MI Craft Beverage Council Final Report

Proposal Title: Role of planting date and seeding rate in optimizing winter survival, yield and quality of malting barley (grant# 21 * 1197)

Principle Investigator: Dr. Maninder "Manni" Singh (MSU Cropping Systems Agronomist)
Graduate student: Patrick Copeland

Abstract: Although winter malting barley is of interest to Michigan farmers and maltsters, there are gaps in knowledge on agronomic management. The goal of this project is to evaluate the role of planting date and seeding rate in optimizing winter barley production. Variety Teepee was planted at five different dates (mid-Sept. to mid-Nov.) and five different seeding rates (0.8 to 2.4 m seeds/ac) at Mason, MI. Results continue to show that early planting (end Sept to early Oct) is critical in maximizing yield and malt quality. Relatively higher seeding rates ($\geq$ 1.6 m/a) were required but did not change with delay in planting.

Goals and Objectives: The overall goal of this project is to evaluate the role of planting date and seeding rate in optimizing winter survival, yield, and quality of malting barley. This will maximize quality of locally grown malting grain, leading to improved farmer and maltster profitability. Our specific objectives are to:

- Evaluate the impact of planting date and seeding rate on stand establishment, winter survival, and grain yield of winter malting barley. Hypothesis: delayed planting will result in poor winter survival and lower plant stand, increasing seeding rate will compensate for negative impacts of delayed planting.
- Improve winter malting barley quality by optimizing planting date and seeding rate. Hypothesis: planting too late will lead to poor grain quality; poor stand establishment will result in variable grain quality.

Material and Methods: Winter barley (variety: Teepee, selected in consultation with Vince Coon) was planted at MSU Mason research farm during the 2020-21 growing season. Field experiment was laid out in a split plot design with four replicates. Main plots consisted of five planting dates (Sept. 17, Sept. 29, Oct. 14, Oct. 29, and Nov. 12), starting soon after hessian fly free date (Sept 17 for Ingham County). Subplots consisted of five seeding rates (0.8, 1.2, 1.6, 2.0, and 2.4 million seeds/acre) and consisted of six rows spaced 7.5'' apart and 12'' in length, with a 6' alley between plots. Plots were planted with an Almaco HD grain drill equipped with a packet planter. All general winter barley management practices except treatments were consistent across plots. Nitrogen application was limited to 75 lbs N/ac in spring (30 lbs/ac in fall) to limit protein accumulation (compared with 120 lbs N/ac spring target in wheat). Affinity Broadspec (0.8 oz/ac) was applied for weed control. Prosaro (8 oz/a) was applied around Feekes 10.5.1 (flowering) to control Fusarium head blight and associated deoxynivalenol (DON) accumulation. Data collection in-season included stand counts in the fall, winter survival, and canopy cover (using canopeo app). At maturity, plots were harvested with a Winterstieger

Quantum research combine equipped with an H2 Harvest Master system to obtain yield, moisture, and test weight. A subsample from each plot was collected for malt quality analysis including kernel weight and uniformity, protein, moisture, pre-harvest sprout, DON, germination, and plumpness. Proc GLIMMIX in SAS was used to test treatment effects. Planting dates, seeding rates, and their interactions were treated as a fixed effect. Replication was treated as random effects.

Results and Discussion: Data on yield and important quality parameters are reported here since farmers will be more interested in yield response to treatments while masters will be more interested in quality parameters. Other data (stand, canopy cover, test weight, moisture, DON, pre-harvest sprouting etc.) are available but not reported here. Data reported here is from second year of field trials. It is recommended to use data from multiple site years while making decisions on management practices. Data from third and final year of trials (along with first two years) will be reported in final report next year.

First three plant dates (Sept. 17, Sept. 29, Oct 14) emerged before winter dormancy, with number of fall tillers per plant ranging from 2-5 for first two planting dates and none for mid-Oct planting. Last two plantings (Oct 29, Nov 12) emerged only in spring. Coming out of winter dormancy, barley plots (especially first planting date) looked yellow in color compared to wheat plots planted the same time (Image 1). However, this was not indicative of winter injury and barley grew out of this and had dark green canopy color soon after.

