant, NE

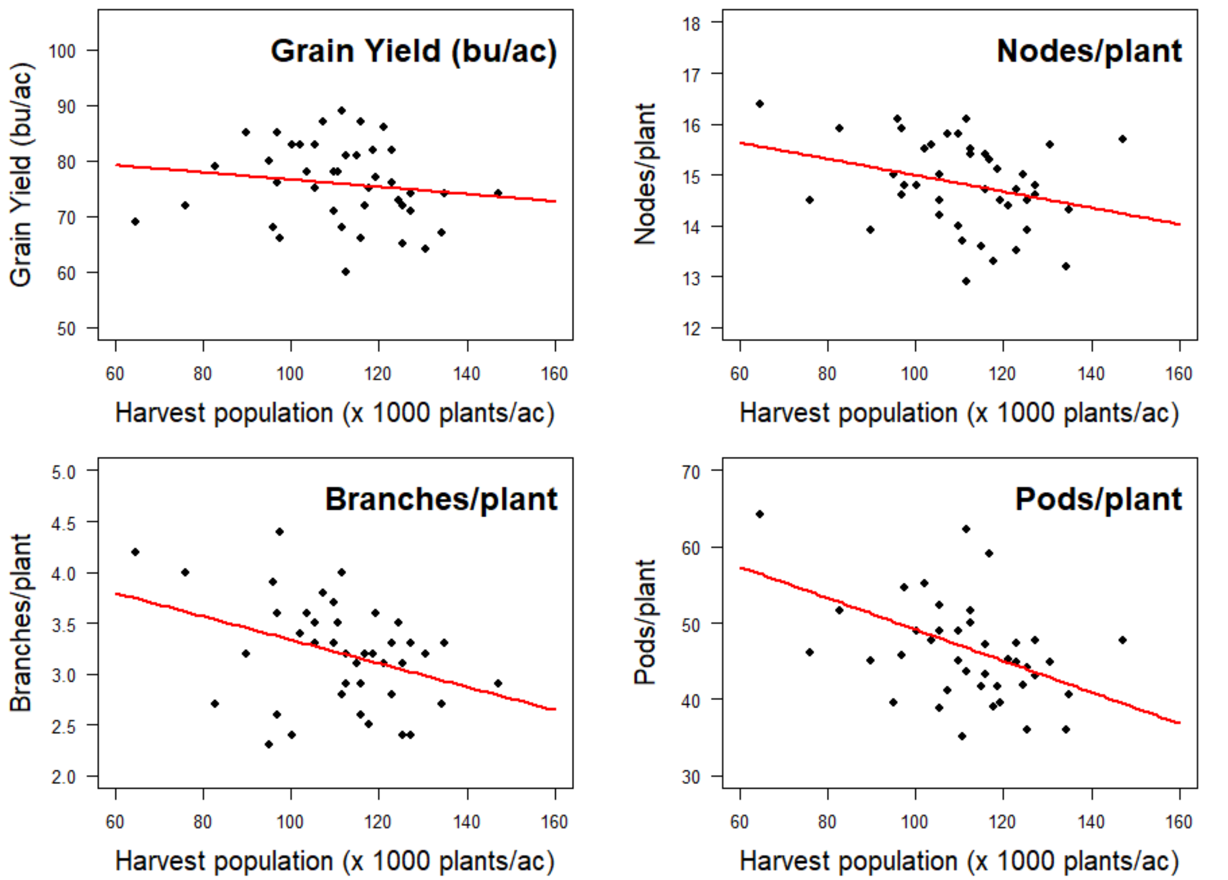

Figure 3. No yield (bu/ac) response of soybean to increasing harvest population (70,000 to 150,000 plants/ac) due to lower number of nodes, branches and pods on individual soybean plants; study conducted during 2019 growing season at Grant, NE.

