Title: Evaluating the Role of Seed Placement and Planting Strategies in Optimizing Yield, Quality, and Profitability in Winter Wheat

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Project goals and value for Michigan Wheat Growers

There is interest in evaluating the benefit of precision planting technology for improved seed placement in small grains production compared to the use of a conventional seed drill. However, broadcast incorporation of wheat seed for faster planting has gained some traction in recent years with no publicly available data on its performance. Farmers are also trying to figure out the best configurations for current precision planters they have on the farms. This project compared planting equipment on commercial farms, allowing growers to learn about various planting technologies and their performance (e.g., speed of operation, accuracy, yield potential). Additionally, small plot research was utilized to study the influence of other factors, such as seeding depth, variety, time of planting, and seeding rates on plant development, yield and grain quality.

Results of Project

There was an interaction between year and planting date in determining yield ($p < .01$), likely due to differences in precipitation during the grain fill period (May–June) each year. Yield declined with delayed planting (data not shown) in every year of the study, but this decline became highly variable as planting was delayed into late October and November. Planting on October 1, October 15, October 30, or November 12 resulted in a 7–10%, 17–21%, 24–33%, and 24–47% decline in yield, respectively, compared to planting optimally on September 19. These results demonstrate the value of avoiding late planting, as well as the increased uncertainty resulting from planting delays. The reduction in yield appears to have resulted primarily from a decrease in heads ac^{-1} (data not shown; 2021: r = .66; 2022: r = .66). Heads ac^{-1} decreased by 12–20%, 24–35%, 37–40%, and 35–46% on October 1, October 15, October 30, and November 12 planting dates, respectively, compared to a September 19 planting date (data not shown). We saw no consistent response of quality factors (protein and TKW) to planting date.

Regression analysis using relative yield for a given planting date showed a consistent trend toward higher optimal seeding rates and greater yield penalties under low seeding rates as planting was delayed (Figure 1). Our results showed that there is potential to reduce seeding rates below 1.0 million seeds ac^{-1} when planting in September but that they should be progressively increased as planting is delayed into October and November, although at a lower magnitude than the current university recommendations ranging from 1.2 to 1.6 million seeds ac^{-1} under early planting and 1.6 to 2.2 million seeds ac^{-1} when planting late. The agronomically optimal seeding rates (AOSRs) for the five planting dates were 0.93 million seeds ac^{-1} for mid-September planting, 1.37 million seeds ac^{-1} for late September planting, 1.47 million seeds ac^{-1} for mid-October planting, 1.54 million seeds ac^{-1} for late October planting, and 1.85 million seeds ac^{-1} for mid-November planting. Moreover, an examination of actual yield by planting date (data not shown) showed that increasing seeding rate is not effective at reducing yield loss resulting from