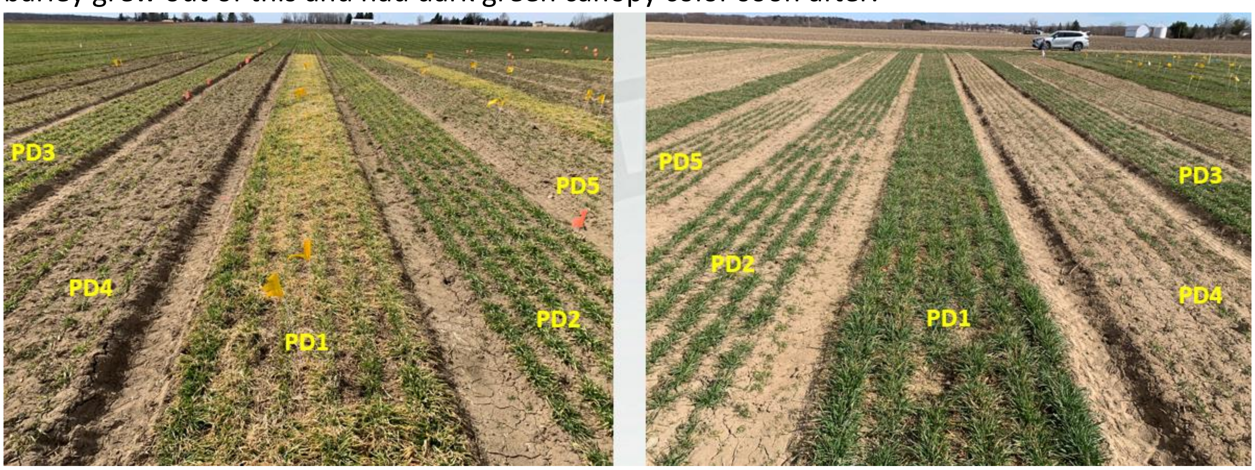


Image 1. Plots with different planting dates (PD 1-5 corresponding to five planting dates) in barley (left panel) and wheat (right panel).

No interaction was observed between plant date and seeding rate for yield (P = 0.43), meaning seeding rate responses were similar across planting dates. Planting around mid-Oct resulted in >30% yield loss regardless of the seed rate used. Daily yield penalty of delay in planting after September was much higher compared to what was observed in winter wheat trial at the same location (Fig. 1), indicating importance of early-season winter barley planting.

