2019 MI Craft Beverage Council Final Report
Proposal Title: Variety Selection and Agronomy Practices for Soft Winter Wheat Malting
(grant# x)

Principle Investigator: Dennis Pennington (MSU Wheat Extension Specialist)
Collaborators: Dr. Eric Olson (MSU Wheat Breeder), Vince Coonce (Independent Barley and Malt), Dave Dyson (The Andersons, Inc)

Abstract: Craft brewing is a large and growing economic sector in Michigan, but the malting industry is held back by lack of a local supply of quality raw grains. Wheat beers already comprise an appreciable segment of craft beer production in Michigan and the U.S. Demand for wheat beer products is growing. Often grains with the best malting characteristics have the lowest yield potential for farmers, creating a dichotomy between maltsters and farmers. The goal of the project is to identify wheat varieties and agronomic production practices that provide acceptable quality to maltsters and high yield potential for farmers. Four wheat varieties were selected based on previous grain quality responses and planted in a split plot design with six fertility treatments (3 nitrogen plus 2 potassium). Yield, moisture and test weight data was collected at harvest. Subsamples were sent to the Center for Craft Food and Beverage Center at Hartwick College for pilot malting and full malt analysis.

Materials and Methods: Dave Dyson provided input on fertility treatments with the goal of producing the highest grain yield, while keeping protein content low. Twelve varieties from the 2019 MSU Wheat Performance Trials were pilot malted by Vince Coonce. Data from the pilot malt was used to select four varieties to include in the trial (6771 EXP, Kokosing, W 304 and Dyna-Gro 9362W). Small plots (5 foot x 12 foot) were planted at the Saginaw Valley Research and Extension Center near Frankenmuth, MI. Plots were planted with an Almaco HD grain drill equipped with a packet planter. Plots were arranged in a split plot design with fertilizer rate as the main factor and variety as the sub factor. Main factor treatments include 3 nitrogen rates (0, 40, 80 lbs. per acre) plus 2 potassium rates (0, 60 lbs. per acre). Sub factor treatments include the 4 varieties selected from the preliminary screen.
Treatments (rates are pounds of actual nutrient per acre):

1. 0 nitrogen, 0 potassium (control)
2. 40 lbs. nitrogen, 0 potassium
3. 80 lbs. nitrogen, 0 potassium
4. 40 lbs. nitrogen, 60 potassium
5. 80 lbs. nitrogen, 60 lbs. potassium
6. 0 lbs. nitrogen, 60 lbs. potassium

