Title: Optimizing planting practices in winter wheat: role of precision planting, row spacing, seeding rate, and varietal canopy

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Project goals and value for Michigan Wheat Growers

The overall goal of this research is to evaluate planting practices that can help develop an ideal wheat canopy, maximizing interception and use efficiency of solar radiation, leading to sustainable yield and profit improvements for growers in Michigan and across the Great Lakes Region. Growers will learn about the implications of precision planting technology that is scalable to their farms and can be used for multiple crops. If successful, this approach could lead to improved yield and profitability for Michigan wheat growers by matching row spacing with ideal seed placement, seeding rate, and varietal canopy.

Results of Project

A field trial (plot-scale) was conducted at KBS (Kellogg Biological Station) in Hickory Corners, MI during the 2023-24 growing season. A precision planter was used to plant in row spacings of 5”, 10”, and 15”. A conventional seed drill was used to plant in typical 7.5” rows, as well as 15” row spacing. Two droopy or planophile varieties (AgriMAXX 513, Dyna-Gro 9070) and two erect or erectophile varieties (MCIA Wharf, KWS 405) were tested under all five row spacing comparisons, for a total of 20 treatments. The experiment design was a randomized complete block design with four replications. Red clover was frost-seeded in all plots. Other management followed MSUE recommendations (e.g., Sept planting, 1.2 million seeds/ac).

A second complementary trial was conducted at KBS during the 2023-24 growing season to quantify optimal wheat seeding rate. A precision planter (5” row spacing) and conventional seed drill (7.5” row spacing) were used to plant winter wheat at four seeding rates (0.4, 0.8, 1.2, and 1.6 million seeds per acre) in a randomized complete block design with four replications. An erect canopy variety (MCIA Wharf) was used for this trial, planted during the optimal window (end-Sept.).

Measurements included soil moisture and temperature from field sensors in a subset of plots, daily weather from closest MAWN (Michigan Automated Weather Network) station, plant stand count on fall, seed depth, seed-to-seed spacing, pre-harvest stem and effective head count (Feekes 11.4), tiller angle using width between tillers at 30cm from soil level, percentage of intercepted radiation across four different canopy height using Delta-T Sunscan Canopy System (Feekes 10.5), yield, and grain quality. Around a month past harvest, red clover biomass was harvested from a subset of treatments to assess total dry biomass and determine establishment differences across different row spacings. Only a subset of data are presented here for brevity, rest are available upon request.

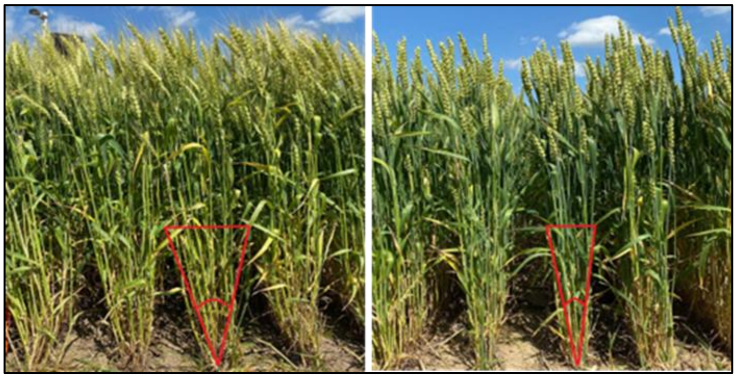

Fig. 1. Droopy (1) versus Erect variety (2) and the visual difference in tiller angle capture on the field.

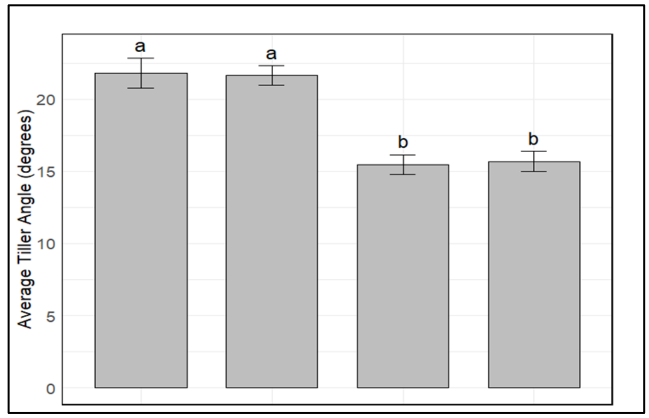

Fig. 2. Tiller angle of two canopy types: Droopy (left) and Erect (right).

