Minnesota Soybean Research and Promotion Council

Final Research Progress Report

Due November 1st

Project Title: Explorations in soybean growth habits under different planting populations and with simulated hail damage in order to enhance the agricultural learning of future agriculture professionals

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Project Period: 1/1/23-12/31/23

Research Question/Objectives:

Objective 1: Describe how different soybean planting populations can impact plant architecture/biomass, canopy development (quantified by drone photography), and final yields.

Objective 2: Demonstrate/Educate SMSU students about how even simple field management decisions (alteration of planting population) can change the trajectory of a growing season, and provide hands-on learning/training opportunities in agriculture to SMSU students.

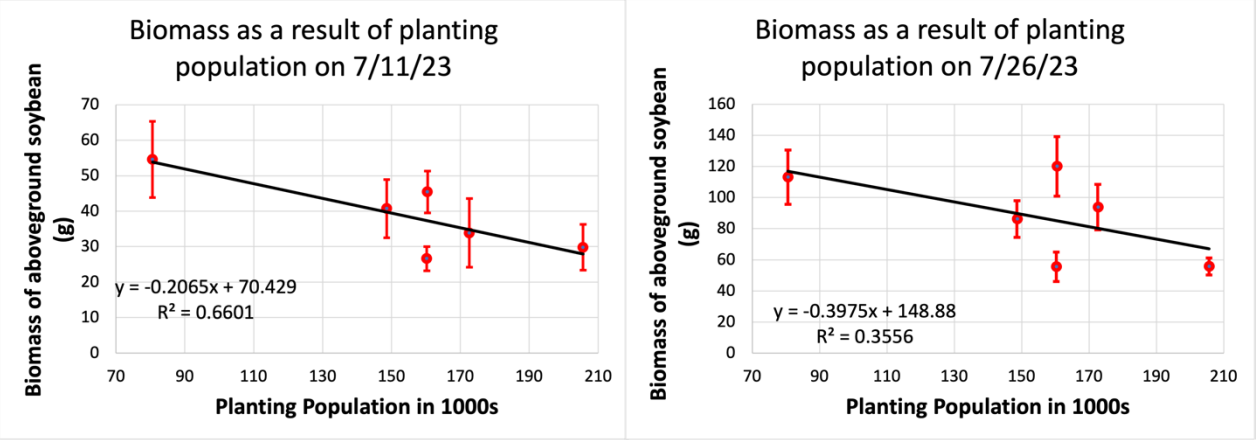
Results:

Objective 1:

Overall, this project was a success in both research results, and educational outreach. No major hiccups occurred with the exception of planting. The table on the right provides our targeted planting rate, and our actual planting rate based on stand counts. In all cases the actual planting rate was higher than the targeted. This is the result of our planter not having the right combination of driver/driven sprockets for accurate calibration. Additionally, it seems that in at least one instance (Treatment 2) our planting chain drive was on the opposite driver/driven sprocket designation and we over planted by quite a bit. Regardless, for this type of experiment, the data can still be used and will be presented below.

Trt #	Targeted Planting Rate	Actual Calc. Planting Rate
1	75,000	80,598
2	100,000	160,478
3	125,000	148,612
4	150,000	172,607
5	175,000	205,622
6	150,000	160,263

The first data type worth reporting is the biomass. Biomass measurements were taken on 7/11/23 when plants were in R1, and again on 7/26/23 when plants were in R3/R4. The results of both are graphed below.



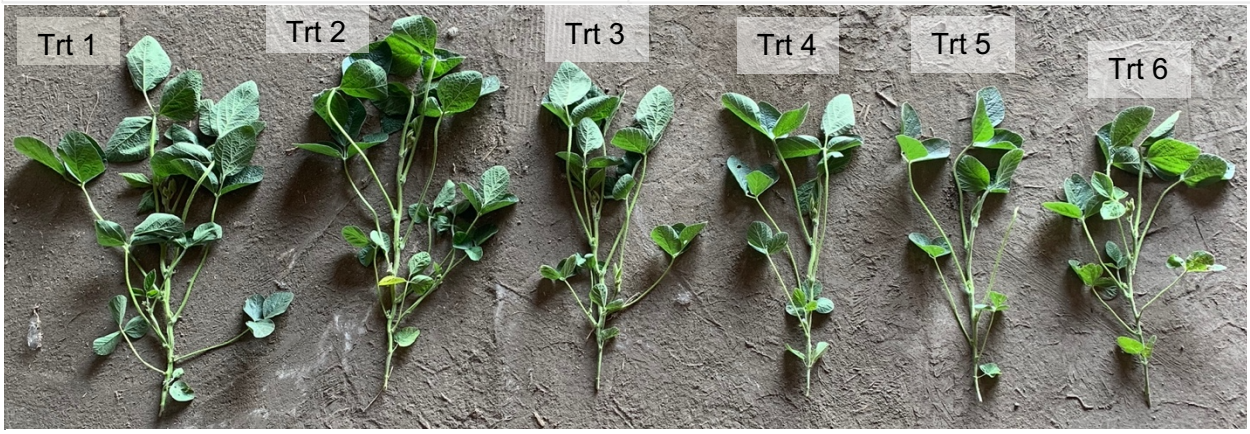


Figure 1 Representative soybean plants from biomass sampling taken on 7/11/23. A visible decrease in plant size can be seen based on initial planting population.