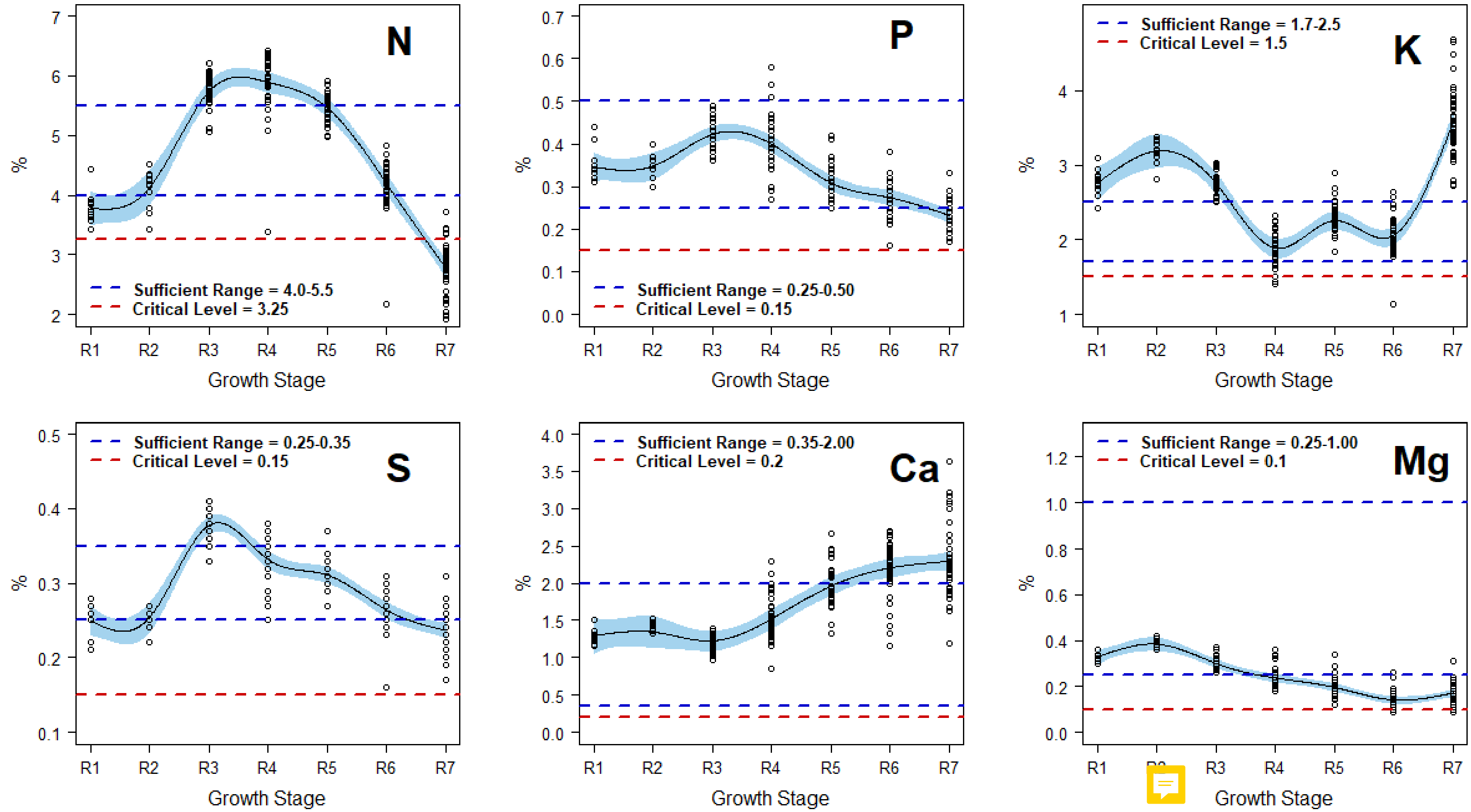

Figure 4. Change in concentration of macronutrients (N, P, K, S, Ca, Mg) in soybean leaf tissue during the reproductive growth stages (R1-R7) averaged over 12 fertility treatments; study conducted during 2019 growing season at Grant, NE.