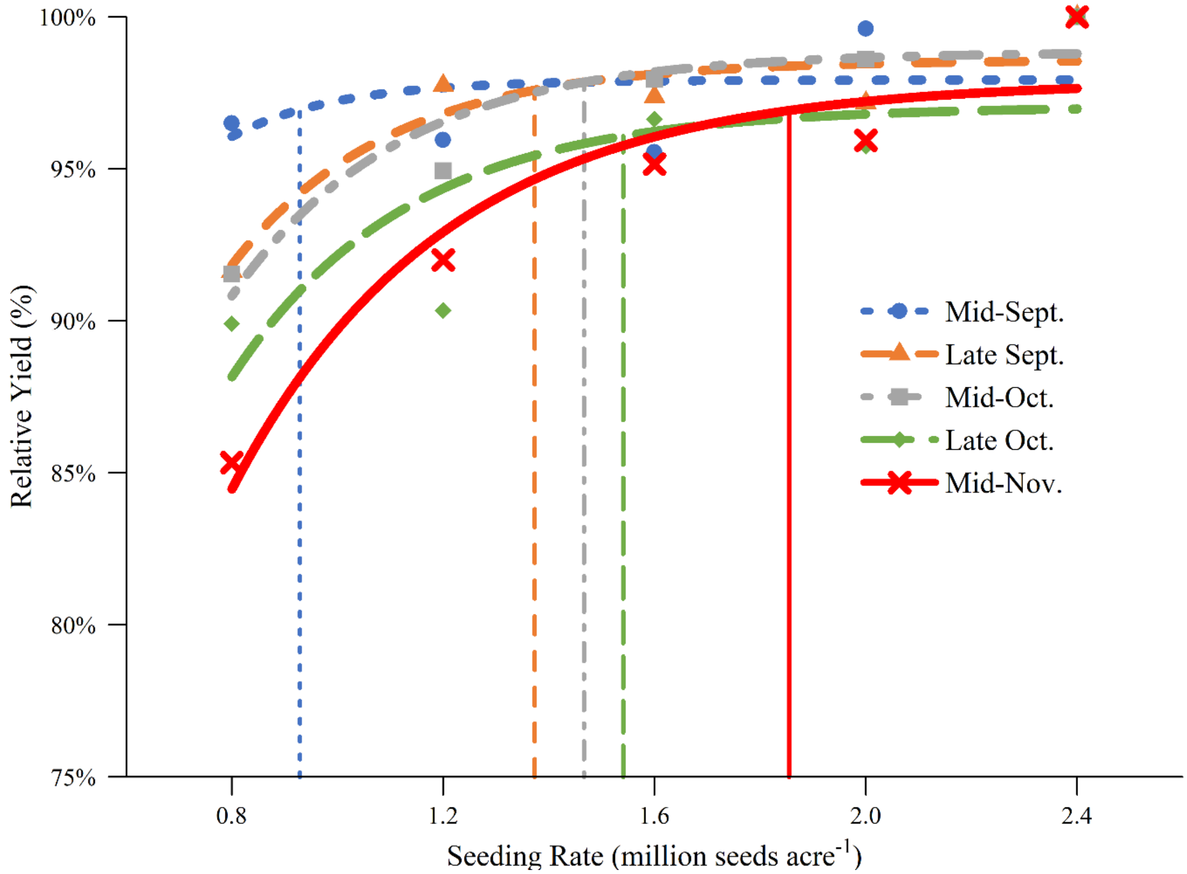

Figure 1: Regression models with least square asymptotic trendlines for winter wheat relative yield for a given planting date as a function of seeding rate across 2020–22 growing seasons in Mason, Michigan. Relative yield is defined as percentage of maximum treatment (combination of planting date and seeding rate) average within a given planting date. Vertical lines indicate agronomically optimal seeding rate (AOSR, 99% of asymptote) for the respective planting dates.

delayed planting. The reason for the lower AOSR under early planting may be because earlier planting allows more time for fall tiller production, facilitating production of more heads plant^{-1} under lower seeding rates and maintaining similar heads ac^{-1} as under higher seeding rates. Under delayed planting, the time for fall tillering is diminished, reducing the ability of lower seeding rates to achieve the same heads ac^{-1} as higher seeding rates.

Three planting methods for winter wheat, including precision planter, grain drill or air seeder, and broadcast incorporation, were evaluated for their impact on yield. Precision planting resulted in 8–33% higher yield than planting with an air seeder at 3 out of 4 site-years (Genesee 2021, Huron 2021, and Huron 2023) and 13–17% higher yield than planting with a drill at 3 out of 9 site-years (Huron 2021, Huron 2023, and Ingham 2022; Figure 2). Furthermore, there was no consistent difference in yield between plots planted using broadcast incorporation and those planted using a drill or air seeder (Figure 3); and increasing seeding rate for broadcast incorporation resulted in only a marginal (2%) increase in yield (Figure 4). Protein was similar among treatments for all site-years, and no DON was detected in any of the samples that were tested (data not shown).

The yield increase from precision planting was most directly connected to an increase in kernels ac^{-1} (data not shown). This may be driven by increased tillering resulting from a more uniform distribution of plants. This improved uniformity is likely a combination of more uniform spacing within the rows and narrower row spacing allowing for increased seed spacing within the rows and reduced spacing between rows, bringing the two measurements closer together.

