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
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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 was to evaluate the role of planting date and seeding rate in optimizing winter barley production. Variety Teepee was planted on five different dates (mid-Sept. to mid-Nov.) at five different seeding rates (0.8 to 2.4 m seeds/ac) in Mason, MI. Results showed that early planting (end Sept to early Oct) is critical in maximizing winter barley 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 was 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 the MSU Mason Research Farm over three growing seasons (2019-20, 2020-21, and 2021-22; hereafter referred to as 2020, 2021, and 2022, respectively). The field experiment was laid out in a randomized complete block design in a split-plot arrangement with four replicates. Main plots consisted of winter barley planted on five separate planting dates, starting soon after Hessian fly-free date (Sept 17 for Mason, MI), then every 12–18 days until mid-November (Table 1). Sub-plots consisted of five seeding rates (0.8, 1.2, 1.6, 2.0, and 2.4 million seeds acre^{-1}). Each plot included six rows spaced 7.5” apart and 12’ in length, with a 6’ alley between plots.

In all three growing seasons, the soil type was Conover loam (fine-loamy, mixed, active, mesic Aquic Hapludalf) with a pH range of 6.0–6.7 and cation exchange capacity range of 9.8–10.2 meq 100 g^{-1}. Previous crop was soybean in all years. 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.

Table 1: Locations and planting dates for field trials at Mason, MI for 2019–20, 2020–21, and 2021–22 (referred to as 2020, 2021, and 2022, respectively).

	2020	**2021**	**2022**
Location			
Latitude	42.627931	42.6287805	42.628328
Longitude	-84.427539	-84.4271304	-84.430175
Planting Dates:[a]			
Mid-Sept.	19 Sept.	17 Sept.	19 Sept.
Late Sept.	7 Oct.	29 Sept.	30 Sept.
Mid-Oct.	18 Oct.	14 Oct.	23 Oct.
Late Oct.	29 Oct.	29 Oct.	3 Nov.
Mid-Nov.	15 Nov.	12 Nov.	16 Nov.

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 research plot combine (Wintersteiger, Ried im Innkreis, Austria for 2020 and 2021 seasons; Kincaid, Haven, Kansas for 2022). All grain was bagged and weighed to obtain yield. Moisture and test weight were also measured using a GAC2100 grain analysis computer (DICKEY-john Corporation, Auburn, Illinois). 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 maltsters will be more interested in quality parameters. Other data (stand, test weight, moisture etc.) are available but not reported here.

No interaction was observed between planting date and seeding rate for yield in any of the three years ($p = .17$, 2020; $p = .30$, 2021; $p = .87$, 2022), meaning seeding rate responses were similar across planting dates. Planting around mid-Oct resulted in 24-78% yield loss, regardless of the seeding rate used. Daily yield penalty of delay in planting after September was much higher compared to what was observed in a winter wheat trial at the same location (Fig. 1), indicating the importance of early-season planting of winter barley.

Seeding rates below 1.6 m/ac resulted in a yield penalty. The increase in yield with higher seeding rate (slope of line in Fig. 2, lower panels) was higher in barley compared to the

