Exploring Planting Strategies and Variety Canopy Architecture for Maximizing Winter Wheat Yield

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Introduction

- To maximize winter wheat (*Triticum aestivum* L.) yield, crop canopy architecture should be designed to optimize interception of solar radiation as well as its and its use efficiency.
- This can be achieved by optimizing various planting strategies such as seed placement accuracy, row spacing, seeding rate, as well as selection of ideal wheat varietal canopy architecture.
- Recently concluded research has tested some of these practices along with their yield benefits and showed 8–33% yield increase by using narrow row spacings (Fig. 1) using precision planting compared to conventional drill.
- However, non-ideal precision planting equipment was used in these studies resulting in non-uniform row spacing.
- Moreover, interaction between various practices (e.g., row spacing and variety canopy types) were not studied for any synergistic benefits.

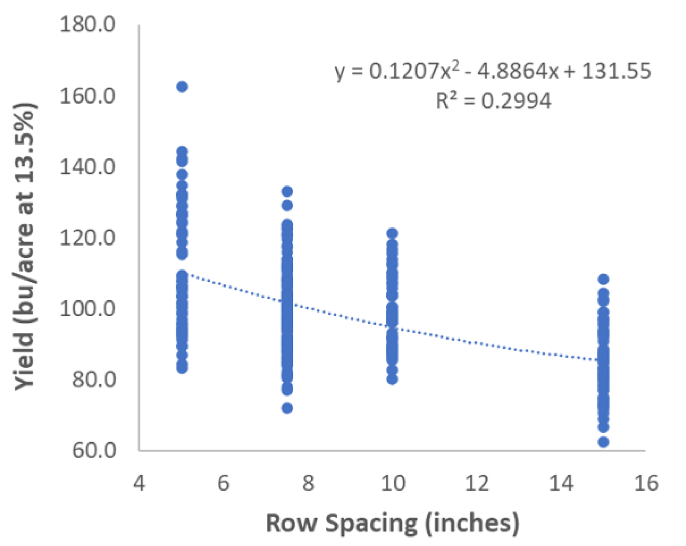

Fig. 1. Relationship between row spacing and winter wheat yield over 2 years (2018-2019) at 2 locations in Michigan.

Objectives

- Evaluate planting methods (and row spacings) in winter wheat for their impact on seed placement and canopy development.
- Quantify difference in wheat varietal canopy architecture and their implication on interception and use efficiency of solar radiation as well as seed yield.
- Compare the optimal seeding rate in winter wheat planted using a precision planter and a conventional grain drill.

Fig. 2: Custom build Monosem precision planter with capacity to plant in 13 cm row spacing (using 2 toolbars, with row units spaced 26 cm apart on each)

Materials and Methods

- Field trials were conducted in Hickory Corners, MI comparing two planting methods (Fig. 3), allowing four row spacings (13, 19, 25, and 38 cm), using four varieties with differing canopy architecture (Fig 4).

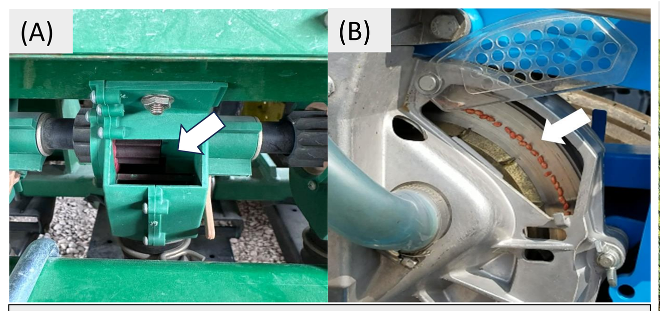

Fig 3: Grain drill **(A)** no metering system; Precision Planter **(B)** with seed disc

Fig 4: Wheat in **(A)** 13 cm rows, **(B)** 38 cm rows, using **(C)** Planophile variety, **(D)** Erectophile variety.

- SunScan Canopy Analysis System was used to measure radiation interception at four canopy heights.
- Tiller angle (Fig 4 c-d) was measured to quantify differences in varietal canopy architecture (Fig 6).
- Canopy coverage was measured using Canopeo app at around 10 days interval until full canopy cover.
- A second field trial was conducted comparing precision planter (13-cm rows) and conventional drill (19-cm rows), using four seeding rates (ranging from 0.98 to 3.95 million seeds ha^{-1}).
- All trials were laid out in randomized complete block design with four replications.

