IMPROVING MALTING BARLEY YIELD & QUALITY IN NORTHERN CLIMATES

2018 ANNUAL REPORT

NORTHERN ONTARIO FARM INNOVATION ALLIANCE

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Introduction

The beer economy contributes $13.68 billion to Canada's GDP and in 2016, supported 149,000 Canadian jobs. Ontario has over 200 craft beer breweries and the Ontario Craft Brewers Association predicts upwards of 500 breweries in Ontario over the next decade. In recent years, craft beer has been the fastest growing segment within the LCBO's beer category, with annual increases of 20-30%. With this growth in craft beer, there is an increased demand for regionally produced malt.

Currently, most of the malting barley is produced in Western Canada, with Ontario importing over 300,000 tonnes per year. However, with increased demand for Ontario malt, there is strong market potential for Ontario-grown malting barley. The climate in Northern Ontario is somewhat like that of Western Canada and offers a promising opportunity to support further growth in malting barley production. That being said, malting barely must be grown with appropriate management practices to meet all the standards required for brewing, which can be intensive and risky for farmers. Research on variety evaluations and nutrient management techniques will support Ontario growers in accessing these markets.

The Northern Ontario Farm Innovation Alliance is coordinating a three-year research project (2018-2021) on "Improving Malting Barley Yield and Quality in Northern Climates", in partnership with the Grain Farmers of Ontario and the Canadian Agricultural Partnership (through the Agricultural Adaptation Council). This is a pan-northern research trial evaluating malting barley varieties and best management practices in different regions across Northern Ontario. The research outcomes will help Ontario's grain farmers grow malting barley to maximum yield and quality, targeting the domestic market and adding a potential new crop to farmers' rotations.

Research Trials

Trials are being conducted at the New Liskeard Agricultural Research Station (NLARS) in New Liskeard, the Lakehead University Agricultural Research Station (LUARS) in Thunder Bay, and the Emo Agricultural Research Station (EARS) in Emo. On-farm trials are being coordinated by the Rural Agri-Innovation Network (RAIN) in Algoma looking at dual-purpose malting barley varieties (can be used for either feed or malt).

The work at the three research stations is assessing:

1. Ten high yielding varieties of malting barley, including Bentley, AAC Synergy, CDC Bow, CDC Kindersley, CDC Fraser, AAC Connect, Lowe, Newdale, Copeland and OAC 21 for yields & quality.
2. Nitrogen and sulphur management strategies to improve yields while maintaining protein content to acceptable levels. Nitrogen has a major impact on protein levels in the crop, while sulfur levels have been declining in Ontario soils. Both nutrients are likely to increase yields, but the downside is adverse effects on the overall malt quality of the barley. Therefore, varying rates of these nutrients are being tested to determine the best nutrient management plan for malting barley in Northern Ontario. Seven different rates of nitrogen using urea and ESN and three rates of sulfur using gypsum are being tested. These nutrient tests are being done on CDC Bow.

Additionally, dual-purpose varieties are being assessed on-farm in Algoma as these can be used for both malt and feed and would help mitigate risk for farmers if conditions are not conducive to growing high quality malting barley.

Results

The results from the three stations have been summarized below. Aggregate samples were also sent to Canada Malt for quality testing. Barley quality analysis determined whether the samples were suitable for malt production – if they were, they underwent additional analysis to assess malt quality.

Barley Quality

The following include some of the variables that are important for barley quality:

- Protein – barley protein within the range of 11-12.5% can be used by maltsters to meet many brewers' needs. Barley with high protein levels results in lower extracts and slows down water uptake during steeping, which can affect final malt quality. Low protein levels lack the enzymes necessary to modify the barley kernel and to break down the starch during brewing.
- Moisture – barley over 13.5% moisture does not store well. It can be dried but must be done very carefully as excessive heat can damage germination in the kernels.
- P & B – limit of 5% or less for properly threshed barley. Barley is commonly rejected for malting if there are too many peeled and broken kernels, mostly caused by improper combine adjustments.
- Plump – barley with greater than 80% plumpness is desirable as plump kernels contain higher levels of starch, which will produce more beer from a given weight of malt.
- Germination energy – barley with greater than 95% germination is acceptable for malting. If this threshold isn't reached, the barley won't have enough energy to be efficient during the malting process.

