Evaluation of Malting Barley Potential for Atlantic Canada

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Executive Summary

The objective of the project “Evaluation of malting barley potential for Atlantic Canada” was to build infrastructure and industry-driven support to growers looking to add value to barley grown in Atlantic Canada. Malting barley can almost be considered to be a different crop compared to conventional feed barley. This project built a foundation for the potential development of malt barley production in Atlantic Canada by measuring the quality of malt barley grown in the Maritimes. Results and information generated by this project have shown that there is a high potential to achieve quality malt barley here, and has initiated the discourse regarding malting barley production in Eastern Canada. As malt barley is currently worth almost three times the value of feed barley, information and processes developed through this project will provide support to growers seeking to improve economic returns of management decisions to include malting barley as part of their cropping systems. This project has shown that malting barley production in Atlantic Canada is possible; a significant knowledge infrastructure has been developed which will contribute to the success of malt barley production in the short term, will provide support for further work on malt quality, and will facilitate the further development of micro-malting operations over the long term. A significant amount of work was invested into developing malting protocols for East Coast malt. This project has allowed for conversations between researchers, brewers interested in a locally-produced products, and farmers to determine a mutually beneficial goal.

Background

Barley production has a long history in Atlantic Canada. The crop grows relatively well, and is an essential part of traditional and novel cropping systems. Barley or cereals in general, in the cropping system serve to break pest and weed cycles for higher value crops, including soybean and potato. When rotations contain multiple hosts of the same pest or pathogen, background pest levels increase, and the producer becomes more vulnerable to crop failures in the future. However the lower price garnered for feed barley deters producers from inserting barley in the cropping system. Lack of diversity in a cropping system leads to a decrease in soil quality, and results in an increased intensity of pesticide use for crop production.

In Eastern Canada, barley is grown principally as a feed source, but it is now being considered as an alternate crop as a source of food vegetable protein or for biomass fuel production. Both of these production streams serve to increase the value of barley, making it attractive as a rotational crop. The prospect of producing malting grade barley is another potential possibility to increase the value of barely produced in Atlantic Canada.

Currently, efforts are being made to evaluate the suitability of Western Canadian malting barley varieties to growing conditions in both New Brunswick and Prince Edward Island. The objectives of the present variety evaluations are to measure the effects of conventional barley agronomic management on malt quality in terms of kernel size, degree of staining, and a general resistance to fusarium head blight and DON levels. Personal communication with existing micromaltsers (Valley Malt, Hadley, MA), indicated that DON levels up to 2 ppm are acceptable for malting quality provided the beer brewed with the malt is not to be bottled. If the malt is infected with fungus, and the beers are bottled, there is a chance that Presence of fungal hydrophobin proteins from fusarium results in “gushing” when present at a level of 0.003 ppm (Sarlin, Kivioja et al. 2012). This effect was previously believed to be directly associated with DON levels in the grain, however researchers have recently determined that the two compounds are uncorrelated (Sarlin, Laitila et al. 2005; Sarlin, Nakari-Setälä et al. 2005). Malt containing hydrophobins would only be suitable for brewing at the micro- or nano- level where the product is consumed relatively quickly, and is carbonated and served under CO_2, and is not bottled.

The objective of this project was to trial several western malting barley varieties for malting quality when grown on the East Coast. The proposed project built on a pilot study conducted during the previous year which showed that there was some promise for further development work.

Methods

Based on the preliminary findings from the initial crop grown during the 2012 growing year, treatments were established to measure the effects of conventional management on malt quality for Western lines grown in Eastern Canada (Table 1). Trials performed during the 2013 growing season were conducted in Prince Edward Island at the Harrington Research Farm. The intent of the experiment was to measure gene X environment interactions of all of the varieties tested during the previous 2012 growing year as described above. Measured variables included total yield, number of heads m^{-2}, and most physical and chemical analyses required to determine malting quality.

All barley varieties suitable for malting were to be malted under lab conditions using conventional methods (Evans, Goldsmith et al. 2011). Following the selection of positive candidates for making malting quality based on chemical and physical analyses, grains were then to be further processed through a malting process which would include predetermined steeping, germination, and kilning steps. Malt quality was then determined. Pending acceptable quality, malted barley was then be used to produce beer at the micro- or nano-scale in collaboration with stakeholders in the local craft brewing industry.

Table 1: Malting barley varieties selected for the project.