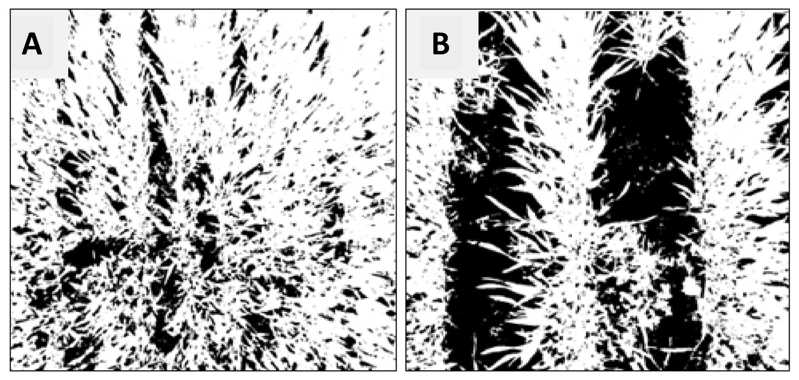

Fig 5: Canopy cover image from canopeo app for 13 cm (A) and 38 cm (B) row spacing.

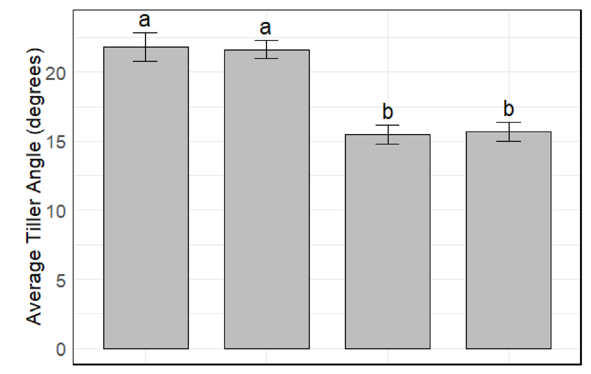

Fig. 6. Tiller angle of two canopy types: planophile (left) and erectophile (right).