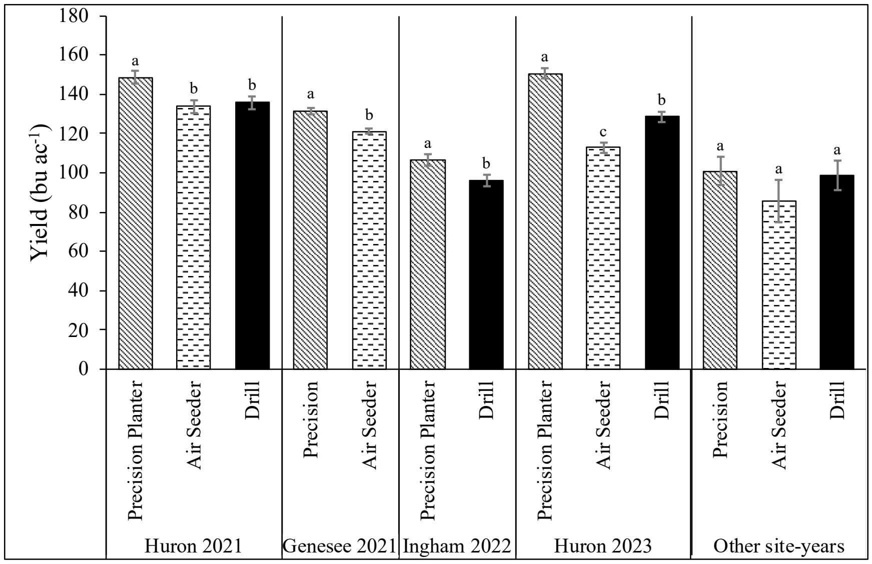

Figure 2: Winter wheat yield in plots planted using a precision planter vs a traditional grain drill or air seeder at 11 site-years in Michigan. Bars with the same letter within a site-year are not significantly different (α = .10). Other site-years represents data pooled from 7 site-years where significant differences were not observed among the tested treatments. Error bars show ±1 standard error of the mean for each treatment at each site-year.

Broadcast incorporation resulted in more variable seed depth than the other planting methods (Figure 5). Yet, despite this greater variability in seed depth and lower emergence, wheat planted using broadcast incorporation generally yielded similarly to wheat planted using a conventional grain drill. This is likely due to increased tillering of plants when broadcast incorporation is used (data not shown), resulting from a more uniform distribution of plants, which made up for any yield potential lost due to variable seed depth and low emergence. A common concern among growers is that even if broadcast incorporation performs adequately when planting within the optimal window, the lack of seed placement accuracy might exacerbate the yield penalty associated with delayed planting. This is particularly of interest since growers are more likely to resort to broadcast incorporation to speed up planting when planting is