At both sampling events, it is evident that a higher planting rate resulted in an overall smaller, less heavy plant. On 7/11/23, 66% of the variation in soybean biomass could be explained by planting population alone; On 7/26/23, planting population explained 36% of that variation.

Planting population also had a significant impact on the final yield of each plot (Planting Population: $F_{5,15}$= 4.163, p-value=0.0143; Block: $F_{3,15}$=3.014, p-value=0.0630). In this experiment, the lowest planting population (Treatment 1 at ~81K) had an average yield of 38.07 bu/acre. Treatment 2, at ~160K had the highest average yield at 58.43 bu/acre. All other treatments were in the high 40s to low 50s. Based on these findings, it seems the sweet spot in this experiment was a 160K planting population as we observed decreases in yield at both lower and higher planting populations.

Treatment	Actual Planting Population	Average Yield
1	80,598	38.07b
2	160,478	58.43a
3	148,612	47.48ab
4	172,607	52.11ab
5	205,622	48.25ab
6	160,263	47.33ab

Finally, despite being beaten up by a weed whip, treatment 6 still yielded in the high 40s and at a similar level of performance to treatments 3-5. Based on similar planting densities between treatments 2 and 6, and the resultant yields, we can attribute a ~19% yield loss to simulated hail damage alone.

The final data we looked at was how planting populations influence canopy development throughout the season. While canopy data was collected for 7 weeks, only weeks 3-7 were analyzed with an ANOVA. Limited rainfall in the early portion of the growing season led to poor residual herbicide activation and thus poor weed control. While rescue treatments were applied, and worked, the weeds retained their yellow/green color while they died, and this led to artificially inflated canopy area in the

ImageJ program. By week three, treated weeds had finally died and turned brown, which allowed the ImageJ program to accurately measure soybean canopy area.

Treat	Actual Planting Population	Week 3 Soy Canopy %	Week 4 Soy Canopy %	Week 5 Soy Canopy %	Week 6 Soy Canopy %	Week 7 Soy Canopy %
1	80,598	28.18b	12.12b	37.82	38.29	41.35b
2	160,478	44.67a	26.47a	50.50	44.69	48.46ab
3	148,612	36.58ab	18.00ab	35.10	40.35	46.30ab
4	172,607	40.38ab	22.80ab	46.52	50.79	54.63ab
5	205,622	41.66ab	25.80a	41.66	48.92	53.31ab
6	160,263	43.01a	23.84ab	47.30	47.95	57.00a

When running an ANOVA on a weekly basis, three of the five analyzed weeks resulted in a significant difference in soybean canopy coverage (**Week 3**: Planting Population: $F_{5,15}$= 3.596, p-value=0.0245; **Week 4**: Planting Population: $F_{5,15}$= 4.418, p-value=0.0113, **Week 7**: Planting Population: $F_{5,15}$= 3.074, p-value=0.0417). Across all weeks, treatment 1 consistently scored the lowest canopy coverage, when statistically significant or otherwise. This makes sense given the vastly lower planting population. Interestingly Treatments 2 and 6 (160,478 & 160,263 plants per acre) consistently ranked as having the highest canopy coverage when significant differences existed despite there being other higher plants per acre treatments (Treatments 4&5). In one instance treatment 5 (205,622 plants per acre) ranked similarly to treatment 2, but this was not consistent. Based on the results of this study, the sweet spot for maximizing yield, and canopy coverage seems to be around 160,000 soybean plants per acre.

One final observation is that the canopy coverages change over time. In particular, canopy coverages as a whole drop from week 3 to week 4. Part of this is due to sampling day variation. Differences in light quantity and quality between weeks influences the amount of green pixels that ImageJ is able to detect. The other part has to do with precipitation patterns. The field site was hurting for water around week 4 and by week 5 we actually got some precipitation which “greened-up” the plot and made weed/soil/soy differences in color more apparent.

Objective 2:

We consider the experimental portion of this project a success, but the research is only the first half this project. The second half, is primarily focused on increasing the educational component. The following is a list of direct visitors and use of the soy plots, and future uses of data associated with this grant which will be used in classes.

Direct use and visitation of the soy plots

85 people for the SMSU field day held in mid-July where attendees were introduced to the aims of the project and to soybean growing in general

~20 people including MN congressional reps Michelle Fischbach + Pete Stauber, along with numerous other staffers of the western caucus visited for the plot tours on July 31st

~15 people from local USDA-NRCS offices for a plot tour on 8-15-23.