Variety	Source
AC Metcalfe	Brandon Research Centre
Norman	Brandon Research Centre
Cerveza	Eastern Grains Ltd.
Newdale	Brandon Research Centre
Island	Eastern Cereal & Oilseed Research Centre
Major	Brandon Research Centre

Results and Discussion

Yield

Data are presented from two growing seasons (2012 and 2013). Although only the 2013 growing season was included as part of the project, the previous years results (pilot project) are presented to illustrate the gene X environment interactions from year to year (Figure 1). During the 2012 growing season, weather was hot and dry following a sufficient amount of early summer rain. It was considered to be nearly a perfect growing season for grains. The following year in 2013 was also an excellent growing season, but would be considered to be more typical of the average growing season in PEI. The most interesting aspect of this is that the one variety which was developed in Eastern Canada, Island, shows the least amount of variability from year-to-year, and was relatively low-yielding during the atypical year and was relatively high yielding during the typical year.

Barley net blotch was rated at two points during the season. There were no significant differences in the disease ratings between different varieties. Overall disease incidence and severity was higher in AC Metcalfe, Island, and Major than in the other three varieties.

Barley quality analysis

Barley samples were sent to New Brunswick Community College Fermentation Technology Lab for pre-malt analysis, physical analysis, and for the samples to be malted. The malt physical analysis showed that there was variability between the varieties in terms of the presence of desirable attributes (Table 2). Varieties that would most likely make the grade based on physical analysis were AC Metcalfe and Newdale. However many of these physical attributes would be affected by an adjustment in management practices.

Pre-malt analysis also included preliminary tests to measure the chemical properties of the grains to evaluate suitability for malting (Table 3). The factors % moisture, 1000 kernel weight, and protein were in the general acceptable range for malting in all varieties. However, only Island, Major and Newdale were acceptable for malting based on germination energy.

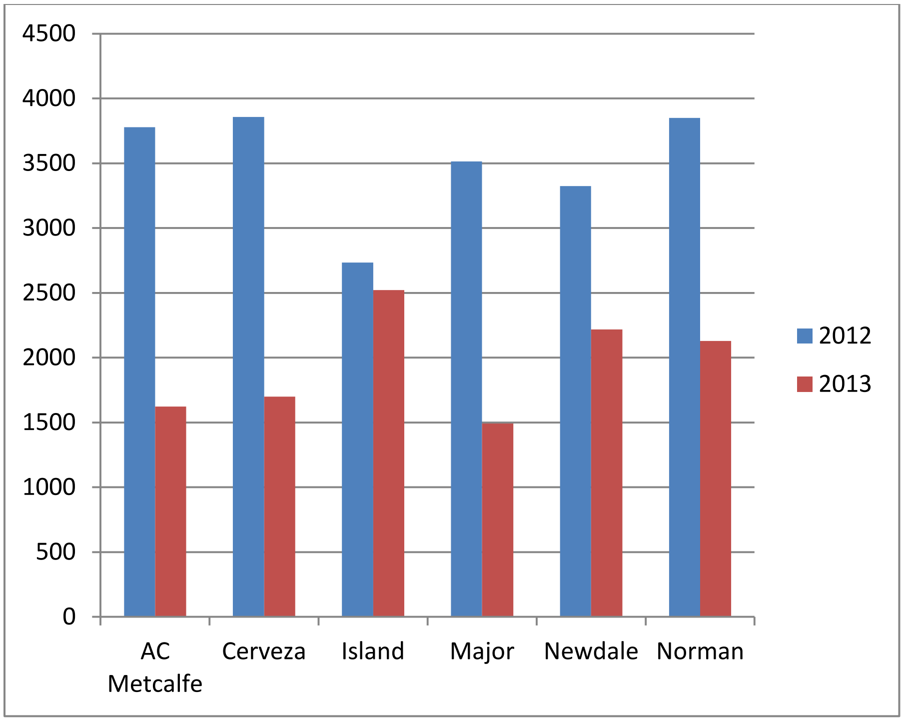

Figure 1: Overall yields of all tested varieties from both the 2012 and 2013 growing seasons.