Winter wheat varieties differed in their canopy architecture. This difference was visually observed in field (Fig. 1) and was quantified (Fig. 2) by estimating tiller angle using width between tillers at 30cm from soil level. Droopy varieties showed greater tiller angle (21.0˚) compared to Erect (15.1˚) varieties.

There was a difference in light interception when comparing droopy vs. erect varieties planted with different equipment (see fig. 4 below) in narrow and wider row spacings, due to the differences in their canopy architecture. Droopy varieties showed greater light interception in all layers of wheat canopy compared to erect varieties across row spacings (Fig. 3). Droopy canopies tend to intercept more light because they reach canopy closure quickly and capture a larger amount of seasonal radiation compared to erect canopies. Greater differences were noticed in middle layers of the canopy. In narrow rows (5”), erect varieties allowed greater light penetration through the canopy compared to their planophile counterparts. This can help improve radiation use efficiency in these dense canopies, and suggest that erect varieties can be ideal for high yielding environments (e.g., narrow rows, early planting).

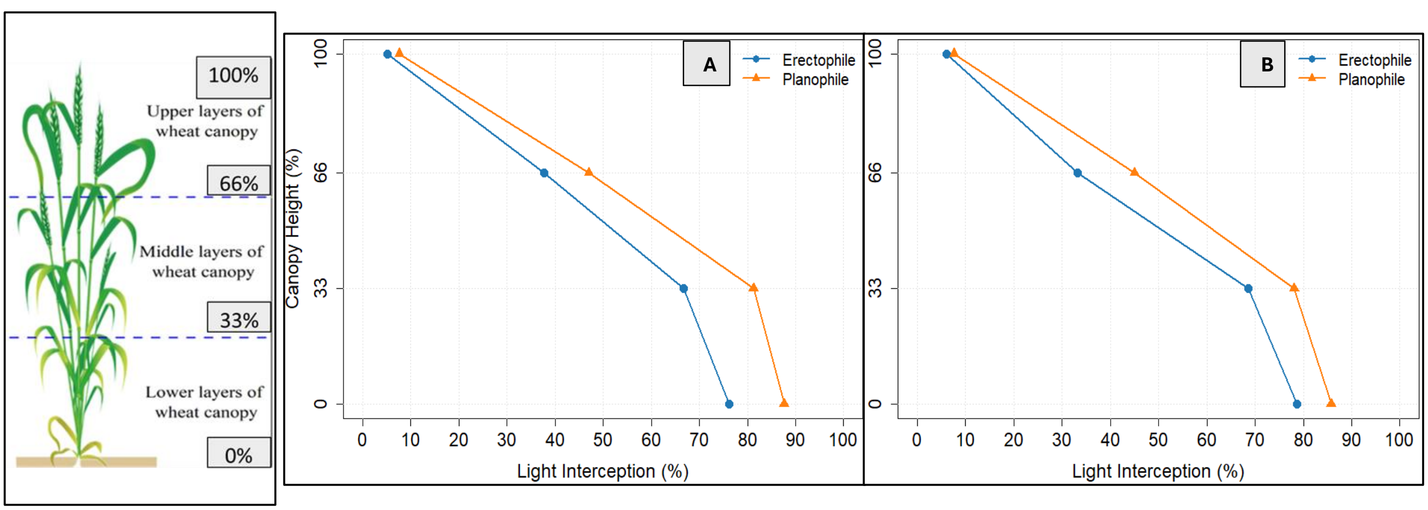

Fig. 3. Intercepted Photosynthetic Active Radiation (PAR) measured in four different layers within wheat canopy (**0% = soil surface; 0-33% = lower layer; 33-66% = middle layer; 100% = top layer of the canopy**) for two row spacing (A: 5”, B: 7.5”) across two canopy architectures.