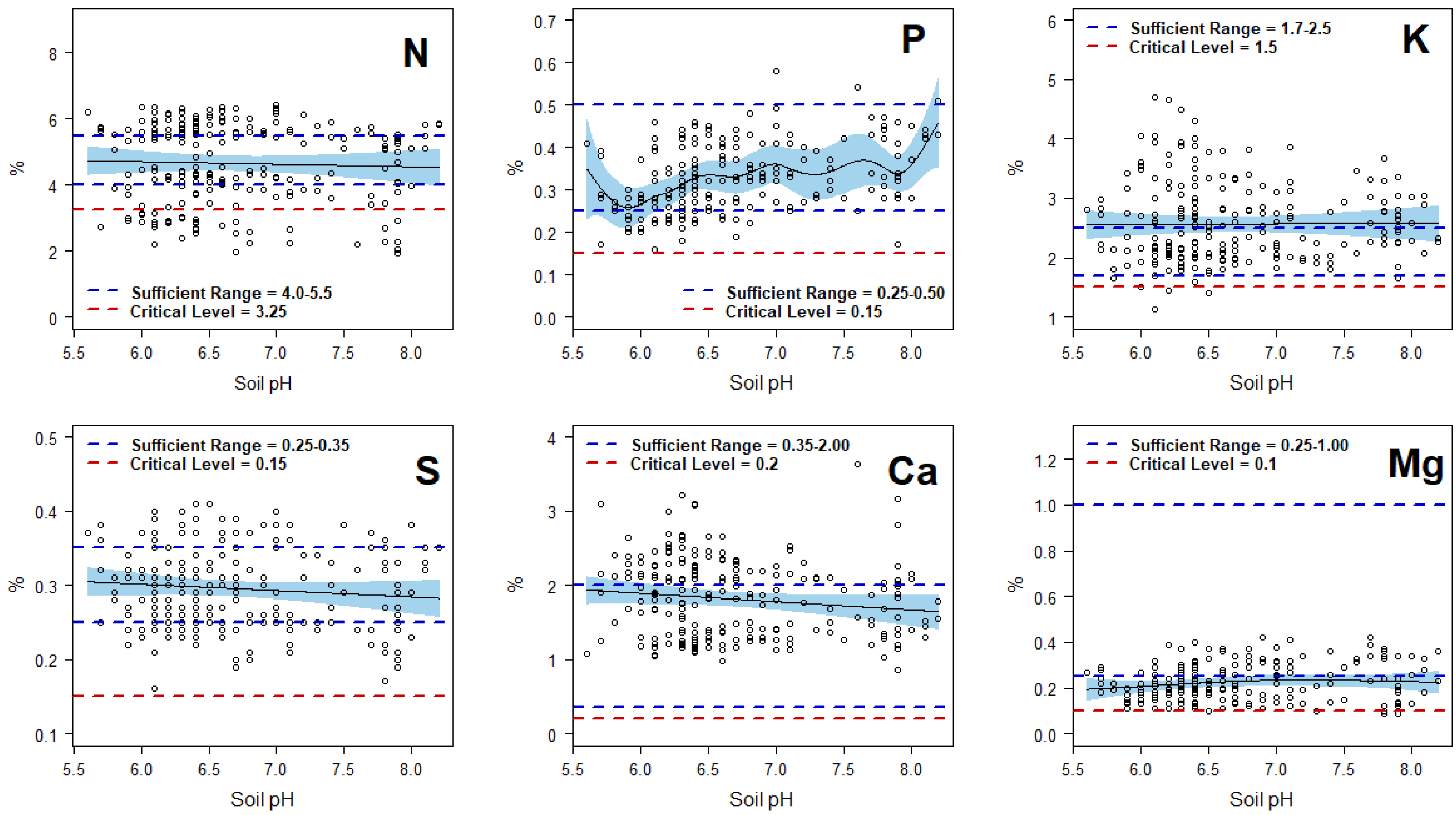

Figure 5. Concentration of macronutrients (N, P, K, S, Ca, Mg) in soybean leaf tissue as affected by soil pH; study conducted during 2019 growing season at Grant, NE.

