Yield loss because of planting delay across MN:
Impact of maturity rate adjustment

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Summary:

The project aims to evaluate the effects of planting date and maturity rating on soybean yield across Minnesota. We set up four experiments throughout the state. Data generated allowed us to estimate a yield potential of close to 95 bu/ac. This yield potential could be attained in early planting dates coincident with better resource capture and utilization. Delay from early plantings during May resulted in a yield loss of about 0.4 bushels per acre per day, increasing to 1.0 bushel per acre per delay day in June. The research found no yield advantage for switching to shorter maturity varieties. Water stress emerged as a critical factor that would outweigh the benefits of early planting under drought conditions. The findings highlight the importance of early planting but also the need to balance it with risk management strategies to avoid replanting. The study suggests further research on the interaction between planting dates, radiation, temperature, and water availability to inform soybean management practices in Minnesota's diverse growing conditions.

Goal: To assess the individual and interactive effects of planting date and maturity rating on soybean yield potential across MN

In Minnesota, soybeans maintain most of their yield potential when planted up until mid-May. After this point, decreases in yield potential become increasingly more significant. However, on average across the past 5-years, barely half of the state's soybean acreage has been planted before the end of this optimum time-window. Moreover, on average, ~20% of the acreage was planted during June.

Delays in planting are associated with weather conditions that are difficult to predict. On the other hand, some more predictable reasons such as landscape position or agricultural practices, such as drainage, no-till systems, cover crops or weed control may affect plating date. There is no reason to think that weather driven planting delays will be reduced in the future, thus relevant questions should be: **How much total production are we losing due to planting delays? What is the value to individual farmers for earlier planting?**

Current guidelines for managing delayed or replanted soybeans indicate that farmers should not adjust soybean maturities until the beginning of June. The basis for this delayed change is that lower yield potentials of shorter varieties would not compensate for their better fit to the remaining cropping season. However, there has been a great advancement in genetics for early maturing varieties (Kadel, 2022). Therefore, another relevant question that arises for farmers is: **Can an earlier shift to short maturity with modern varieties attenuate the yield loss generated by planting delay? Then, the question that follows is: What is the threshold date to shift to shorter maturities, and what reduction in RM is more appropriate for the various regions of Minnesota?**

Project Objectives:
i) Redefine the impact of the delay in planting date and the maturity rating on soybean yield potential using current elite cultivars.
ii) Generate local estimations of the impact of planting delay on potential yield of soybean across MN.
iii) Generate local guidelines for the management of maturity rate according to the planting date delay across MN.

Four field experiments covering a wide latitudinal range were conducted across the State. Experiments were located in St Paul (UMN Campus), Waseca, Crookston, and Grand Rapids. Crops were planted under conventional tillage, 30 inch rows, 160,000 pl/ac, no nutrient limitations. At St Paul, experiments were maintained free of water limitation (the crop was irrigated to ensure that water will not limit growth). Crops were maintained free of weeds, insects, and diseases. The experimental design was a split plot design with four replicates; where the planting date was the main plot and maturity rate the sup-plot. Plots were 4 rows by 25 feet in length.

This project proposed to evaluate different maturity ratings and planting date combinations in controlled field experiments using recently released and high-yielding varieties in combination with a calibrated crop simulation model to extend the predictions to the main soybean cropping area of MN. This information was not currently available and provides further insight on location-specific management across soybean cropland of the state.

Results:
This project aims to explore the significance of planting dates in determining soybean yield among Minnesota farms. Through the presentation of locally generated and modeled data, we seek to underscore the importance of early planting, address the risks associated with replanting, and examine the impact of water stress on planting date decisions.