Canopy coverage pictures were taken in different growth stages throughout the season and pictures were analyzed using Canopeo App. Narrow row spacing closed canopy faster than other rows spacings across varietal canopy types (Fig. 4), with 15” rows never reaching canopy closure during the growing season. Planophile varieties achieved greater canopy coverage in 15” rows compared to erectophile varieties, indicating potential benefit of such varieties under wider row spacings (and other environments where light interception can be a limiting factor).

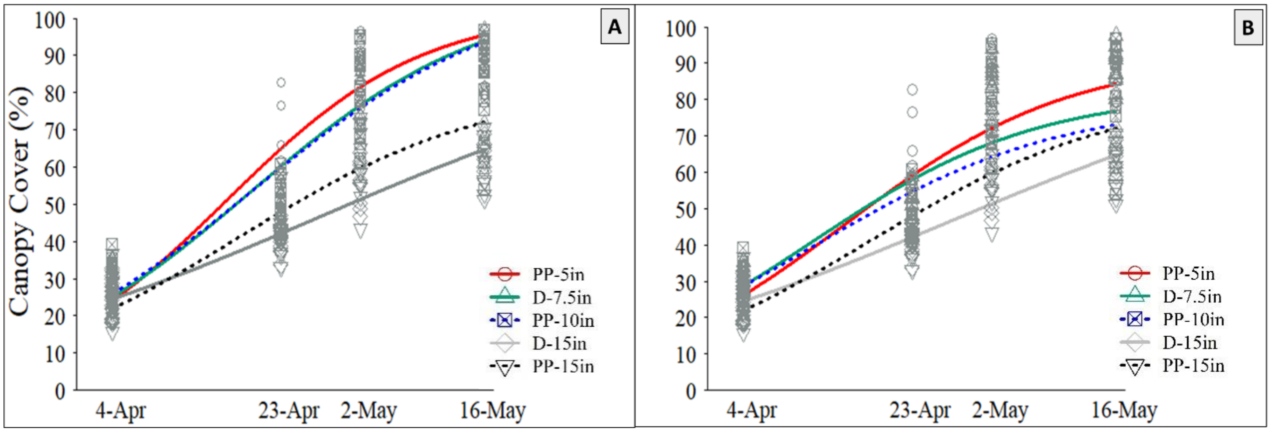

Fig. 4. Canopy cover (%) across various row spacings (PP- precision planter, D- drill – see fig. 4 below) for (**A)** planophile varieties and (B) erectophile varieties

We compared different seeding rates using both planting methods (Fig. 4), a precision planter (5” row spacing) and conventional seed drill (7.5” row spacing). All seeding rates expressed in final plant population were regressed against yield and the best model was fitted to the data (asymptotic through the origin). Plant population for maximum yield (intercepting line) was lower for precision planter (in 5-in) with 1.03 million plants ac^{-1} compared to 1.6 million plants ac^{-1} (highest rate in our trials) for conventional drill (7.5 in row spacing). Lower optimal population (and seeding rate) with precision planting equipment indicate potential for cost savings by reducing seeding rate without any yield penalty.

Fig. 4. Two planting methods used in the study: Grain drill (left) and precision planter (right).

