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# 20 * 1796)
Principle Investigator: Dr. Maninder (Manni) Singh (MSU Cropping Systems Agronomist)
Graduate students: Kalvin Canfield, 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 showed that early planting (end Sept to early Oct) is critical in maximizing yield and malt quality. Relatively higher seeding rates ($\geq$ 2.0 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 2019-20 growing season. Field experiment was laid out in a split plot design with four replicates. Main plots consisted of five planting dates (Sept. 19, Oct. 7, Oct. 18, Oct. 29, and Nov. 15), 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 to limit protein accumulation (compared with 120 lbs N/ac 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. Treatment means were compared using the lsmeans statement with the Tukey method at $\alpha=0.10$.

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 only from one site year of field trials. It is recommended to use data from multiple site years while making decisions on management practices. Data from second and third year of trials will be reported in future reports.

First three plant dates (Sept. 19, Oct 7 and 18) 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 (Image 1). Last two plantings (Oct 29, Nov 15) emerged only in spring. Final plant stand achieved was relatively lower than expected, in part due to low seed germ. Obtaining seed with high quality is important in ideal stand establishment in barley, especially for varieties where certified seed is not easily available. Minimal winterkill was observed across plots due to milder winter conditions.

Image 1. Winter barley plots with different planting dates showing differing maturity (left panel) and plants from different planting dates showing difference in fall tillering (right panel).

No interaction was observed between plant date and seeding rate for yield (P = 0.18), meaning seeding rate responses were similar across planting dates. Planting after mid-Oct resulted in

>50% yield loss regardless of the seed rate used (Table 1). 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.

Table 1. Influence of plant date (P <0.001) and seeding rate (P <0.001) on barley yield. Numbers followed by different letter within a variable are significantly different at P <0.1.

Plant date	Yield (bu/ac)	% decline (from 19-Sep)
19-Sep	123.9 A	
7-Oct	64.5 B	48
18-Oct	32.2 C	74
29-Oct	16.8 D	86
15-Nov	24.0 CD	81

Seed rate (per ac)	Yield (bu/ac)	% decline (from 2,400,000)
2,400,000	62.6 A	
2,000,000	59.0 AB	6
1,600,000	52.7 BC	16
1,200,000	46.6 CD	26
800,000	40.6 D	35

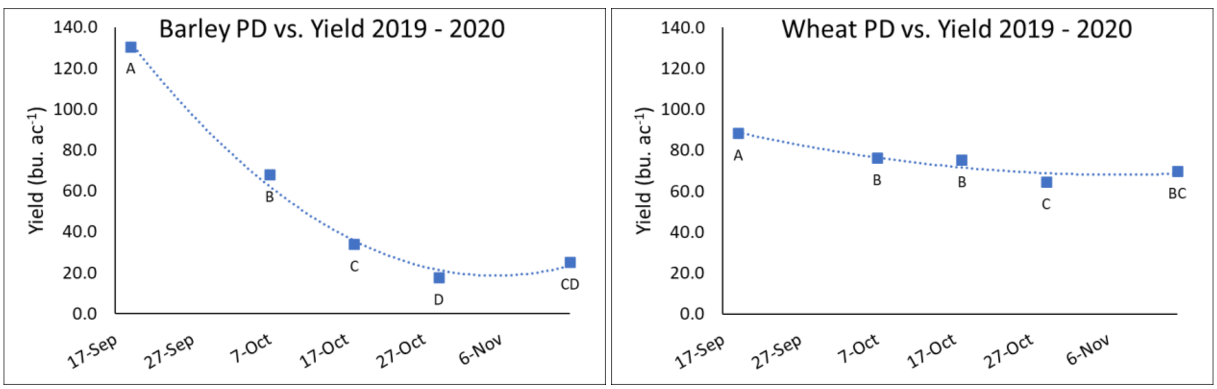

Figure 1. Yield decline with the delay in planting in barley (left panel), and wheat (right panel). Data showed a significantly higher reduction in yield in barley compared to wheat with the delay of planting. Data points followed by different letter are significantly different at P <0.1.

Seed rate below 2.0 m/ac resulted in >15% yield penalty (Table 1). 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, indicating importance of relatively higher seeding rates in winter barley planting. Low plant stand (driven by poor seed germ on the variety used) might have confounded these results, therefore high-quality seed and compensation for low germ in seeding rates calculations might help avoid issues related to stand establishment.