The impact of planting date on yield: Research consistently demonstrated that the timing of soybean planting influences soybean yield. Early planting offers a distinct advantage, resulting in higher yields compared to delayed planting. This advantage is attributed to resource capture and utilization. As planting is delayed from the earliest possible date the more critical reproductive stages are shortened and exposed to a reduced incident radiation (Figure 1a), resulting in reduced radiation capture. Temperatures during these stages are also lower as planting is delayed (Figure 1a). That in turn reduces the efficiency to transform radiation to growth. Consequently, as planting date is delayed, both reduced radiation and efficiency in radiation utilization impact crop growth during these critical stages, affecting yield.

Potential yield: The data generated under irrigation at St Paul in combination with the use of a crop simulation model allowed us to illustrate these concepts locally for the average 2000-2023 conditions (Figure 1b). Generated data indicates that without stress, soybean yield (potential yield) for southern Minnesota could be on average close to 95 bu/ac. This is a relevant estimation to establish the productivity target for fields that are conducted close to potential conditions: irrigated farms for example. According to several studies, target productivity should be near 85% of the potential yield, which in this case should be close to 80 bu/ac.

Potential yield depression per day of planting date delay: Still considering growing conditions without stress of any kind a progressive yield loss is observed, with reductions ranging from 0.4 bushel per acre per day of planting delay during May and increasing to 1.0 bushel per acre per day of planting delay during June. Expressed in relative terms, this depression is less than 0.4% per day in May and claims to close to 1% in June. For instance, a 10-day delay in May, may result in a yield depression close to 4 bushel per acre, while the same delay in June may lead to a 10 bushel per acre yield loss. Therefore, advancing planting dates under these conditions increases yield without any extra cost.

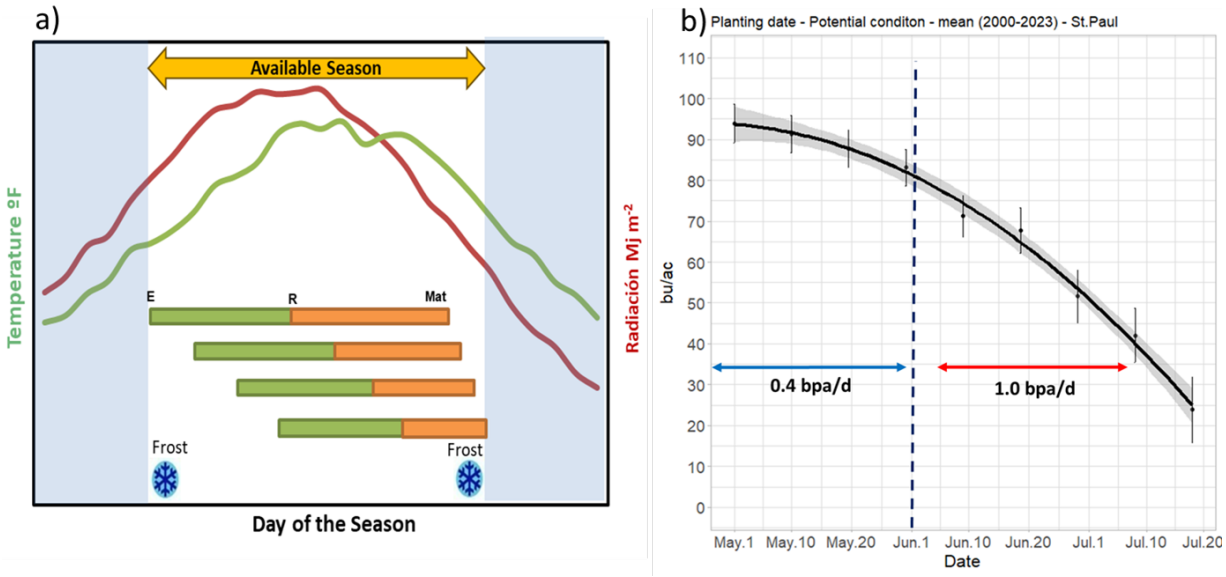

Figure 1: a) Schematic representation of temperature and radiation dynamic across the season and the temporal location of the vegetative (green) and reproductive (orange) stages of a soybean crop planted in different planting. b) Potential soybean grain yield as a function of the planting date for St Paul MN. Data were simulated using a crop model (Cropgro) calibrated and validated with local data generated under this project.