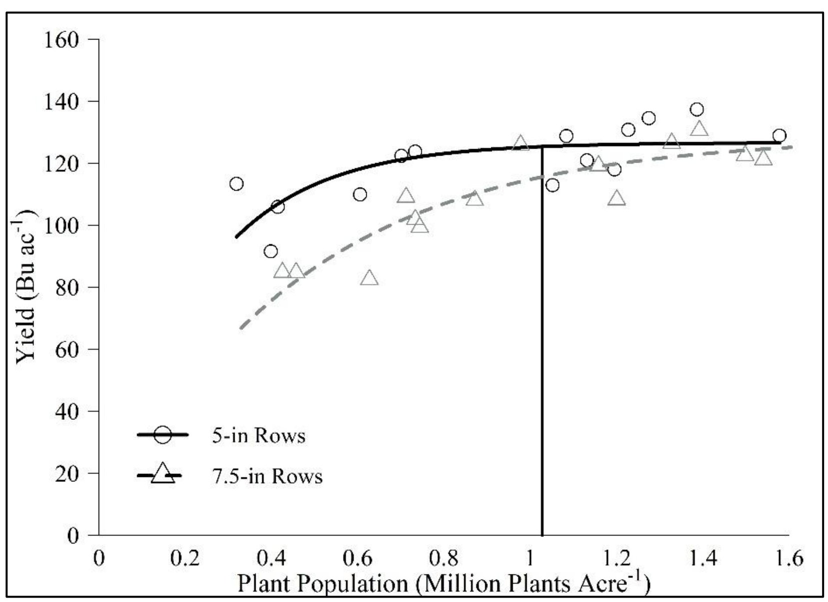

Fig. 5. Yield response to plant population for precision planter (5-in rows) and drill (7.5-in rows). Vertical line: optimal population for 5-in

An increasing trend in wheat yield with narrower row spacings was observed (Fig. 6, $p < 0.05$), with greatest yield observed in 5-in spacing (114.7 Bu ac^{-1}). Erectophile canopies showed a trend of achieving higher yields under narrow rows, while planophile canopy performed better under wider rows. These data showed the potential of combining narrow rows, precision planting, and erectophile canopies for improving yield potential in winter wheat.

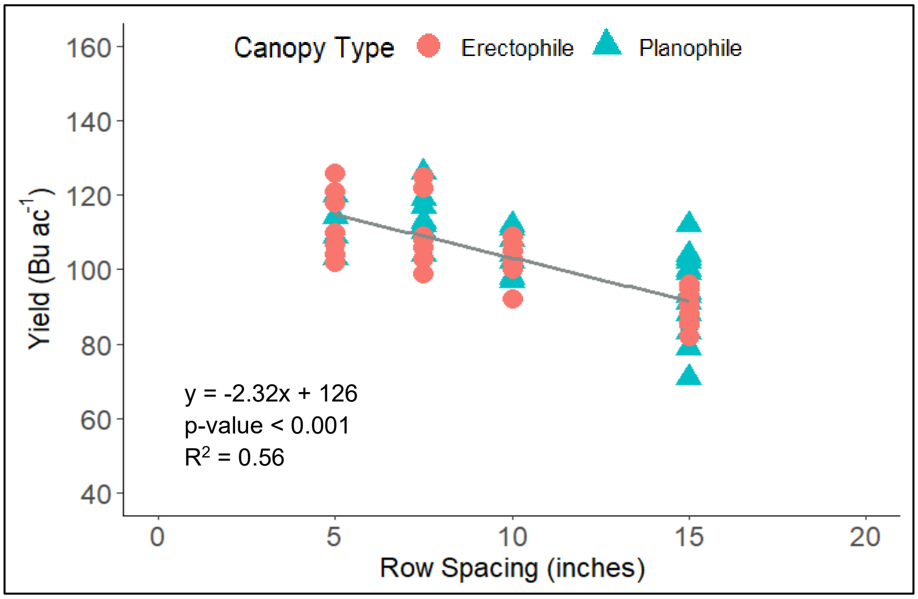

Fig. 6. Wheat yield (at 13.5% moisture) for two canopy types (Erectophile and Planophile) across different row spacings (5, 7.5, 10, and 15 in).

Another variable measured was seed depth (Fig. 7), collected from the seeding rate trial on plots of 1.2 million seed per acre treatment. Precision planter (monosem_5") presented lower coefficient of variance (12.8) and greater seed depth (1.5 inches) when compared to drill treatment (19.7 and seed depth of 1.3 inches). Overall, precision planter helped improve seed placement accuracy and able to plant wheat in narrow rows (5").