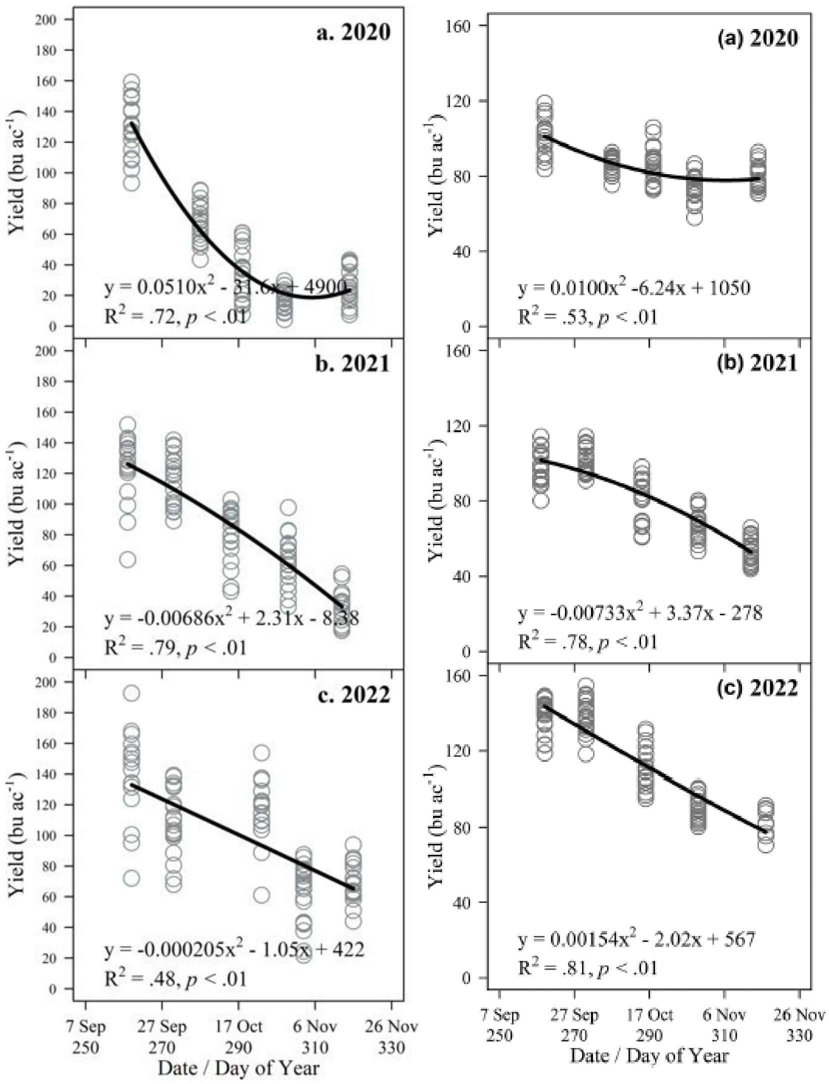

Figure 1: Yield decline with delay in planting in barley (left panel), and wheat (right panel). Data showed a significantly higher reduction in yield in barley compared to wheat with delayed planting. Data points followed by different letters are significantly different (α = .10).

response observed in a wheat trial at the same location during all three growing seasons, indicating the importance of relatively higher seeding rates in winter barley. Therefore, good stand establishment using high quality seed (with high germ) is critical in achieving good stand and high yields.

Planting date also impacted various quality parameters (Table 2), but seeding rate or interaction between planting date and seeding rate had minimal impact on all quality parameters (except plump kernels and protein in 2021 and 2022). Low protein content (<12%) is desirable for malting. Later planting resulted in higher protein levels; and in 2020 and 2021, only the first planting date (Sep. 19 and Sep. 17, respectively) were below threshold level. In 2022, the first three planting dates (Sep. 19–Oct. 16) were below the threshold level. Plumpness 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 number of plump kernels. In 2020 and 2022, most planting dates were close to the threshold, with the first planting date in 2020 and the fourth planting date in 2022 being below the threshold. In 2021, all planting dates resulted in the number of plump kernels being below the threshold. The trends in planting date's effect on plump kernels were inconsistent from year to year. Percent thin kernels were above threshold for all planting dates in 2021 and below threshold for all planting dates in 2020 and 2022, but both earlier and later planting dates resulted in slightly higher numbers of thin