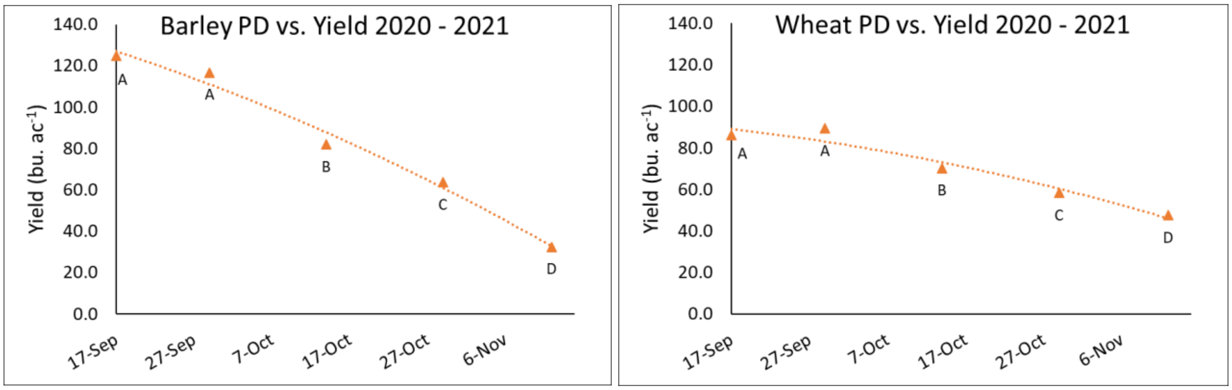
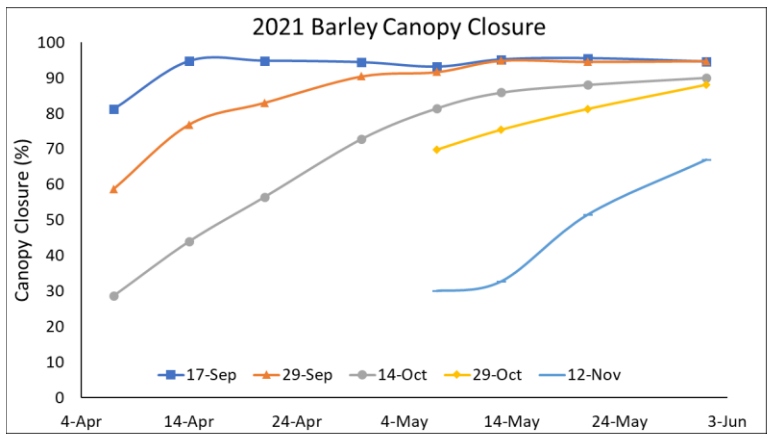


Figure 1. Yield decline with the delay in planting in barley (left panel), and wheat (right panel). Data showed a significantly higher reduction in yield in barley compared to wheat with the delay of planting. Data points followed by different letter are significantly different at P <0.1.

Canopy cover data using Canopeo app can explain yield differences between planting dates. Canopy cover (i.e., light interception potential) was similar between first two dates, but reduced in third date to some degree. However, last two planting dates (and especially Nov planting) had delayed and much lower canopy cover than desired (~90% or more) and led to significant yield losses.



Seed rate below 1.6 m/ac resulted in >14% yield penalty. Increase in yield with higher seeding rate (slope of line in Fig. 2) was higher in barley compared to the response observed in wheat trial at the same location during both 2019-20 and 2020-21, indicating importance of relatively higher seeding rates in winter barley planting. Seed germ was accounted in seed rate calculations and improved plant stands compared to 2019-20. Therefore, good stand establishment using high quality seed and accounting for seed germ in seeding rate values is critical in achieving good stand and high yields. Use of canopy cover app (such as Canopeo) can also help in making decisions during spring regarding keeping barley/wheat crop or switching to corn/soybean if stand is poor. More research is needed however in streamlining these decisions.

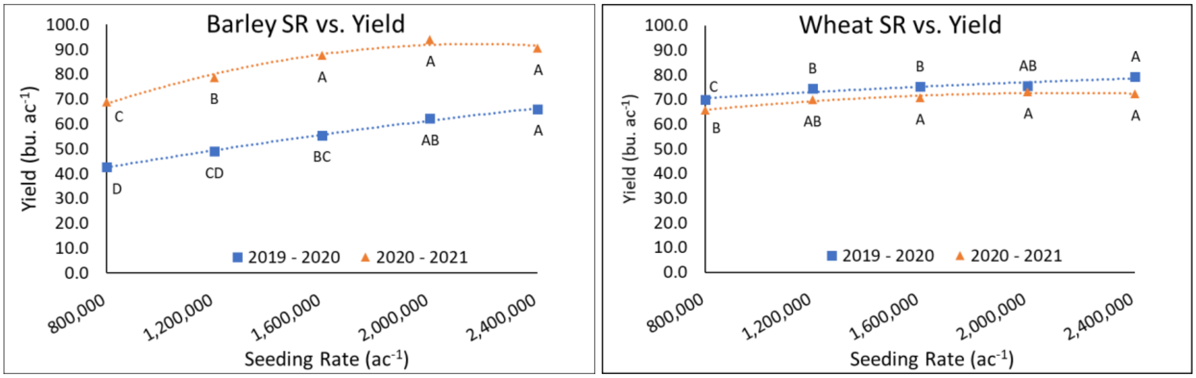


Figure 2. Yield response in relation to seeding rate in barley (left panel), and wheat (right panel). Data showed a significantly higher seeding rate to maximize yield in barley compared to wheat. Data points followed by different letter are significantly different at P <0.1.