Considerations for risk management: While early planting offers yield advantages, it's crucial to assess potential risks such as frost events or adverse soil conditions affecting crop establishment, which may necessitate replanting. For instance, advancing the planting date by a week in early May could lead to almost a 3 bu/ac yield increase (7 days x 0.4 bu/ac day = 2.8 bu/ac). However, if replanting is required due to poor stand conditions and occurs three weeks after planting, a yield loss of almost 6 bu/ac is expected compared to a farmer who did not advance the planting date (14 days x 0.4 bu/ac day = 5.6 bu/ac). Replanting also incurs additional costs, including seed and labor expenses, which may amount to up to 7 bu/ac. Thus, while early planting is advantageous, it's crucial to mitigate the risk of stand reduction or replanting to avoid a yield loss that exceeds the initial advantage.

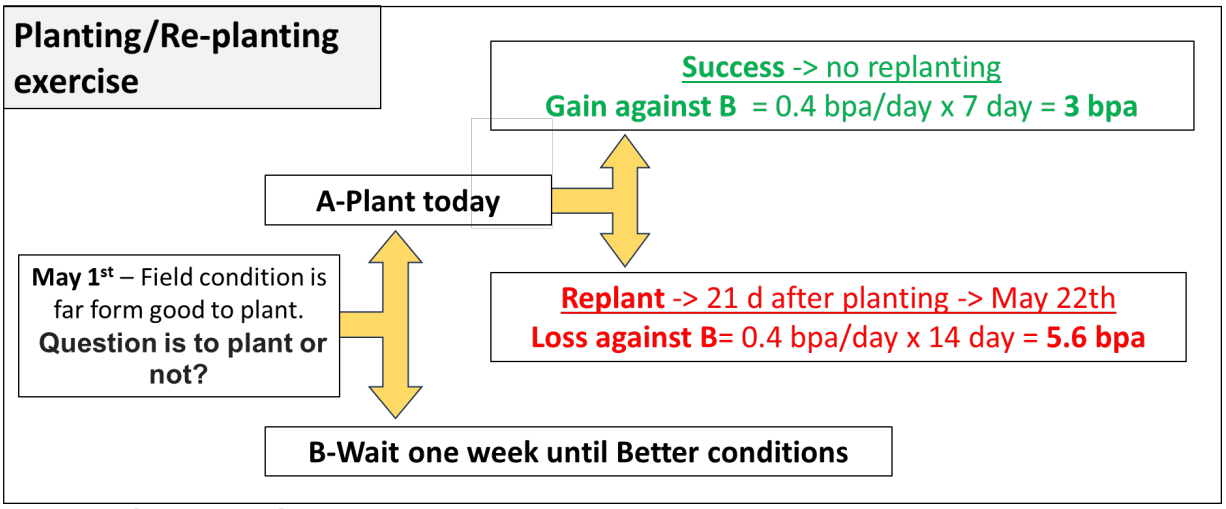

Figure 2: Planting/replanting comparison exercise.

Maturity group and planting date: As planting date is delayed, crop cycle adjustment can ensure that the crop experiences the most intense solar radiation and optimum temperature possible during those most important reproductive growth stages for yield determination (R4-R6). Previous local reports generated by the University of Minnesota indicated no benefits and even yield depression for switching to shorter varieties for planting date delays before mid-June. This project assessed these concepts using current short and long elite varieties. Generated data was in accordance with the previous recommendation. No benefit was observed in any location for shortening the maturity group when planting date was before mid-June ($p > 0.05$). However, neither did we find any yield depression for shortening the maturity group for early planting dates. In other words, we found no yield penalty for the shorter maturity groups in early planting, which would be important from a harvest timing and grain moisture standpoint. In the future, an increased number of environmental conditions and a higher number of cultivars should be evaluated to establish the relevance of this result.