Results

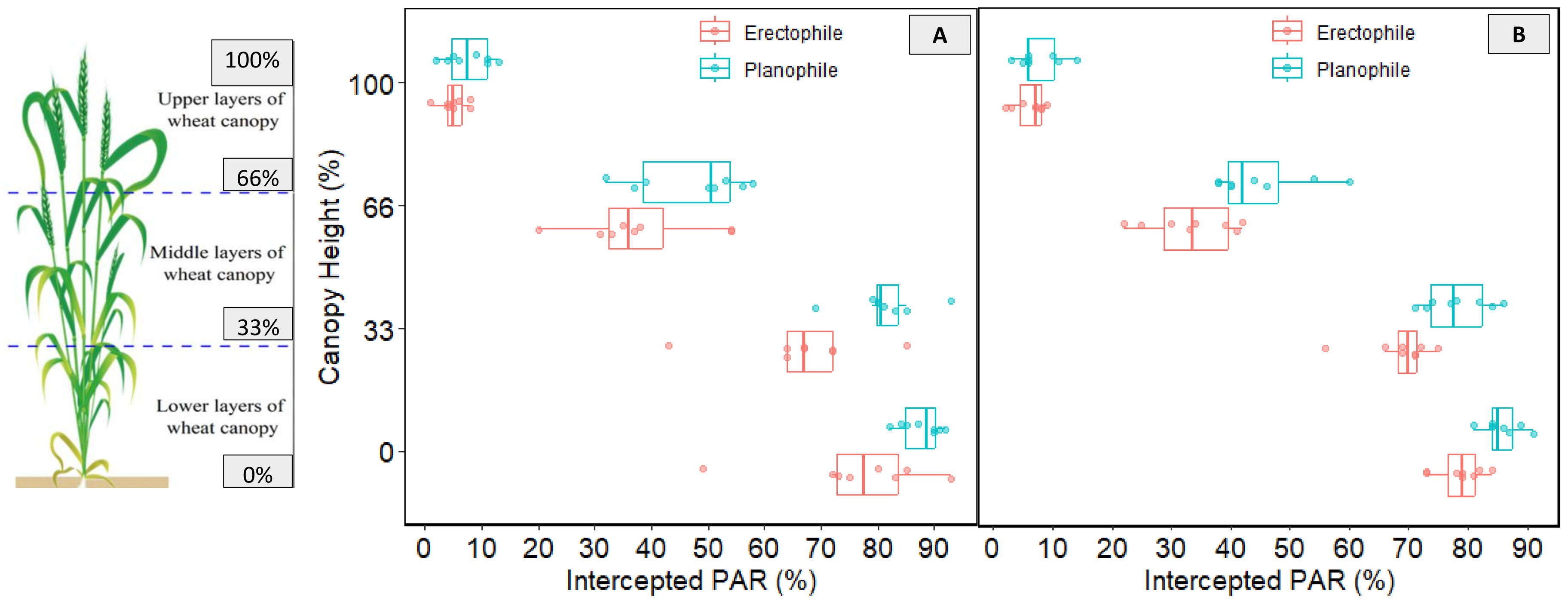

Figure 7. Intercepted Photosynthetic Active Radiation (PAR) measured in four layers within wheat canopy (**0% = soil surface; 0-33% = lower layer; 33-66% = middle layer; 100% = top layer of the canopy**) for two row spacing (A: 13 cm, B: 19 cm) across two canopy architectures.

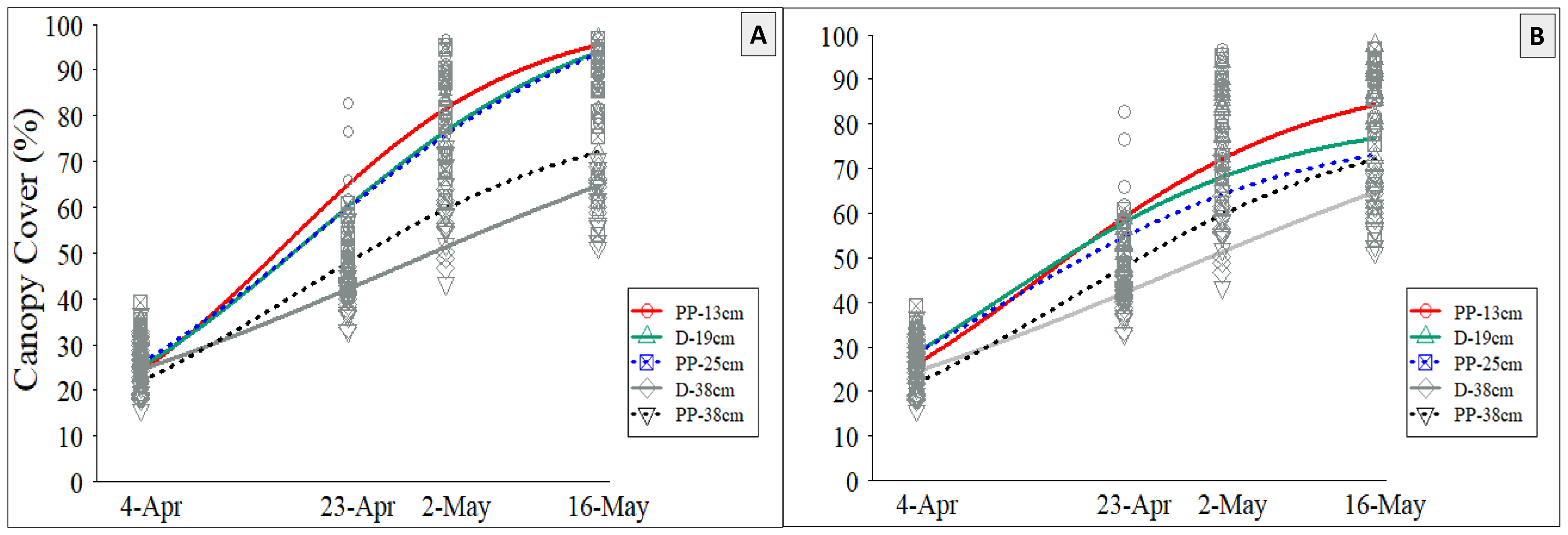

Figure 8. Canopy cover (%) across various row spacings (PP- precision planter, D- drill) for **(A) planophile varieties** and **(B) erectophile varieties.**