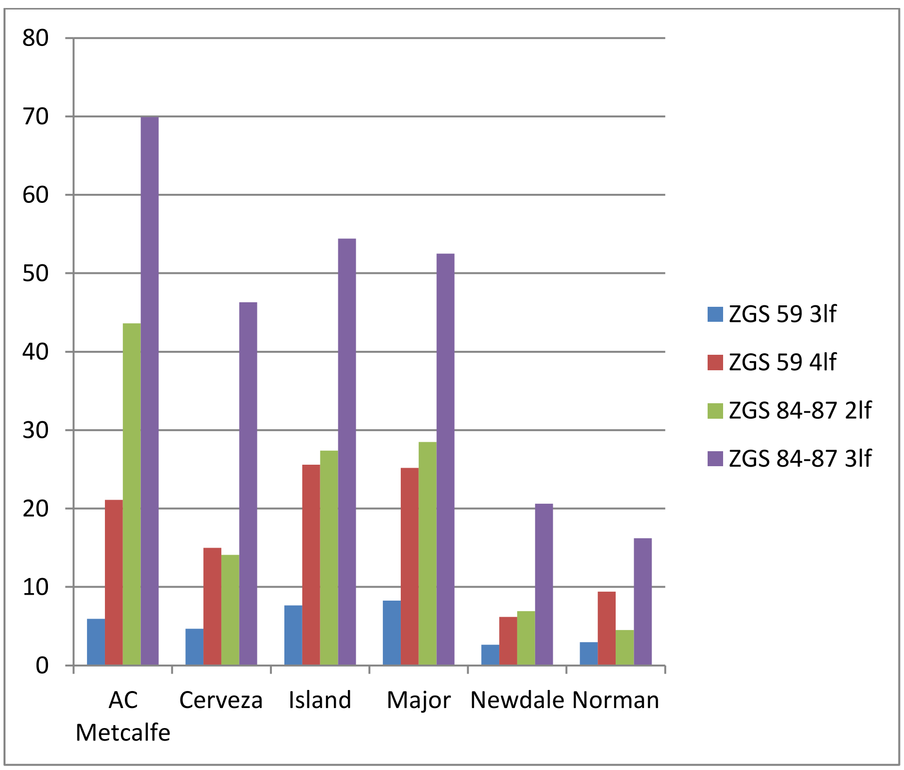

Figure 2: Disease levels of barley net blotch from the 2013 growing season. Ratings were performed at Zadocks growth stages (ZGS) 59 on the 3rd and 4th leaves; at ZGS 84-87 on the 2nd and 3rd leaves.

Table 2: Malt barley physical analysis. A subsample of the barley is taken and is evaluated based on physical factors and observations*.

Variety	Thin	Dockage	Broken	Mildew	Immature	Peeled
	(grams)					
Cerveza	0.4854	0	4.3502	1.3698	0.6865	0.7268
Island	0.3775	0.7852	2.4222	3.6397	1.27	1.2607
Major	0.4177	0.2777	4.9233	1.8813	0.7331	0.8674
AC Metcalfe	0.759	0	1.291	0.6524	0.3443	0.3897
Newdale	0.7789	0.0214	1.7669	1.9178	0.5565	0.4044
Norman	0.6103	0.0432	4.5842	1.7881	0.1527	0.9198

* Based on a 900 g sample.

Table 3: Barley quality based on preliminary, pre-malt analysis. Cells marked green fall within acceptable guidelines for the acceptance of malting barley; cells marked red would not be acceptable for malt.

Variety	Moisture (%)	Germination Energy		1000 Kernel wt. (g)	Protein (%)
		48 hrs	96 hrs		
Cerveza	7.4	75	80	319.67	12.6
Island	6.7	97	98	325.33	13.3
Major	6.8	71	97.5	340	13.2
AC Metcalfe	6.4	53	83	351.33	13.2
Newdale	6.7	94.5	97.5	348.67	13.1
Norman	6.9	58	70.5	367.33	13.5

Malt quality analysis

Malt quality was analyzed by the University of Manitoba in association with the Grain Research Lab in Winnipeg. Overall the malt quality was not consistent or acceptable. There were several severe problems with the malting process as performed by the Fermentation Sciences Lab at New Brunswick Community College. The delivery of the Phoenix Micro-Malting system was behind schedule which put a rush on processing the samples for the project.

Overall the malting system at NBCC was not optimized, nor were the operators sufficiently trained to perform the malt quality analysis. As a result the malt quality was extremely poor compared to what is to be expected according to the typical malt quality observed in conventional samples (Table 4). The poor malt quality has no reflection of the quality of malting barley grown in the project, it is simply a reflection of the use of inappropriate malting procedures on the part of NBCC.

Table 4: Malt quality analysis performed on malted barley that was processed by NBCC.

Variety	Moisture %	Friability %	Fine extract %	Soluble protein %	Malt protein %	S/T ratio	ßeta-glucan Ppm	Viscosity cps	Diastatic power °L	Alpha amylase D.U.	Wort color	FAN mg/L
AC Metcalfe	18.2	27.1	74.1	6.15	15	41	346	1.99	44	< 10	12.3	357
Newdale	12.6	29.6	82.3	5.3	11.1	47.7	452	1.64	108	27.2	4.24	322
Cerveza	8.3	25.6	78.7	4.64	11.4	40.7	728	1.92	90	< 10	6.57	258
Island	11.5	11	80.4	3.79	12.92	29.3	1287	2.33	34	< 10	4.71	189
Major	15.3	16.9	87.4	6.07	13.14	46.2	1180	1.96	67	13.4	10.9	283
Norman	8.8	27.3	80.4	7.72	12.8	60.3	114	1.67	61	16.3	14.34	450
Canadian standard values for acceptance*	<5.0	>80.0	>81.0	4.5-5.5	11-13	38-45	<120	<1.5	>120	>50	<3.0	>180

* These values are the ranges for what is normally considered to acceptable malt quality.