9 agronomy majors in AGRO 341 Principles of Pest Management scouted the soybean plots for insect and weed pests as an assignment. They were able to collect soy insects as well as see the more problematic weeds in soybean.

11 students for AGRO 132 Principles of Crop Production in which we introduced ag majors to a soybean

production field. They learned about soybean staging and how the plant grows/responds to its growing environment.

11 agriculture students in AGRO 390 Introduction to Precision Agriculture used drone photos of soybean plots to demonstrate how canopy growth can be monitored and quantified via drone

7 students for an Residential Assistant plot tour event. Majors included Graphic Design, Culinology, Agronomy, Ag communication.

~10 People from the general public not affiliated with the school but just interested in Ag and asked for a plot tour

Future uses of data provided from the funding of this grant
In AGRO 212 Grain and Forage Crops (Fall 2025) data on yield as an result of planting population and hail damage will be incorporated into future lectures with photos.

In AGRO 454 Experimental Design (Spring 2025) plant population, canopy coverage, plant biomass, and yield data will all be used in labs in order to teach/reinforce ANOVAs, linear regressions, and other statistical models via coding in the R statistical programming language.

Application/Use: The use of this project's data is primarily limited to educational purposes. SMSU is one of the few 4-year ag schools in MN so providing hands-on learning opportunities to the students is incredibly important in order to provide a well-educated and multi-experienced workforce. The many ways in which this project enhanced the educational experience at SMSU is described in the results section above.

Materials and Methods: In order to investigate and provide educational opportunities on the role planting rates have on canopy development, yield, and above-ground biomass in soybeans, 6 experimental treatments were created as follows:

Trt #	Targeted Planting Rate	Hail Damage?
1	75,000	N
2	100,000	N
3	125,000	N
4	150,000	N
5	175,000	N
6	150,000	Y

Fertilizers (10-23-30) were drop spread and shallowly incorporated 5/17/23 and soybean seed planted on 5/18/23. Each targeted planting population was replicated 4 times, and each experimental plot was 20' wide and 60' long. On 5/19/23 Sonic was applied at label rates as a preemergent herbicide and a Enlist/Cornerstone blend was applied at label rates on 6/5/23 to deal with grass weeds in some of the plots. To monitor how canopy rates developed as a result of different planting populations, drone photos were taken on 5/31/23 and continued weekly until 7/19/23.

Biomass measurements were taken to demonstrate how soybean can respond to the increased canopy space/soil resources it receives at lower planting densities. Each biomass sampling event consisted of randomly selecting 6 plants from each treatment across the plot, clipping the plants at the soil level, and weighing the resulting aboveground biomass. Finally, to demonstrate the impact a late season hail event could have on soybean yields, all treatment 6 plots were attacked with a weed

whacker/whip which was walked up and down each row on 8/4/23 when plants were in R4/R5. Harvest of soybean plots took place on 10/5/23 and yield was recorded with a weigh wagon.

Each statistical model used ANOVA with planting population and block as predictors. An alpha value of 0.05 was used, and a Tukey post-hoc was used to separate means when a significant predictor was determined.

Economic Benefit to a Typical 500 Acre Soybean Enterprise: While this grant does have an experimental component, the main strength, and main purpose of this project, is in its potential to provide educational experiences. Through the use of the award funds, SMSU has been able to increase soybean familiarity to scores of individuals, most of which are college students, in Southwest Minnesota. Soybean is a common crop in this part of the state, and as such, even non-farmers have some familiarity with the crop. Despite that, we believe the best type of education is an experiential one at SMSU. Getting students out to the research plots, having professors being able to talk about a project from its conception to finish, and hiring student labor to do the vast majority of field work all augment learning opportunities. This grant was put together to help capitalize on an already heavy hands-on learning environment and further increase students familiarity with soybean production systems. SMSU is one of the few MN universities with an Agronomy Major and our graduates go on to be the future crop scouts, consultants, product sales service, and researchers that our MN wheat farmers rely on. A broad and robust agricultural education during their college years will not only ensure they can identify and get the jobs best suited to their individual abilities, but once hired, will allow them to excel and help MN wheat growers to be agricultural leaders they always have been. When you have a better trained workforce, on-farm decisions come more quickly, and with more confidence.

Related Research: Additional competitive grant funds were awarded from MNWR&PC, but that project dealt with how varying the rates of N fertilizer can impact wheat growth rates, canopy development, final yield, and the overall protein content of the grain. Another MNSR&PC competitive grant was awarded to help prepare students for the CCA exam and to offset its cost. It's the goal of SMSU Agronomy to have all Agronomy majors pass the CCA local and International exam by graduation. Neither grant overlapped with this one other than providing an hands on example of a soybean field for CCA studying.

Recommended Future Research:

References:

Schneider, C.A., W.S. Rasband, and K.W. Eliceiri. 2012. NIH Image to ImageJ: 25 years of image analysis. Nature Methods 9: 671-675

Publications: None