Planting date also impacted various quality parameters (Table 2). However, seeding rate or interaction between planting date and seeding rate had minimal impact on all quality parameters. Low protein content (<12%) is desirable for malting. None of the planting dates differed in protein, however only first two dates (Sept 17 and 29) were below threshold level. Plump is a measure of kernel size and is the proportion of seed that will not pass through a 6/64 screen. Larger kernel size in barley is strongly correlated with higher extract yield meaning more beer can be made from the same number of kernels. So, it is desirable to maximize the plump. Most planting dates were close to the threshold, with middle three no different from each other. However, both earliest and latest planting caused decline in plump. Percent thin kernels varied between planting dates, with only last date levels above threshold. Germination was lower than threshold in all dates, and lowest in last planting. Overall, quality traits in early plantings were similar or better than later planting dates. Sep 29 planting had more traits closer to threshold than Sept 17 planting, so too early planting might result in some quality concerns.

Table 2. Winter barley quality as influenced by planting dates across all seeding rates, along with threshold levels for high quality malt. Vomitoxin (DON) was not a concern as 2021 was a low Fusarium year.

Plant date	**Protein (%)**	**Plump kernels (%)**	**Thin kernels (%)**	**Germination (4ml 72 hr GE)**
Threshold	≤12%	>90%	<3%	>98%
17-Sep	11.5 A	86.9 B	1.4 B	90.1 B
29-Sep	11.9 A	90.6 AB	1.0 BC	93.7 A
14-Oct	12.6 A	93.0 A	0.7 C	93.6 A
29-Oct	12.6 A	94.6 A	0.8 C	91.7 AB
12-Nov	12.8 A	88.0 B	3.3 A	80.1 C
P value	0.08	<0.001	<0.002	<0.003

There was more tillering observed in barley compared to wheat, especially at lower seeding rates. This resulted in variability in tiller development. Most tillers were formed later in season, had more prostrate growth habit, and probably did not contribute to yield (due to lack of effective tillers and low harvest index). Lower seeding rates would also result in lower quality measures due to increased variability among seeds within the same plot. Barley matured earlier than wheat, around 7-10 days, except in low seeding rate plots. Variability among tillers in those plots resulted in later maturity and issues during harvesting (green stems) and probably contributed to lower quality.

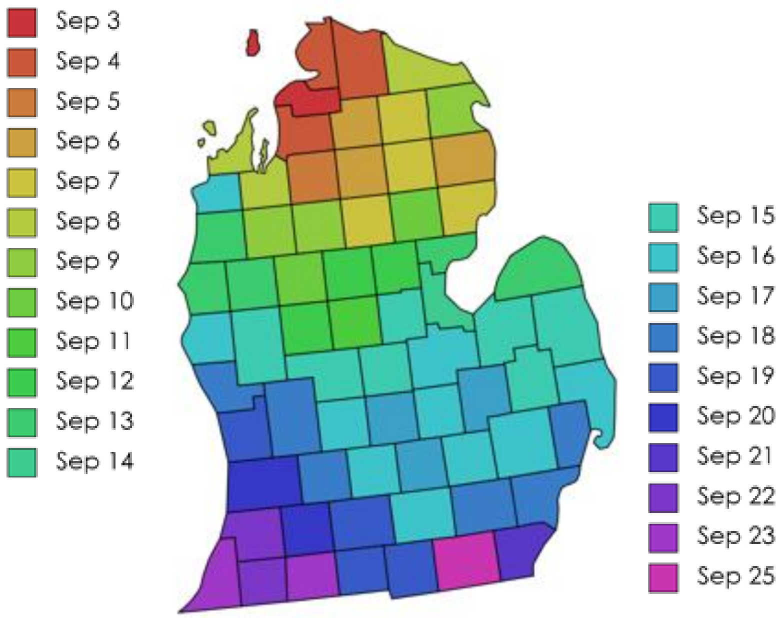


Figure 2. Hessian fly-free dates for Michigan counties in the lower peninsula. Planting winter barley soon after this date is critical in achieving high yield potential based on two years of field research in