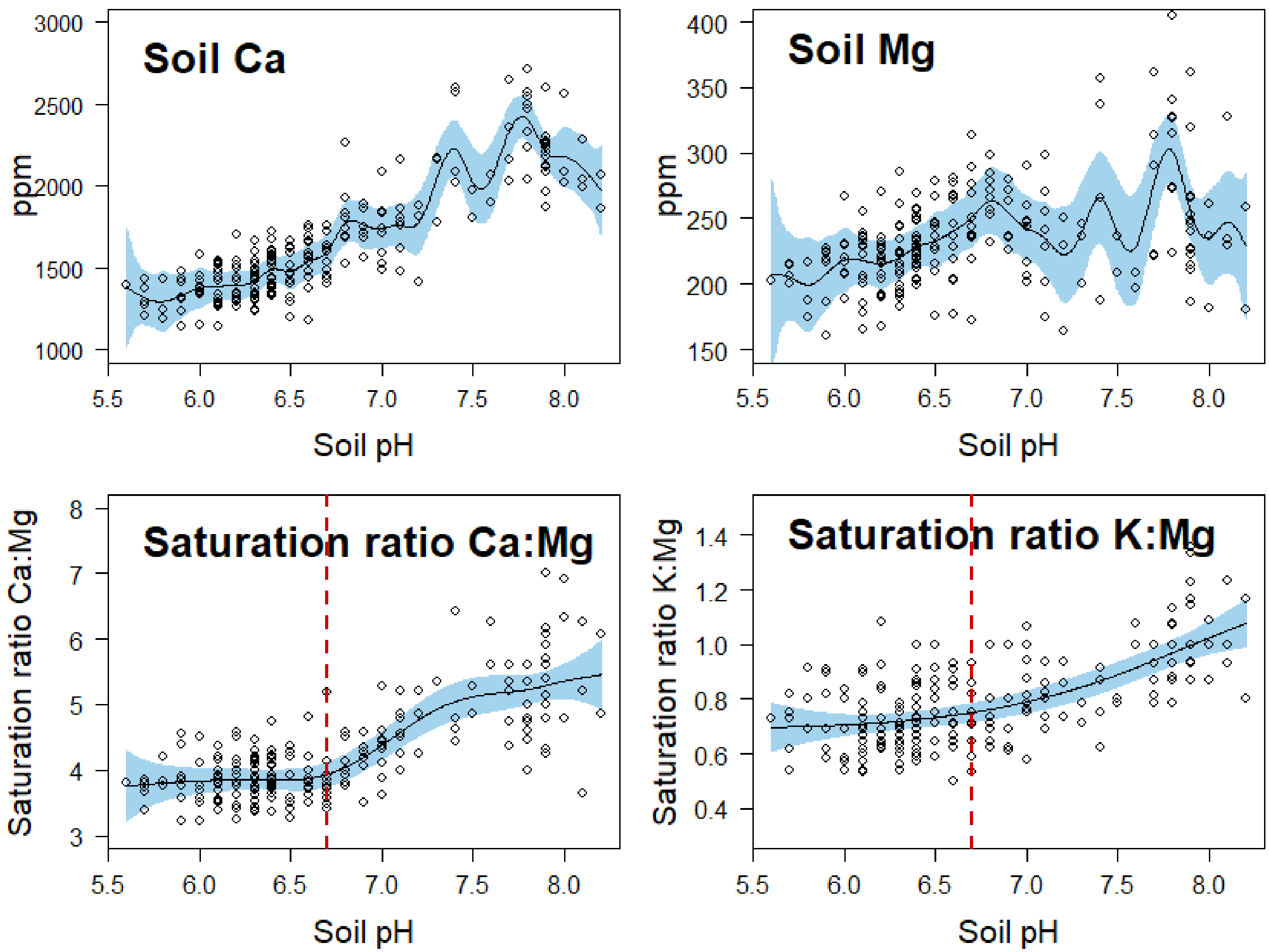

Figure 6. Concentration of Ca and Mg in the soil solution and their Saturation ratio as affected by soil pH; study conducted during 2019 growing season at Grant, NE.