Variety Trial

The highest grain yielding variety at NLARS, LUARS and EARS was AAC Synergy (see Fig. 1). All the varieties tested at NLARS had protein content greater than the 12.5% limit, while several of the varieties at both LUARS and EARS tested within the acceptable range for protein (see Fig. 2). Though protein levels at NLARS were too high, moisture and plumpness generally fell within acceptable ranges. Moisture content for all varieties at EARS were below the limit, but moisture content for all varieties at LUARS were above the limit. All the varieties at both EARS & LUARS fell below the threshold for P&B, indicating properly threshed barley. All the varieties at LUARS tested above the threshold for plumpness, while only AAC Synergy and Fraser tested above the threshold at EARS. Several varieties at LUARS and EARS were above the threshold for germination energy. When examining overall potential of barley for malt (acceptable protein, plumpness and germination), AAC Synergy at EARS and CDC Fraser, AAC Connect, Lowe and CDC Copeland at LUARS seem to have the most potential. Tables 1, 2 and 3 give summaries of the malting barley quality for all ten varieties at EARS, LUARS and NLARS.

Variety Trial Malting Barley Quality Summary for Research Stations

Table 1. EARS Malting Quality Summary			
Variety	**Protein**	**Plumpness**	**Germination**
Bentley	OK		
AAC Synergy	OK	OK	OK
AAC Connect	OK		OK
Newdale	OK		OK
Lowe	OK		
CDC Bow	OK		
CDC Copeland	OK		OK
Kindersley	OK		OK
Fraser		OK	
OAC 21	OK		

Table 2. LUARS Malting Quality Summary			
Variety	**Protein**	**Plumpness**	**Germination**
Bentley		OK	OK
AAC Synergy	OK	OK	
AAC Connect	OK	OK	OK
Newdale		OK	OK
Lowe	OK	OK	OK
CDC Bow		OK	OK
CDC Copeland	OK	OK	OK
Kindersley	OK	OK	
Fraser	OK	OK	OK
OAC 21		OK	

Table 3. NLARS Malting Quality Summary			
Variety	**Protein**	**Plumpness**	**Germination**
Bentley		OK	
AAC Synergy		OK	
AAC Connect		OK	
Newdale		OK	
Lowe		OK	
CDC Bow		OK	
CDC Copeland		OK	
Kindersley		OK	
Fraser		OK	
OAC 21			OK