Overall, results from 2020-21 trials showed that planting barley after mid-Oct can result in a significant (>30%) yield loss as well as lower quality regardless of the seed rate used. This decline in yield was much severe than that observed for wheat, indicating relative importance of early-season winter barley planting. Planting barley soon after hessian fly free date (Figure 2) is critical in achieving high yield and quality. These data indicated that farmers who plant barley after mid-Oct (due to slow soybean harvest progress and/or rainy weather) might experience yield reduction to such an extent to render barley production unprofitable. Use of higher seed rate (>1.6 m/ac) is also critical in maximizing yield and quality. Availability of high-quality seed and adjustment for low seed germ (where seed quality is questionable) in seed rate calculations is critical in successful stand establishment and high yields. More site years are needed to verify results, and future reports will present data from all three years of field trials. Overall, these data will help in developing recommendations for optimal planting time and seeding rate for winter barley. These could help adoption of more winter barley in Michigan cropping systems and help improve farmer revenues (including potential for double cropping) and provide ecosystem services in terms of winter cover, soil erosion reduction, and improved water quality.

Activities, Accomplishments, and Impacts:
Winter malting barley is a relatively new crop to farmers in Michigan and the Great Lakes region. We continue to face challenges related to development of sustainable markets, but our ongoing research has shown that high yields of high-quality malting barley can be produced in Michigan. Data reported here is only from one site year of field trials (second of 3-yr project). It is recommended to use data from multiple site years while making decisions on management practices. Data from all three years of trials will be reported in final project report and used in developing winter barley planting time and seeding rate recommendations for Michigan.

Project results have been and will continue to be communicated to stakeholders via outreach activities such as presentations at field days, demonstrations, and meetings in addition to online publications, guides, and fact sheets. A field day was held in June 2021 where results were presented to craft brewers, maltsters, and farmers. Results were also shared during April 2021 virtual happy hour event. We will continue working with MSU Extension and stakeholders (Origin Malt, Independent Barley and Malt etc.) to distribute research findings to stakeholders. Resources will also be available online as free pdfs through the website https://www.canr.msu.edu/agronomy/Extension/Small_Grains. Data will also be published in peer-reviewed journal article for communication to a broader audience. These activities will help in delivering results beyond the project period.

<u>List of presentations and publications:</u>

Copeland, P., and M.P. Singh. 2022. Management practices to optimize winter barley yield and quality. Michigan's great beer state conference & trade show. Jan 13. Attendees: 20

Singh, M.P. 2021. Winter barley management consideration. Field day at KBS. June 25. Hickory Corners, MI. Attendees: 40

Singh, M.P. 2021. Management practices to optimize winter barley yield and quality. Grains for Brewing and Distilling Virtual Happy Hour. April 2. Live attendees: 11. Views: 28. Link- https://www.youtube.com/watch?v=sYQiPj5MR9s

Budget: The project was conducted consistent with the budget proposed by the principal investigator and approved by the State of Michigan.

Independent Barley and Malt provided barley seed for the 2020-21 field trials.

Grant from SARE was leveraged in developing double crop systems involving winter barley. A grant was also submitted to USDA AFRI for complementary work (on weather and pest resiliency) but was unsuccessful.

- North Central Region Sustainable Agriculture Research and Education Partnership Grant Program. M.P. Singh, B. Wilke, E. Anderson, B. MacKellar, and R. Hamilton. "Developing profitable double-crop systems after winter barley". $26,730 ($2,673 to Singh). 04/01/2018 - 03/31/2021.