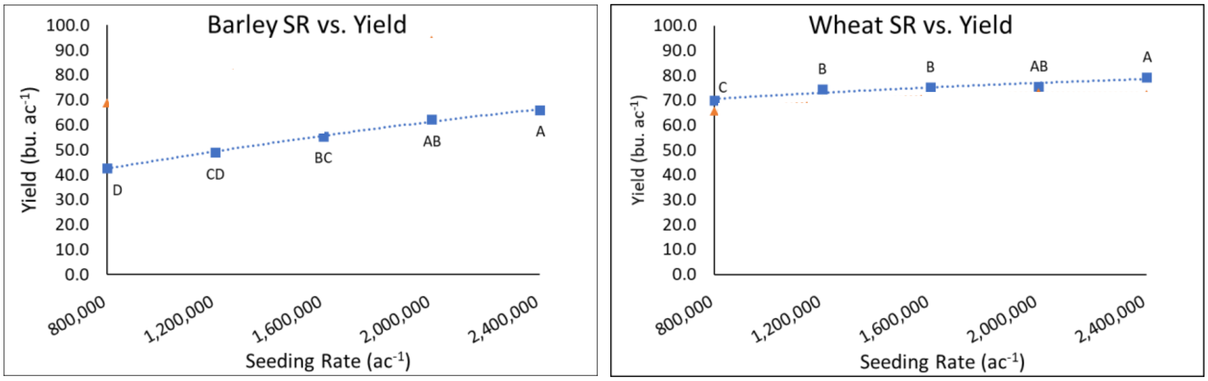

Figure 2. Yield response in relation to seeding rate in barley (left panel), and wheat (right panel). Data showed a significantly higher seeding rate to maximize yield in barley compared to wheat. Data points followed by different letter are significantly different at P <0.1.

Planting date also impacted various quality parameters (Table 2). Low protein content (<12%) is desirable for malting. First planting (Sept 19) had significantly lower protein compared to all other dates and was the only date with values <12%. Similar to yield, delay in planting (especially after early-Oct) resulted in much higher protein than 12%. Plump is a measure of kernel size and is the proportion of seed that will not pass through a 6/64 screen. It is desirable to maximize the plump. Oct 7 and 19 plantings had the highest plumb and was reduced with both early and late planting. Sept 19 planting had the lowest plump (below threshold) and highest thin kernels, and was the only negative quality trait associated with early planting. Germination was highest in early planting as well and well above threshold levels.

Table 2. Winter barley quality as influenced by planting dates (data averaged from three highest seeding rates), along with threshold levels for high quality malt. Pre-harvest sprout was a concern (<120 RVUs) only for November planting (116 RVU), while vomitoxin (DON) was not a concern (<0.15 ppm) in any samples as 2020 was a low Fusarium year.

Plant date	Protein (%)	Plump kernels (%)	Thin kernels (%)	Germination (4ml 72 hr GE)
19-Sep	10.3 C	84.4 C	2.2 A	99.2 A
7-Oct	12.6 B	96.1 A	0.2 B	98.4 AB
18-Oct	14.7 A	95.7 A	0.4 B	93.2 C
29-Oct	16.4 A	90.8 B	1.7 A	95.5 BC
15-Nov	15.6 A	92.4 AB	1.4 A	95.9 BC
Threshold	≤12%	>90%	<3%	>98%
P value	<0.001	<0.001	<0.001	<0.001

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.

Overall, results from 2019-20 trials showed that planting barley after mid-Oct can result in a significant (>50%) yield loss as well as lower quality regardless of the seed rate used. This decline in yield was much severe than the one observed for wheat, indicating importance of early-season winter barley planting. So, planting barley soon after hessian fly free date is critical in achieving high yield and quality. These data indicated that farmers who planted barley after mid-Oct in 2019 (due to slow soybean harvest progress and rainy weather) might have experienced yield reduction to such an extent to render barley production unprofitable. Seed rates below 2.0 m/ac resulted in >15% yield penalty. Adjustment for low seed germ in seed rate calculations might be critical along with availability of high-quality seed in successful stand establishment and high yields. More site years are needed to verify results, and future reports will present data from second and third year 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 (first of the three years proposed for this project). It is recommended to use data from multiple site years while making decisions on management practices. Data from second and third year of trials will be reported in future reports and will be used in developing winter barley management recommendations in 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. 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.

List of presentations and publications:

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

Singh, M.P. 2021. Agronomic management of winter barley and double crop soybean. Discussant presentation. Barley field day. June 20. Hickory Corners, MI. Attendees: 33

Canfield, K., and M.P. Singh. 2020. Planting date and seeding rate response in winter barley vs wheat. Virtual talk, MSU Happy hour. Attendees: 10

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 2019-20 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 (NCR-SARE) 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.