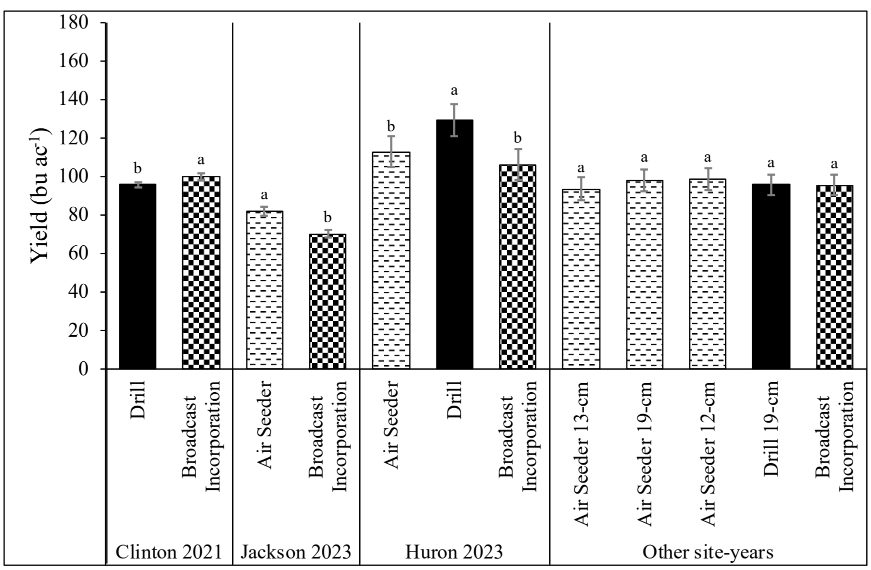

Figure 3: Comparing yield for winter wheat planted using a traditional grain drill or air seeder vs broadcast incorporation at each of 17 site-years in Michigan. Bars with the same letter within a site-year are not significantly different (α = .10). Other site-years represents data pooled from site-years where significant differences were not observed among the tested treatments. Error bars show standard error of the mean for each treatment at each site-year.

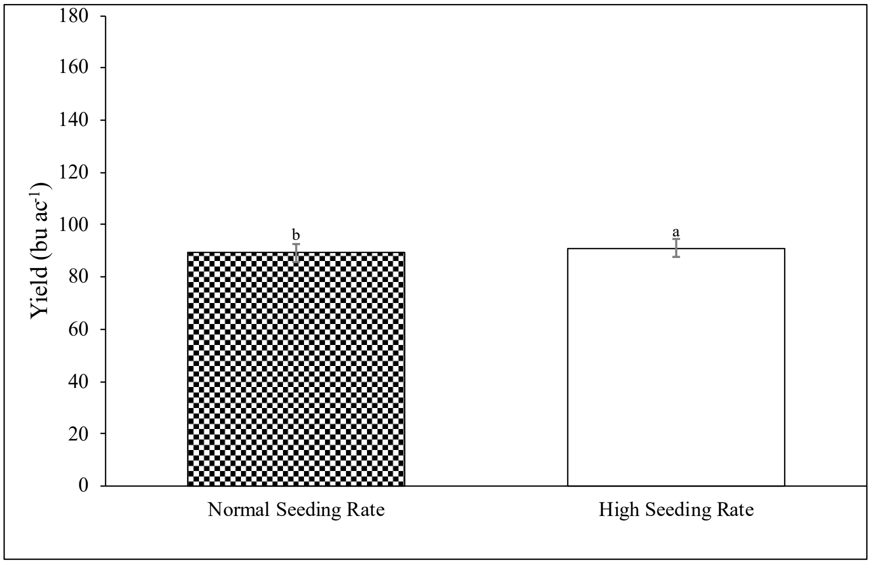

Figure 4: Comparing yield for winter wheat planted using broadcast incorporation at normal and 30% higher seeding rates across 12 site-years in Michigan. Different letters indicate that yields are significantly different (α = .10). Error bars show ± 1 standard error of the mean for each treatment.

delayed. However, we did not see a difference in yield between broadcast incorporation and conventional drill even in the three site-years that were planted after October 15, where our planting date research showed a >20% yield loss compared to optimal planting time.

Growers who utilize broadcast incorporation generally use a higher seeding rate than when planting with a drill due to the concerns related to lack of seed placement accuracy, adding to production costs.

While we did see a marginal yield increase from increasing seeding rate, the difference was likely not sufficient to justify the additional cost of increasing seeding rate. However, growers may still choose to increase seeding rates as an insurance policy against stand-reducing factors.

There were no significant interactions (α = .05) between seeding depth, seeding rate, and coleoptile length in determine yield for any of three growing seasons (data not shown), suggesting that coleoptile length and seeding rate did not have an impact on how seeding depth influenced yield. Therefore, further analysis of our seeding depth study focused on the main effect of seeding depth. In 2022, regression analysis showed a significant, but relatively weak (R^2 = .42), relationship between seeding depth and yield (Figure 6), with maximum yield of 147 lbs ac^{-1} being achieved at the shallowest depth (0.51 in). In 2021 and 2023, there was no significant relationship between seeding depth and yield. Similarly, we saw higher emergence rates at shallower depths (though again with a low R^2 of .40) in 2022 but not in 2021 or 2023 (data not shown). An examination of the daily emergence data also shows faster emergence with shallower seeding depths in 2022 but no discernible trend in 2023 (data not shown).