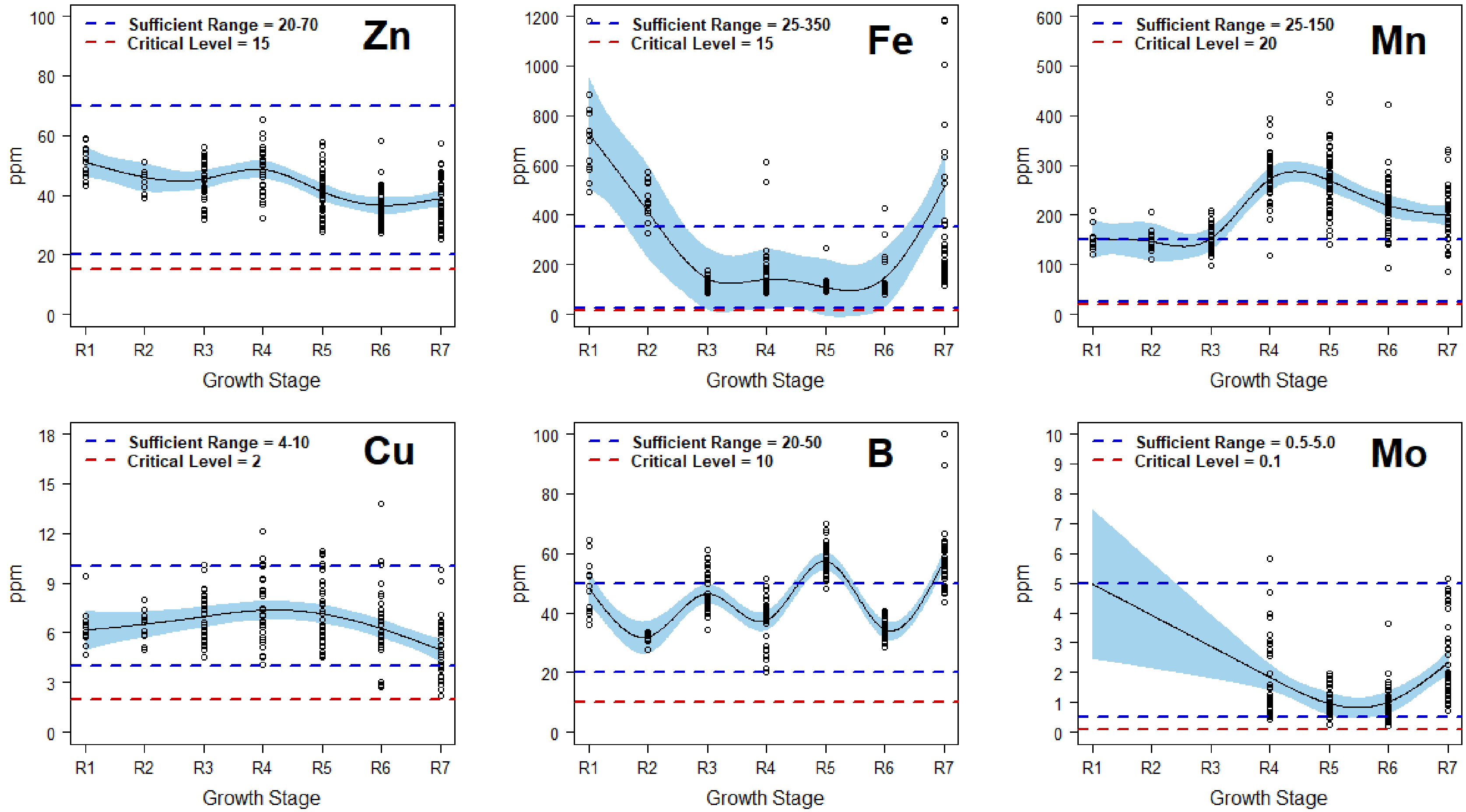

Figure 7. Change in concentration of micronutrients (Zn, Fe, Mn, Cu, B, Mo) in soybean leaf tissue during the reproductive growth stages (R1-R7) averaged over 12 fertility treatments; study conducted during 2019 growing season at Grant, NE.