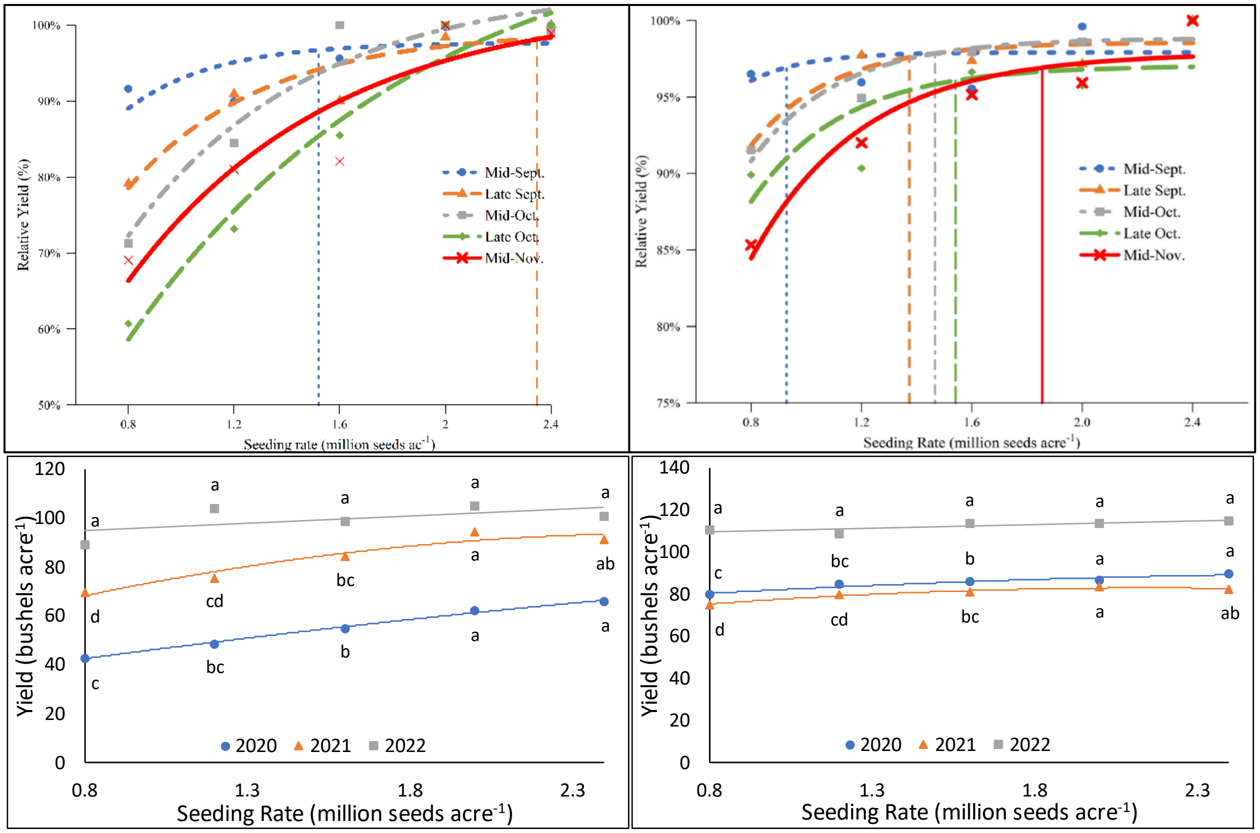

Figure 2: Yield response in relation to seeding rate in barley (left panels), and wheat (right panels). Top panels are presented by planting date with years pooled, while bottom panels show each year separately with planting dates pooled. Data showed a significantly higher seeding rate to maximize yield in barley compared to wheat. Data points followed by different letters are significantly different (α = .10).

kernels. Germination was below the threshold in all dates for 2021, and in the later planting dates for 2020 and 2022 (after October 7 for 2020 and after October 16 for 2022). Overall, quality traits in early plantings were similar to or better than in later planting dates. However, some quality parameters showed a penalty for the earliest planting dates, so planting too early might also result in some quality concerns.

Table 2: Winter barley quality as influenced by planting date (data for 2020 averaged from three highest seeding rates), along with threshold levels for high quality malt. Vomitoxin (DON) was not a concern in 2021, as it was a low Fusarium year.