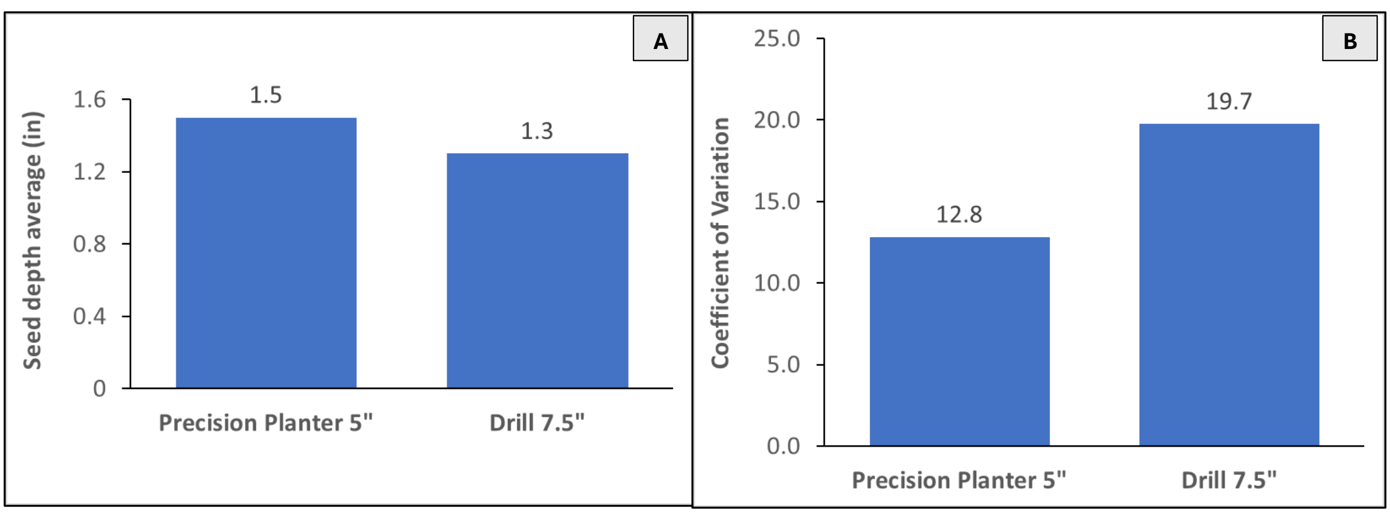

Fig. 7. **(A)** Seed depth average (inches) measured on 15 plants per plot from different rows for precision planter (5in row spacing) and drill (7.5in row spacing). **(B)** Coefficient of variation extracted from the data.

To evaluate seed distribution in the soil bed by the two planting methods used in the study, plant-to-plant spacing was measured in the fall (Fig.8) between 15 to 20 days after planting in a subset of treatments using a meter stick in four different rows per plot (four row meters). Precision planter showed a lower coefficient of variance (0.7) compared to drill (1.0), showing that seeds were distributed with greater uniformity using precision planter.