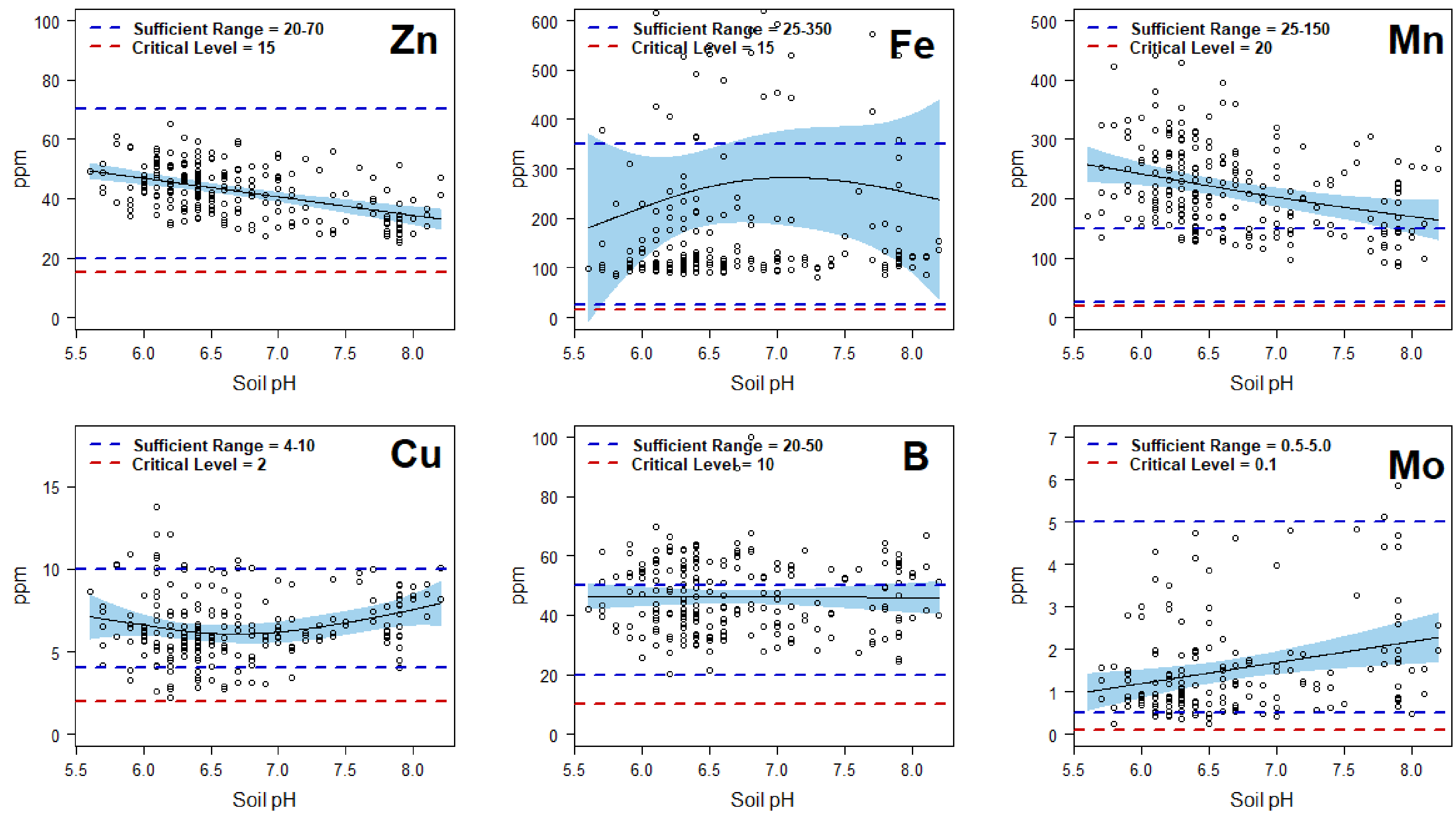

Figure 8. Concentration of micronutrients (Zn, Fe, Mn, Cu, B, Mo) in soybean leaf tissue as affected by soil pH; study conducted during 2019 growing season at Grant, NE.

Outreach Efforts and Impact on Soybean Production in Western Nebraska

Strahinja Stepanovic

Impact of Crop Production Roadshow meetings (Dec, 2017)

Total of 70 people attended representing 301,600 acres; 45% reported significant improvement on late season N-management in soybean; Behavioral change testimonials: "decrease in N costs vs cost of management"

Impact of On-Farm-Research updates at Grant and Alliance (Feb, 2018)

Total of 30 people attended representing 58,813 procurer acres and 823,335 advisor/employee acres; 74 % reported moderate or significant knowledge improvement of in-season N management (includes both corn and soybean); 40 % reported somewhat, likely or very likely to make the changes to their row spacing in soybeans; Behavioral change testimonials: "Narrower row spacing is more profitable", "Planting row widths affecting soybean yield", "Soybean population & spacing".

Combined Impact of before-and-after survey conducted at Cover Your Acre (Oberlin, KS; Jan-2019), August Field Day (Grant, NE; Aug-2019) and John Deere Planting Academy (North Platte NE; Feb-2020). Report includes responses from 160 soybean farmers representing 343,000 acres directly managed.

- 30% of the farmers that used to plant corn first will now give priority to planting soybeans
- Farmers will plant soybeans on average 7 days earlier
- 18% of the farmers will switch from wide rows (30 inch) to narrower rows (< 15 inch)
- Reduction in seeding rates by 25,000 seeds/ac
- 15% of farmers that used to chemigate with N will abandon this practice
- 71% of the farmers will consider applying slow release N fertilizers, compost, manure, coated dry fertilizer, foliar, and/or biological products.

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