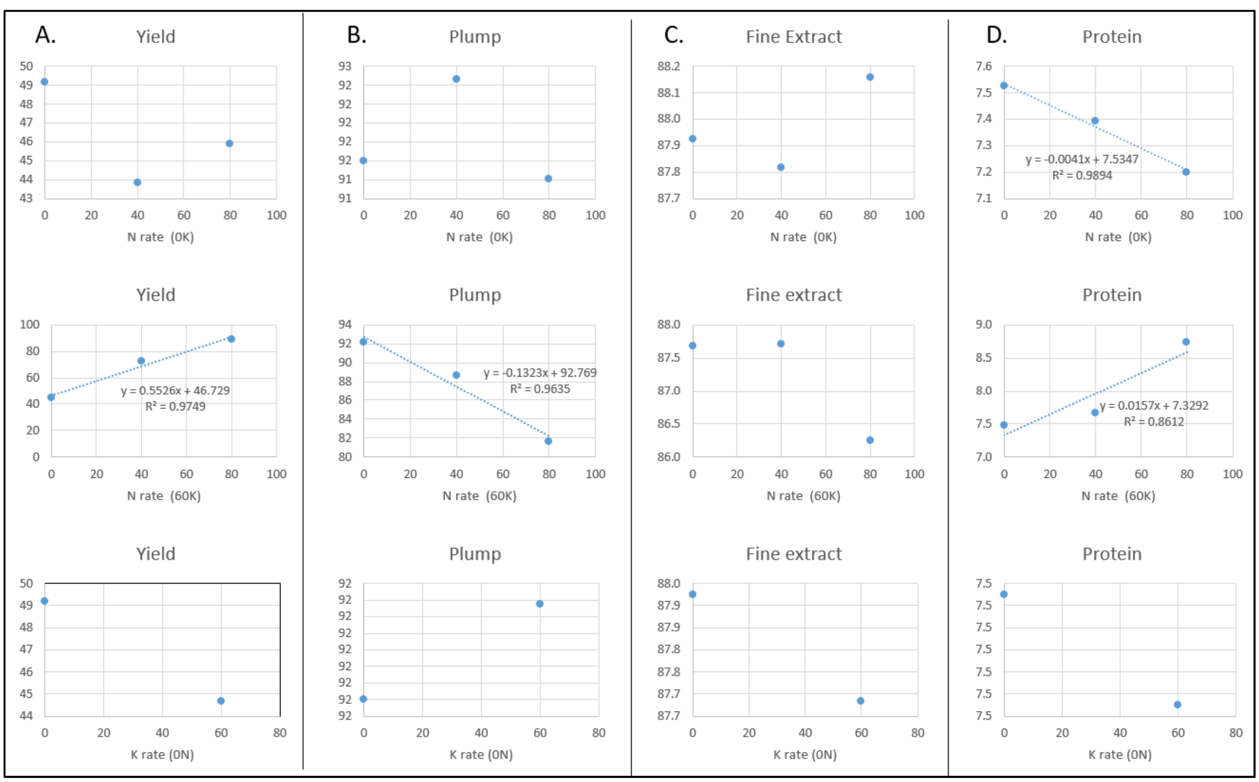
Plots were seeded at 2 million seeds per acre. Affinity broadspec (0.8 oz/a) was applied for weed control. Prosaro fungicide (8 oz/a) was applied at Feekes 10.5.1 (flowering) to control fusarium head blight. Plots were harvested by a Wintersteiger Quantum research combine equipped with an H2 HarvestMaster system to obtain yield, moisture and test weight. All plots were bagged and subsampled. Subsamples from each replication was submitted to Hartwick College Center for Craft Food & Beverage lab for full malt analysis including moisture, assortment, friability, fine extract, coarse extract, f/c difference, β-glucan, fan, soluble protein, s/t, dp, α-amylase, color, pH, filtration time, clarity, DON and protein. Statistical analysis of the data was conducted by the PI using SAS 9.4 Proc Mixed.

Results and Discussion: Farmers will be most interested in the yield response to treatment while maltsters will be more interested in malt quality parameters. Yield, plump, fine extract and grain protein are reported here. Germination, color, ßeta glucan, soluble protein, Kolbach index, FAN, diastatic power, alpha amylase, filtration time and clarity data is available, but not reported here. It is recommended not to draw conclusions from this data as this represents just one year of field trials. Year 2 of this project has been planted and will be harvested in July 2021. When drawing conclusions about what practices to use when growing winter wheat for malting purposes data from more than one year should be considered. This data should be considered to be preliminary.

Data from Figure 1 shows that there was no significant yield response to nitrogen when no potassium fertilizer was added (panel A, top chart). However, the highest yields (reported in bushels per acre) were achieved when potassium was applied at a rate of 60 pounds per acre and the yield response to nitrogen (panel A, middle chart) showed a strong positive linear relationship (r^2=0.9749). In the absence of nitrogen, yield response to potassium was not significant (panel A, bottom chart).

Plump is a measure of kernel size and is the proportion of seed that will not pass through a 6/64 screen. In barley, larger kernel size is strongly correlated with higher extract yield meaning more beer can be made from the same number of kernels. It is desirable to maximize the plump. Here we tested the effect of fertility treatments on plump. In the absence of potassium, plump was not significantly impacted by nitrogen rate (panel B, top chart). In the presence of 60 pounds of potassium per acre (panel B, middle chart), there was a strong negative relationship between plump and nitrogen rate (r2=0.9635). In the absence of nitrogen, plump was not significantly effected by potassium rate (panel B, bottom chart).

Figure 1. Data from year 1 of malting wheat project. Each panel contains a chart showing the response of yield (A), plump (B), fine extract (C) and protein (D) for three different fertility treatments. The top chart is the response to nitrogen in absence of potassium (0K), middle chart is the nitrogen response in the presence of potassium (60 pounds K/a) and the bottom chart is the response to potassium in the absence of nitrogen. Trend lines are displayed where the response was significant at α=0.05.