Water stress and yield depression per day of planting date delay: While radiation and temperature play pivotal roles in yield determination in high productivity environments where there is no other resource limitation (potential conditions), water stress could frequently emerge as a relevant productivity limiting factor. That was the case for crops in several locations throughout Minnesota during the 2023 season, including Waseca, Crookston and Grand Rapids where we conducted experiments for this project. Figure 3 shows rains for Waseca and the effect of planting date on grain yield. We can see that no significant differences in yield were observed, highlighting the overriding influence of water availability on soybean yield under such conditions. Generated data indicate that for cases in which available water was a major limiting factor, the coincidence of the critical reproductive stages with periods of water stress could be more important to yield determination than maximizing radiation capture and use efficiency. At least from the observations during this 2023 season there seems not to be a clear advantage for early plantings in drought prone, low productivity environments. This is relevant, because early planting dates, while potentially advantageous as above mentioned, also entail inherent risks, including frost damage, non-optimum soil condition, and seedling diseases.

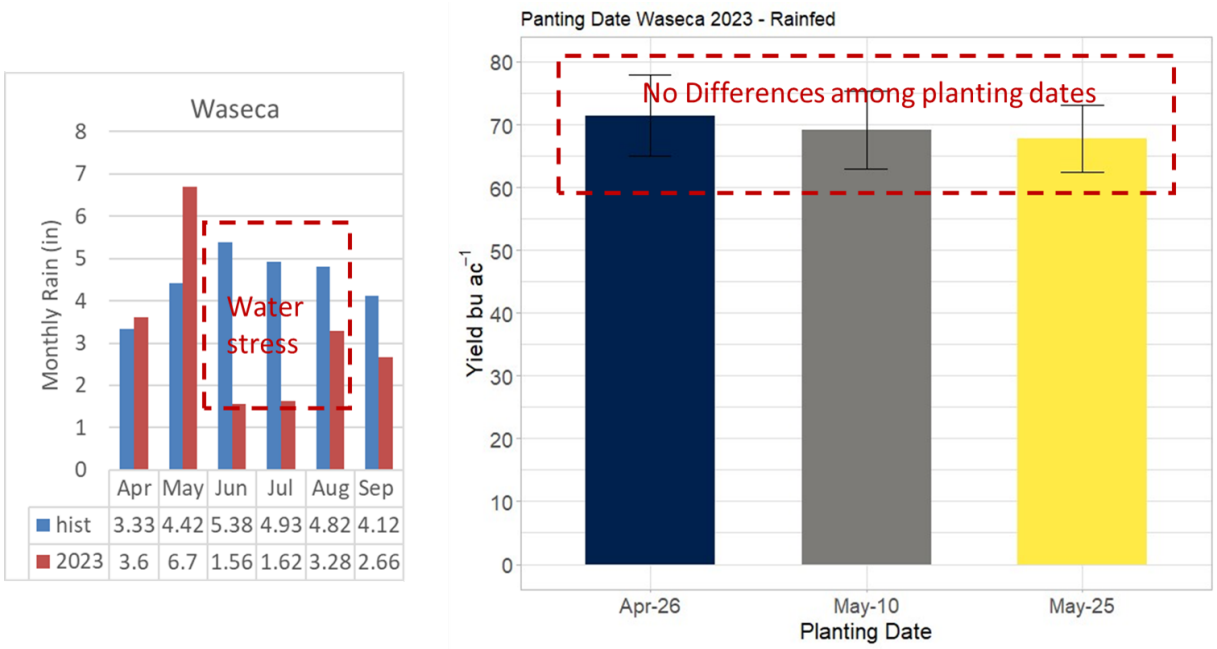

Figure 3: Historic and 2023 season monthly rains and the effect planting date on yield for soybean at Waseca. Each bar is the average of four replications and three maturity groups from 1.5 to 2.5. No differences among maturity groups in any planting date were detected (p> 0.05).