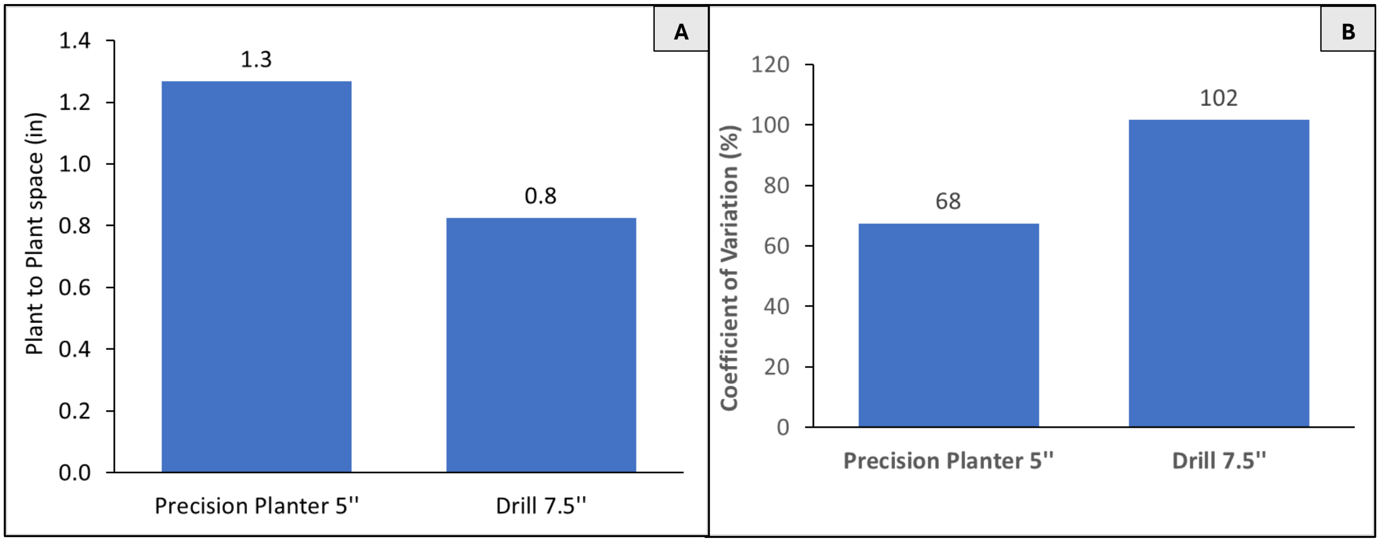

Fig. 8. **(A)** Plant-to-plant space (inches) measured 20 days after planting from 4 different rows (4 row meters in total). **(B)** Coefficient of variation extracted from the data.

Data analyses are ongoing on multiple other variables from field trials associated with this project and results will be presented in future meetings and reports.

Summary

Preliminary data from the first year of this research showed that precision planter improved seed placement accuracy and plant wheat in narrow 5” rows. This resulted in yield improvement over wheat planted using drill in 7.5” row spacing. Additionally, varieties with erectophile canopies decreased shading in bottom of canopies in narrow row spacings and helped improve yield potential under these high yield environments. Planophile varieties increased light interception under wider 15” rows and helped minimize yield losses in such environments.

Moreover, the optimal seeding rate was lower for precision planter than grain drill, presenting an opportunity for farmers to reduce their annual seed cost and increase profits from wheat production. Overall, our results demonstrated that wheat yield and profits can be enhanced by improving seed placement accuracy, reducing row spacing and seeding rates, and matching variety canopies to fit yield environments.

Overall, canopy architecture has shown the expected relationship with yield across row spacings and seeding rates, but additional site years are needed to test our objectives and hypotheses. Data from the first year has validated some of our hypotheses, and we will continue collecting data from multiple site-years in our efforts to develop recommendations for growers.

Future Work

A similar project was submitted to project GREEEN in Jan 2024 to support a graduate student who can lead extensive data collection involved with project objectives. That effort was successful, and we received ~$100,000 funding over 2 years that will support a graduate student (Wallas da Silva) till Summer 2026.

Continued funding from MWP will be used to cover most expenses related to conducting the field trials. Future USDA submission will also involve targeted breeding efforts based on canopy architecture and explore other management decisions in narrow rows.

We are also looking into purchasing a narrow row drill (~5" row spacing) that can be used to compare against narrow rows using a precision planter. Multiple other programs at MSU have also shown interest in narrow row wheat research. The upcoming season of this project would be a good place to start this work, if we can find resources to make this purchase.

Project Changes

Changes for the upcoming year included replacement of two varieties, Dyna-Gro 9070 (Droopy) and KWS 405 (Erect), due to seed being discontinued or not provided in time or quantity for planting by the seed source company. Two new varieties are MCIA Jonah (Droopy) and AgriMAXX Mackinaw (Erect). A second location was added, located on campus at MSU Plant Pathology farm.

Budget Narrative. As described in the proposal.

Intellectual Property. None.

Approach to Disseminate Research

Project findings were shared with growers at multiple field events and extension meetings organized by MWP and MSUE. Data from this project was presented at the American Society of Agronomy's 2025 annual meeting and won a third-place award in the wheat community. Research results will be posted on the MSU Agronomy webpage (agronomy.msu.edu), as well as presented at winter grower meetings and field days. We plan to submit an article for the Wheat Wisdom newsletter in future as well.