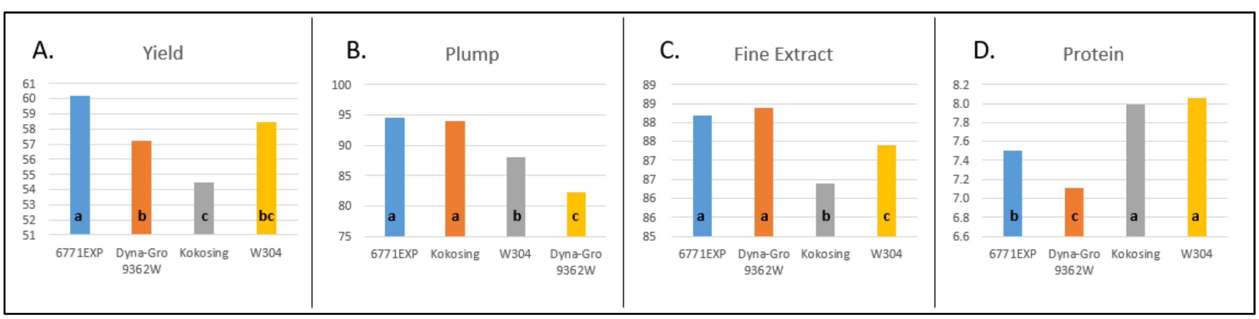


Surprisingly, fine extract was not significantly effected by nitrogen or potassium in any of the comparisons (panel C). This suggests that fine extract is related to some other aspect of production, such as variety. This can be seen in Figure 2, chart C where two varieties (6771EXP and Dyna-Gro 9362W) has significantly higher fine extract compared to Kokosing and W304 varieties.

Total protein Figure 1, panel D showed an interesting and unexpected response to nitrogen and potassium. In setting up this trial, it was discussed with collaborators that in order to grow high yielding wheat with low protein, we need to manage nitrogen very carefully. It is well known that wheat yields increase with nitrogen fertilizer, but so does total grain protein content. In the plant, potassium is involved in protein synthesis. Higher potassium levels generally relate to higher protein synthesis. In this trial, protein response to nitrogen and potassium was mixed. In the presence of potassium (panel D, middle chart) protein increased with nitrogen as expected (r^2=0.8612). However, in the absence of potassium (panel D, top chart) protein level was inversely proportional to nitrogen rate (r2=0.9894). While it makes sense that in the absence of potassium, there would be lower protein production, it was not expected that increasing nitrogen rates would decrease protein. In this case, data from year 2 will be important to verify if this relationship is in fact real or circumstantial.

As expected, there was a significant variety response to yield, plump, fine extract and protein (see Figure 2). Variety 6771EXP has higher grain yield, plump and fine extract and lower protein. These characteristics make this variety a good fit for farmers due to good yield and malsters due to high fine extract yield. In this trial, only 4 varieties have been evaluated. It is recommended that future research evaluate a wider range of varieties. About 115 varieties are tested each year in the MSU Wheat Performance Trial program. There could be additional varieties available that meet farmer and maltster needs.

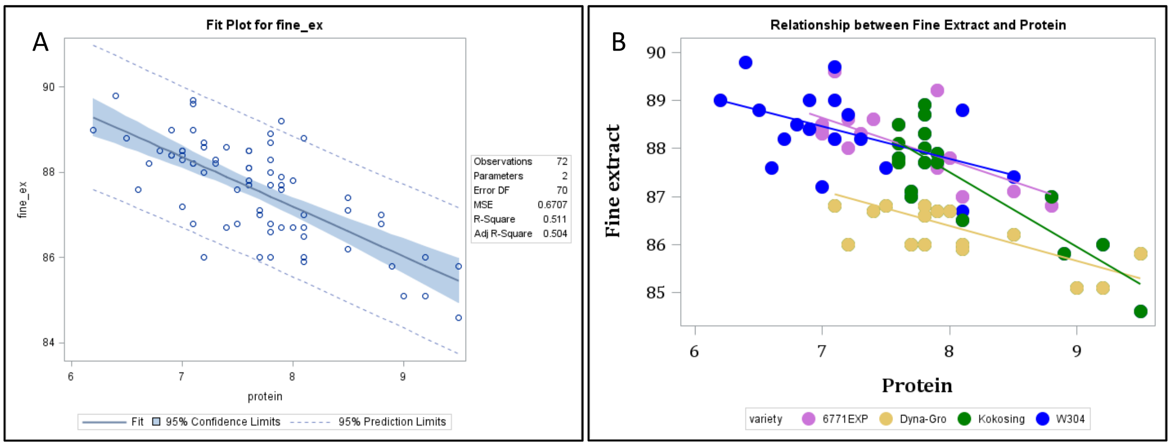
Figure 2. Variety response to yield (A), plump (B), fine extract (C) and protein (D).