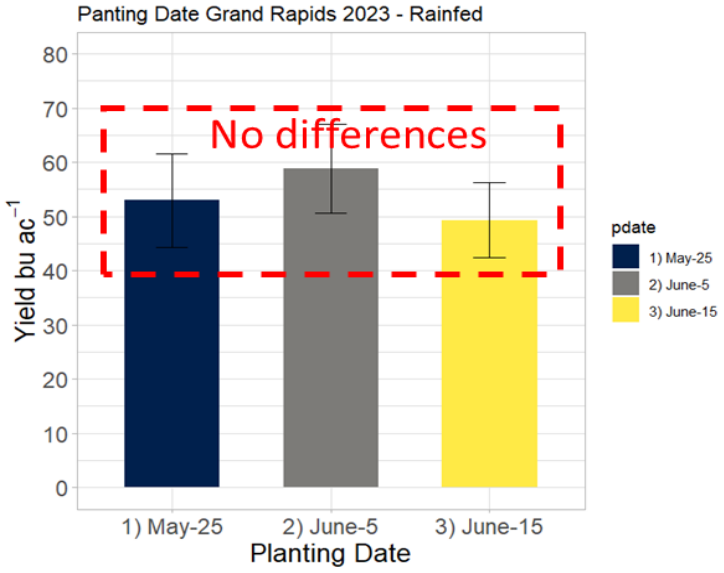

Figure 4: Effect planting date on yield for soybean at Grand Rapids for the 2023 season. Each bar is the average of four replications and three maturity groups from 0.1 to 0.8. No differences among maturity groups in any planting date were detected (p> 0.05).

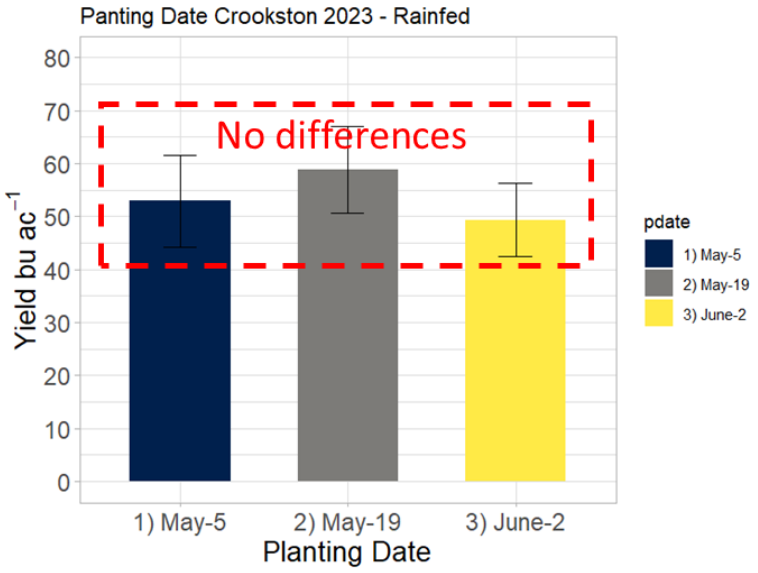

Figure 5: Effect planting date on yield for soybean at Crookston for the 2023 season. Each bar is the average of four replications and three maturity groups from 0.1 to 0.8. No differences among maturity groups in any planting date were detected (p> 0.05).

Conclusions:

In conclusion, the timing of soybean planting stands as one of the most critical management practices for farmers in Minnesota. Early planting offers distinct yield advantages but necessitates careful consideration of associated risks. Yield depression due to planting delay was relatively low during May and presented a sharp increase during June. No effect of the maturity group was found across the different planting dates. Our results indicated that particularly under conditions of water stress, there was no effect of the delay in the planting date until the end of May. Future studies should be conducted to increase our understanding of the interplay between planting dates, radiation, temperature, and water availability. This knowledge should help to make informed decisions in drought-prone environments, which constitute a significant proportion of soybean cultivation areas in the state.