Plant date	Protein (%)	Plump kernels (%)	Thin kernels (%)	Germination (4ml 72 hr GE)	Germination (8 ml 72 hr GE)	Germination (48 hr GC)	RVU	DON (ppm)
Threshold	≤ 12%	> 90%	< 3%	> 98%	-	-	<120	<0.15
2020								
19 Sep	10.3 c	84.4 c	2.20 a	99.2 a	95.3 a	98.8 a	130.2 ab	0.058 b
7 Oct	12.6 b	96.1 a	0.24 b	98.4 ab	93.7 ab	97.8 ab	133.8 a	0.073 ab
18 Oct	14.7 a	95.7 a	0.36 b	93.2 c	84.0 c	96.6 b	129.5 ab	0.099 ab
29 Oct	16.4 a	90.8 b	1.74 a	95.5 bc	86.9 bc	98.5 a	124.8 b	0.091 ab
15 Nov	15.6 a	92.4 ab	1.41 a	95.9 bc	85.8 c	98.4 a	116.1 c	0.114 a
P value	<.01	<.01	<.01	<.01	<.01	.01	<.01	.04
2021								
17 Sep	11.1 e	65.1 a	11.48 a	90.1 b	66.5 c	91.7 a	24.8 d	N/A
29 Sep	12.3 d	67.2 a	9.98 a	93.7 a	73.3 b	94.4 a	67.7 c	N/A
14 Oct	13.7 c	40.0 b	4.58 b	93.6 a	79.6 a	94.2 a	91.1 b	N/A
29 Oct	14.8 b	36.5 b	4.55 b	91.7 ab	76.3 ab	92.6 a	116.9 a	N/A
12 Nov	15.9 a	34.5 b	8.69 a	80.1 c	61.4 c	84.1 b	80.2 bc	N/A
P value	<.01	<.01	<.01	<.01	<.01	<.01	<.01	N/A
2022								
19 Sep	11.3 b	94.5 a	0.68 b	98.7 a	95.0 a	99.35 a	149.2 a	0.260 a
30 Sep	10.8 b	93.7 a	0.65 b	98.7 a	95.3 a	99.4 a	152.5 a	0.236 a
16 Oct	10.8 b	94.2 a	0.45 b	98.4 a	93.5 a	99.6 a	152.0 a	0.215 a
30 Oct	16.2 a	86.1 b	1.77 a	97.8 a	92.9 a	99.0 a	141.8 b	0.219 a
17 Nov	16.6 a	94.5 a	0.67 b	97.2 a	91.9 a	98.9 a	135.7 b	0.253 a
P value	<.01	<.01	<.01	.11	.14	.29	<.01	.80

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 the 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 this trial showed that planting barley after mid-Oct can result in a significant (>30%) yield loss, as well as lower quality, regardless of the seeding rate used. This decline in yield was much more severe than that observed for wheat, indicating the relative importance of early-season winter barley planting. Planting barley soon after the Hessian fly free date (Figure 3) 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 seeding rates (>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 seeding rate calculations is critical in successful stand establishment and high yields. 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.

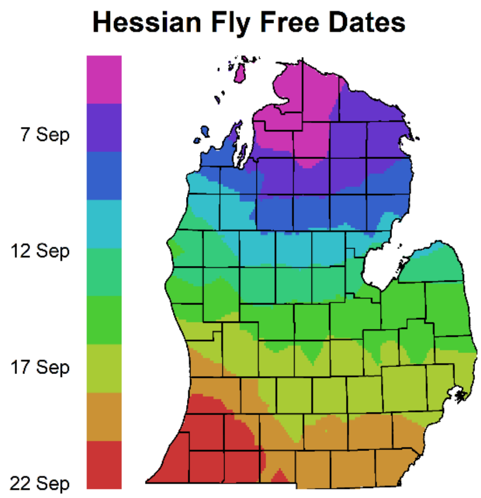

Figure 3. Hessian fly-free dates for Michigan's lower peninsula. Planting winter barley soon after this date is critical in achieving high yield potential based on three years of field research in Mason, MI.

Activities, Accomplishments, and Impacts:

Winter malting barley is a relatively new crop to farmers in Michigan and the Great Lakes region. While we continue to face challenges related to the development of sustainable markets, our research has shown that high yields of high-quality malting barley can be produced in Michigan. It is recommended to use data from multiple site-years while making decisions on management practices. Data from all three years of trials is reported in this project report and will be 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. We will continue working with MSU Extension and stakeholders to distribute research findings to stakeholders. Resources are also available on our [Cropping Systems Agronomy website] (under extension/small grains). Data will also be published in peer-reviewed journal article for communication to a broader audience.

List of presentations and publications:

Singh, M.P. 2024. Planting date and seeding rate decisions for optimizing winter barley yield and quality. Michigan's great beer state conference & trade show. Kalamazoo. Jan 13. Attendees: 15

Singh, M.P. 2023. Planting date and seeding rate decisions for optimizing winter barley yield and quality. Michigan's great beer state conference & trade show. Kalamazoo. Jan 13. Attendees: 15

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: 32. 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

Abstracts:

DeDecker, J, B. Wilke, M.P. Singh, M. Chilvers, C. Kapp, and J. Dykstra. 2023. Trends in malting barley research, production, and quality in the Midwest US. American Society of Brewing Chemists. Pittsburg, PA.

Wilke, B., D. Baas, M. Chilvers, J. DeDecker, J. Dykstra, C. Kapp, N. Shriner, and M.P. Singh. 2022. Lessons learned from six years of winter barley research in Michigan. 23rd North American Barley Research Workers and 43rd Barley Improvement Conference. Davis, CA.