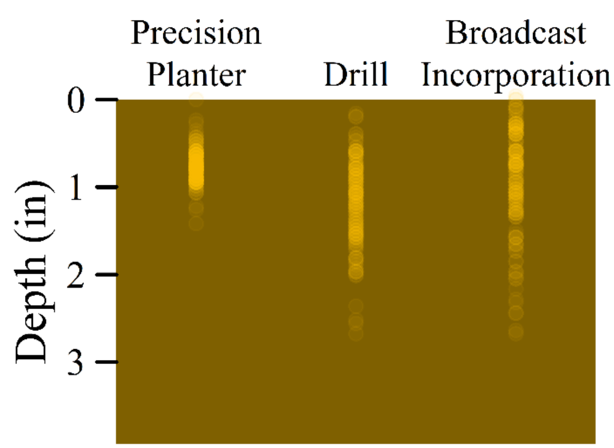

Figure 5: Seed depths measured in Tuscola County, Michigan, in the 2021–22 growing season for winter wheat planted using precision planting, conventional grain drill, and broadcast incorporation, illustrating the differences in depth variability for each planting method.

Lodging was minimal across all years and treatments with no significant trends. Since the study was conducted on the same farm across all three years, the differences between 2022 and the other years are likely weather-related. Warmer fall weather for the 2022 growing season (data not shown) likely allowed for more fall tillering, leading to higher yields, as suggested by the spring stem counts, which were higher under shallower planting (Figure 7). This suggests that warmer fall weather, perhaps combined with adequate rainfall throughout the growing season (data not shown), allows shallower-planted wheat to take advantage of faster emergence to produce greater yields. However, under less ideal conditions, the benefits of shallower planting are balanced out by the risks of shallower planting, eliminating the impact of seeding depth on yield.

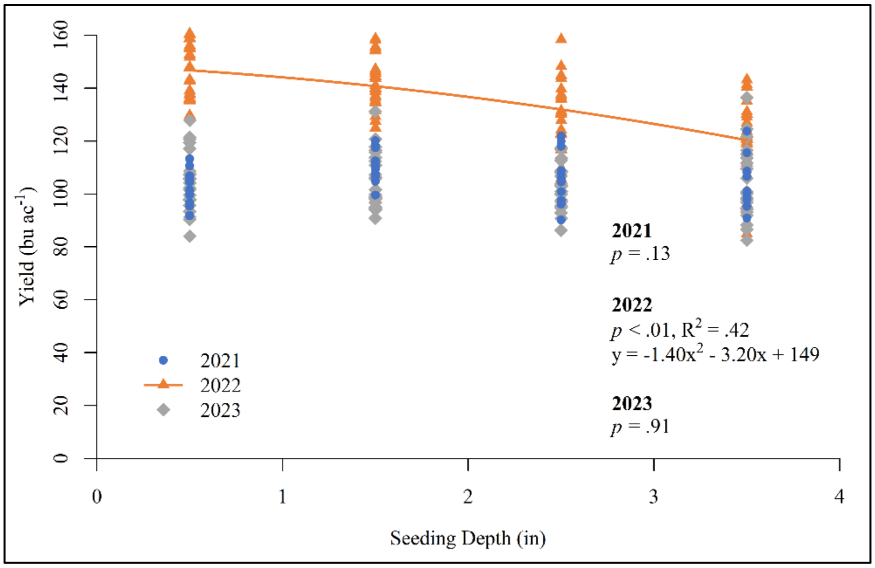

Figure 6: Yield as function of seeding depth, using quadratic regression, in field trials in Mason, MI in 2020–21, 2021–22, and 2022–23 (referred to as 2021, 2022, and 2023, respectively).