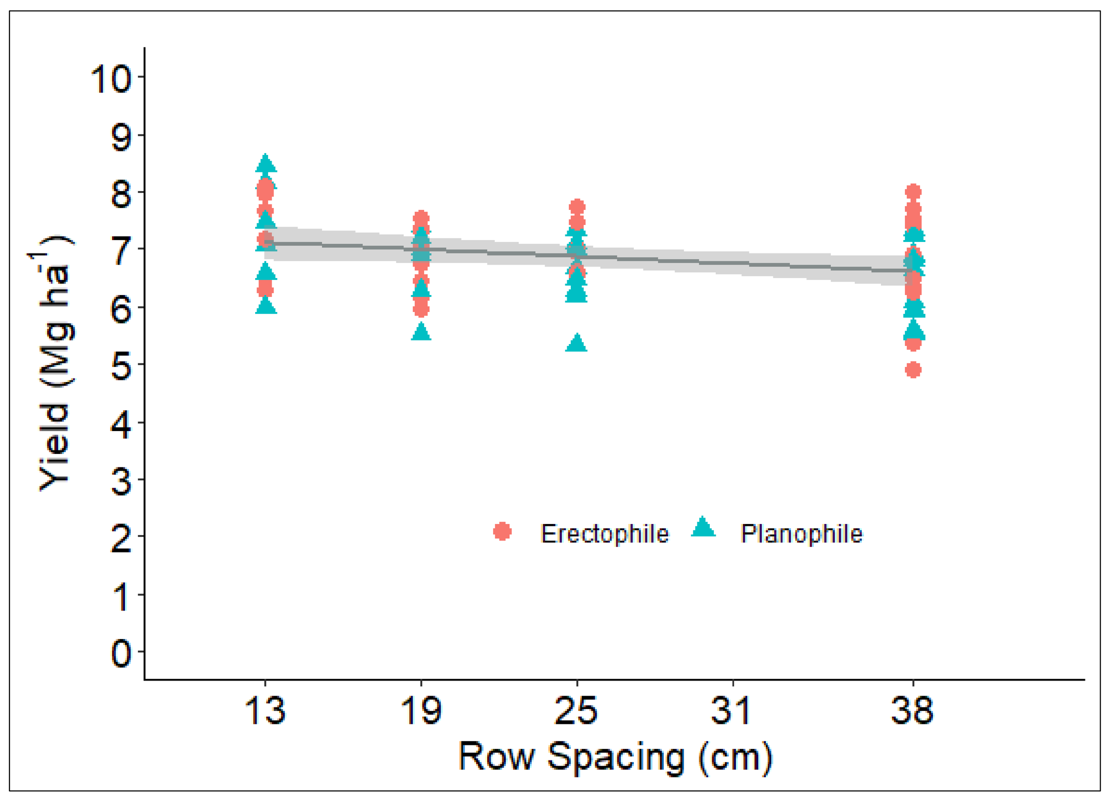

Fig. 9. Wheat yield (at 13.5% moisture) for two canopy types (Erectophile Planophile) across different row spacings (13, 19, 25, and 38 cm).