One of the objectives of this work is to find out what malting characteristics are most important and which ones can be used as predictors for malt quality. Conducting the full malting and lab analysis is prohibitively expensive if we want to expand testing to include additional fertility and variety evaluations for malting quality. For barley, there have been many associations quantified and verified for grain yield and malting quality. This work is lacking for wheat and other small grains that are being increasingly considered to make unique, craft beverages. In this study, protein was evaluated to determine if its relationship with fine extract could be used to reliably predict malt quality. Assessing grain protein is relatively cheap compared to malting. This would allow many more comparisons to be made at lower cost.

There appears to be a weak relationship (r^2=0.511) between protein and fine extract across all treatments and varieties (Figure 3A). When looking at the same relationship for each variety, there are slight differences in the magnitude of the relationship (slope of each line) in Figure 3B. Variety ‘W304’ has the largest amount of variation and lowest relationship. This is just preliminary data as year 2 of the project is under way. Multi-year data is important to determine how different weather (growing seasons) will impact this relationship.

Figure 3. Relationship between kernel protein and fine extract in soft winter wheat.



Finally, the last objective of this study was to look at the profitability of different fertilizer treatments in terms of income potential for farmers, while delivering a product that meets the needs of maltsters. Partial budget analysis is a tool that looks at the income and expense items only for the variables included in the trial. It assumes all other expense items are the same across treatments. Results from this analysis for the ’19-’20 crop year are listed in Figure 4. Data for Yield, Plump, Fine extract and Protein are reported in columns along with the calculated Income and Expense. Income is calculated as yield x $5.54/bushel (MAC Brown City, 11/13/20). Expense is calculated as (N rate x $0.41)+(K rate x $0.30). These fertilizer prices were based on a price of $375 per ton for urea and $365 per ton for potash. The Partial Budget column is calculated as Income – Expense.

Figure 4. Partial budget analysis showing the income potential of each treatment.

Trt	N rate	K rate	Yield	Plump	Fine extract	Protein	Income	Expense	Partial Budget	Diff from Max ($)	Diff from Max ($/bu)
1	0	0	49.2	91.6	87.9	7.5	$272.50	$0.00	$272.50	-$169.40	-$3.44
2	40	0	43.8	92.5	87.8	7.4	$242.85	$16.30	$226.55	-$215.35	-$4.91
3	80	0	45.9	91.4	88.2	7.2	$254.43	$32.61	$221.82	-$220.08	-$4.79
6	0	60	44.7	92.2	87.7	7.5	$247.54	$17.95	$229.59	-$212.31	-$4.75
4	40	60	72.9	88.7	87.7	7.7	$404.02	$34.26	$369.77	-$72.13	-$0.99
5	80	60	88.9	81.6	86.3	8.7	$492.46	$50.56	$441.90	$0.00	$0.00

Farmers would select the treatment that has the highest partial budget number, in this case - treatment 5 at $441.90. This treatment also produces the lowest plump, fine extract and highest protein – all of which are opposite of what a malster is looking for. If a malt company wanted to contract with a farmer to grow wheat and specify a lower fertility program, that could be done with a contract that provides market price plus a premium to offset the lower income potential. The difference from the max (last column) would be the amount of premium needed by the farmer to offset the lower income potential. Discussion of this data with malsters is needed to help determine what is fair and equitable to both parties. Again, another year of data is needed to help verify this relationship and increase confidence in the actual values.