Moisture (%): Usually the lower the moisture, the higher the extract in the malt.
Friability (%): Measurement of “mealy” vs. “glassy” grains. Mealy is better.
Fine extract (%): The measure of the amount of sugar recovered from the malt after mashing.
Soluble protein (%): Sum of all nitrogenous compounds in wort – required for yeast growth.
Malt protein (%): Total % protein.
S/T ratio: Ratio of soluble to total protein – indicative of modification
ßeta-glucan: Increased ßeta-glucan levels may result in increased viscosity and decreased beer filterability (bad)
Viscosity: Decreases as germination proceeds.
Diastatic power: Capacity of the malt to convert starch to sugar.
Alpha-amylase: Measurement of the dextrinizing capacity of the malt – reduction in the molecular weight of starch to lower viscosity.
Wort color: numerical scale based on measurement at 430 nm using a spectrophotometer
FAN (mg/L): concentration of free α-amino nitrogen, required for yeast health

One of the main problems with the malt processed at NBCC, is that the initial malt moisture was too high, which in turn had knock-on effects on the other factors. If malt moisture is too high, then complete conversion of starch to sugars occurs. When additional heat is introduced to drive off moisture there is a darkening of the malt and the enzymes become denatured. This type of malt is called “crystal malt” which tends to be darker in color and most of the conversion of starch into sugar has already occurred. Crystal malts are commonly used in beers to create a darker colour, and contribute a sweeter taste, and do not add to the overall mouthfeel or body of the beer. In the case of malt created at NBCC, this is why most of the malts which show a high moisture, also show a darker color than what is preferred, and there is also a much lower amount of total enzymatic activity (Table 4).

Although many of the malt varieties showed acceptable qualities during the pre-malt analysis, the subsequent malting process rendered the malt to be unacceptable (based on commercial standards) as a base malt for brewing beers. Therefore, the malt quality analyses presented below, do not reflect the potential of the barley produced on the East Coast to be malted as presented above.

Beer quality

Although the malt quality produced by NBCC was not as good as what is normally considered to be acceptable at a commercial scale, they were able to brew two beers using Cerveza and Newdale malt developed from the present project.

As the extract was acceptable and the colour was relatively darker than what was expected, both beers were darker, sweeter, and lighter bodied than they should have been. However, the fact that we were able to brew beer with the malt was a major contribution to show stakeholders that beer can be created from locally grown malting barley. Both beers were “released” as part of the hospitality suite for the Canadian Seed Grower’s Association meeting in December, 2013.

Malt quality improvement

In order to improve the malt quality and analysis for Atlantic Canada, the University of Manitoba was hired to use their facilities in co-operation with the Grain Research Lab, to perform a global analysis of the malting procedures using barley generated from the present project. UofM conducted various iterations of steeping and drying to establish appropriate malting conditions. By including UofM in the study, we have literally saved months of trial-and-error for potential smaller scale micro-malting operations, as well as local testing facilities.

Information, data, and IP on the proper malting procedures for barley grown on the East Coast will reside with the Atlantic Grains Council, and will be used in the future as a consultative measure to improve malting quality, evaluation and the potential for the development of micro-malting operations on the East Coast. This capacity building exercise in developing malting protocols for malt barley grown in Atlantic Canada is pivotal for the overall impact of the present project.

Conclusion

Overall the project can be considered a success. It has served to raise the profile for the production of malting barley in Atlantic Canada. Malting barley was grown under Maritime conditions, malt quality assessments indicate that it is possible to achieve malting quality from barley grown on the East Coast, and there have been major developments to establish appropriate malting protocols through collaborations with University of Manitoba and the Grain Research Lab. One of the most important outcomes of the project is that it has stimulated discussion between brewers, growers, and other stakeholders. By demonstrating that it is possible to grow malt quality barley in Atlantic Canada, brewers can now provide market support to growers and build upon a strong locally-based value chain.

A critical area for future development is with the agronomic management of malting barley to maximise pre-malt quality. Growers in Atlantic Canada are used to growing feed barley which has a heavy emphasis on high protein and yield. With malting barley, high protein is considered to be undesirable, and given the premium paid for malting barley lower yields are acceptable if obtaining a higher quality is preferred. Taken together, the value chain development achieved by this project and potential future agronomic development will help to foster the development of a fledgling industry of malt barley production in Atlantic Canada.