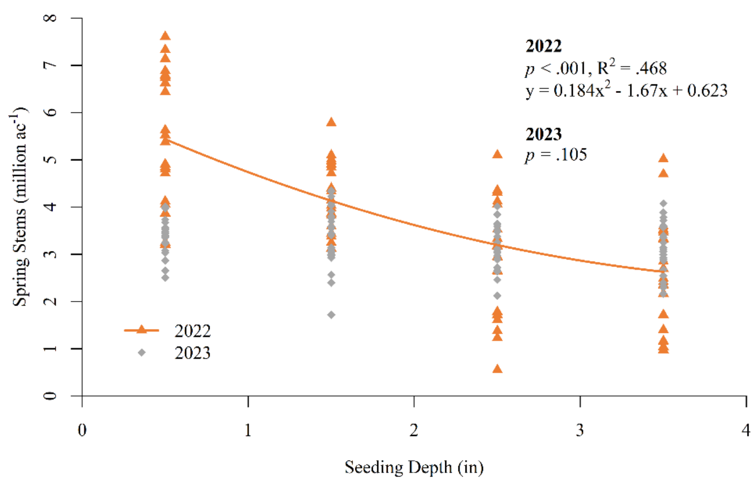

Figure 7: Spring stem counts as function of seeding depth, using quadratic regression, in field trials in Mason, MI in 2021–22, and 2022–23 (referred to as 2022 and 2023, respectively).

Summary

In this research, we saw that timely planting of winter wheat (within a few days after the Hessian fly free date) is critical for maximizing yield, with significant yield reductions occurring when planting is delayed beyond the optimal planting window. Therefore, efforts should be made to identify strategies that will enable farmers to achieve early planting in the face of the realities of weather variability. We also saw that increasing seeding rates will not make up for yield potential lost due to delayed planting, but seeding rates should be progressively increased as planting is delayed beyond the recommended planting window to minimize the reduction in yield potential. Furthermore, planting within the optimal window provides potential to reduce seeding rates even below 1.0 million seeds ac^{-1} due to the reduced yield response to seeding rate under earlier planting. We also found that precision planting in narrow rows has potential to improve yield in winter wheat compared to traditional grain drills and air seeders, but consideration should be given to the cost of precision planting equipment when making the decision to switch from less expensive conventional technologies. For those looking for faster or cheaper ways to plant winter wheat, broadcast incorporation is a viable option, resulting in similar yields to a grain drill or air seeder at similar seeding rates. However, growers should be aware that this planting method does result in variable seed depth and reduced emergence, which could negatively impact yield under certain soil, climatic, or management conditions not encountered in this study. In the seeding depth portion of this research, we saw that seeding depth generally had little impact on yield in winter wheat, regardless of variety genetics or seeding rate. However, in years where fall weather is warm and there is sufficient rainfall, shallower seeding depths may exhibit improved yield due to faster emergence and increased fall tillering. Based on this, we can infer that, in most years, planting methods with poor depth control might be sufficient to achieve maximum yields, but in years with favorable weather conditions, yields may be improved by combining more precise planting methods with shallower seeding depths. On the other hand, growers should be careful about planting too shallow, as shallow-planted wheat can be more prone to winterkill or lodging under conditions favorable to these problems.

Future Work

Future work will focus on best management practices based on canopy architecture type (i.e., erect vs. droopy), including interactions with planting date, seeding rate, row spacing, and use of precision planting technologies. A new custom 10-foot precision planter has been purchased that includes two gangs of row units to allow for planting in 5-inch row spacing in a single pass. This should help to avoid some of the challenges and inaccuracies we have seen in planting with a narrower planter and using two passes to achieve 5-inch row spacing with a 10-inch planter. Furthermore, a new planting date study will be conducted that will include planting times earlier than the current recommendations with an emphasis on determining the current optimal planting time.

Project Changes

Not applicable, as this is a final report.

Budget Narrative. As described in proposal.

Intellectual Property. None.

Approach to Disseminate Research

Multiple extension articles have been published so far using the findings from this research. Data from this project was also presented at the American Society of Agronomy's 2021 and 2022 annual meetings, and Patrick won the 1st place award in the 2021 Precision Agriculture community's MS student competition. Research results will be posted on the MSU Agronomy website, as well as presented at winter grower meetings and field days. An article for the Wheat Wisdom newsletter can be submitted in any month.