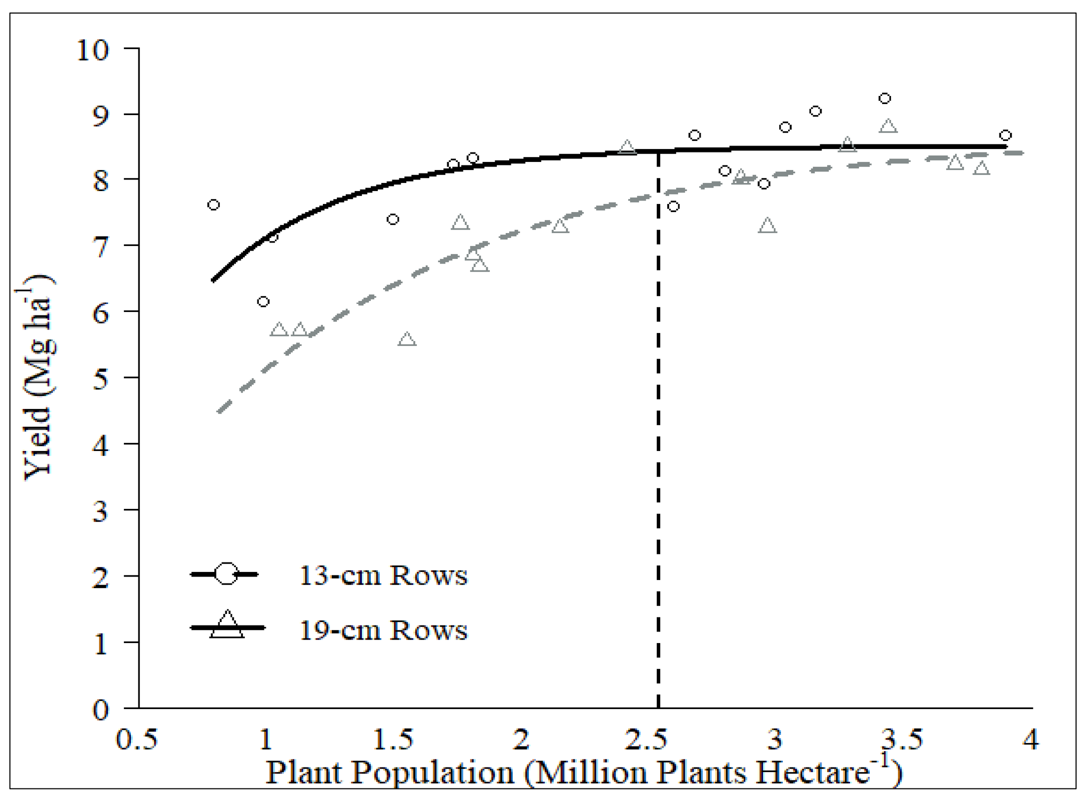

Fig. 10: Yield response to plant population for precision planter (13-cm rows) and drill (19-cm rows). Vertical line: optimal population for13-cm.

Discussions

- Precision planter had lower variability in seeding depth as well as sees-to-seed spacing (data not shown).
- Winter wheat varieties differed in their canopy architecture, with planophile varieties showing greater tiller angle (20˚) compared to erectophile (15˚) varieties (Fig. 6).
- Planophile varieties showed greater light interception in all layers of wheat canopy compared to erectophile varieties across row spacings (Fig. 7). Greater differences were noticed in middle layers of the canopy.
- In narrow rows (13 cm), erectophile 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).
- Narrow row spacing closed canopy faster than other rows spacings across varietal canopy types (Fig. 8), with 38-cm rows never reaching canopy closure during the growing season.
- Planophile varieties achieved greater canopy coverage in 38-cm 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).
- An increasing trend in wheat yield with narrower row spacings was observed (Fig. 9, $p < 0.05$), with greatest yield observed in 13-cm spacing (7.02 Mg ha^{-1}). Erectophile canopies showed a trend of achieving higher yields under narrow rows compared to wider rows.
- These data showed the potential of combining narrow rows, precision planting, and erectophile canopies for improving yield potential in winter wheat.
- Plant population for maximum yield was lower for precision planter (in 13-cm) with 2.53 million plants ha^{-1} compared to 3.95 million plants ha^{-1} (highest rate in our trials) for conventional drill (19 cm 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.

Conclusions

- Precision planter helped improve seed placement accuracy and plant wheat in narrow rows (13 cm). This resulted in yield improvement over wheat planted using drill in 19 cm 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 rows and can help minimize yield losses in such environments.
- Moreover, 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.

Future Directions

- Compare planting systems (optimal vs farmer practice) at field-scale and incentivize industry in development of multi-crop precision planting systems (e.g., for wheat and soybean).
- Evaluation of broader set of varieties for their canopy type and work with breeders in selection of this trait in the germplasm and inclusion in variety release information.

Acknowledgements and References

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