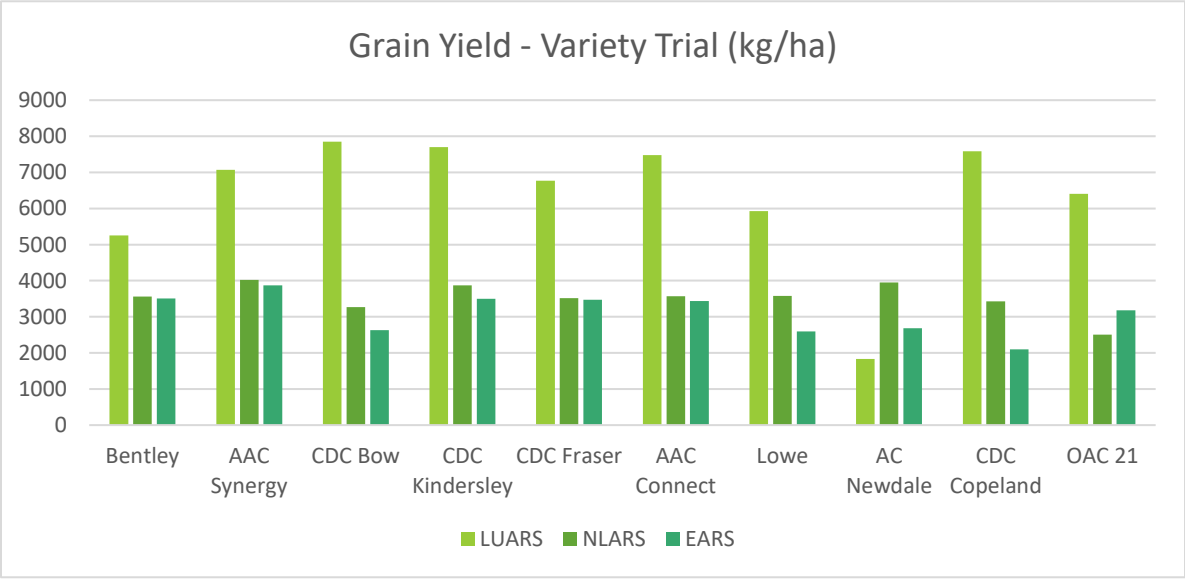

Figure 1. Comparison of grain yields from the ten malting barley varieties across the three research stations.

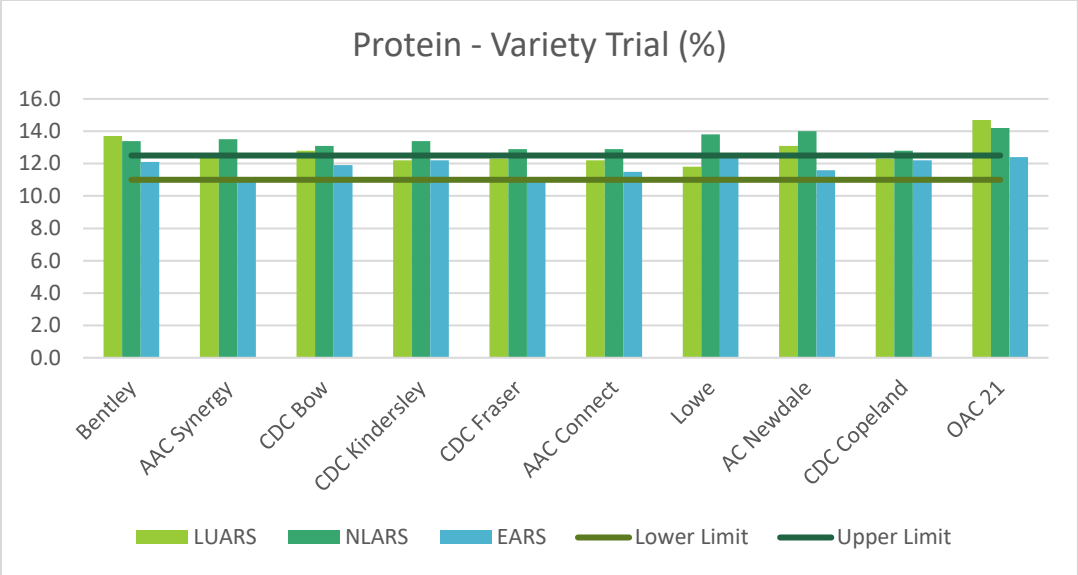

Figure 2. Comparison of protein levels of the ten different malting barley varieties across the three research stations.

When the varieties are assessed across the three stations, all varieties were below the threshold for moisture content, while AAC Synergy, Bentley, CDC Bow and CDC Fraser fell within plumpness parameters, AAC Connect, AAC Synergy, CDC Copeland and CDC Fraser well within protein parameters and AAC Connect, CDC Bow, CDC Copeland, CDC Fraser, CDC Kindersley and OAC21 fell within P&B parameters.

Nitrogen & Sulphur Management Trial

Malt quality is extremely sensitive to nitrogen fertility. In many cases, the best quality is achieved by adding little or no nitrogen. However, this can be difficult to reconcile as nitrogen also drives yield. Therefore, it is important to find a balance between yield and quality. Protein levels can indicate appropriate levels on nitrogen – if protein levels are high, nitrogen applications should be reduced. This general trend between nitrogen, protein and yield can be seen in the graphs below and will be further explored in the final report at the end of the three years. See figures 3, 4 and 5 for a comparison of the nitrogen and sulphur treatments on yields and protein levels at the three different research stations.

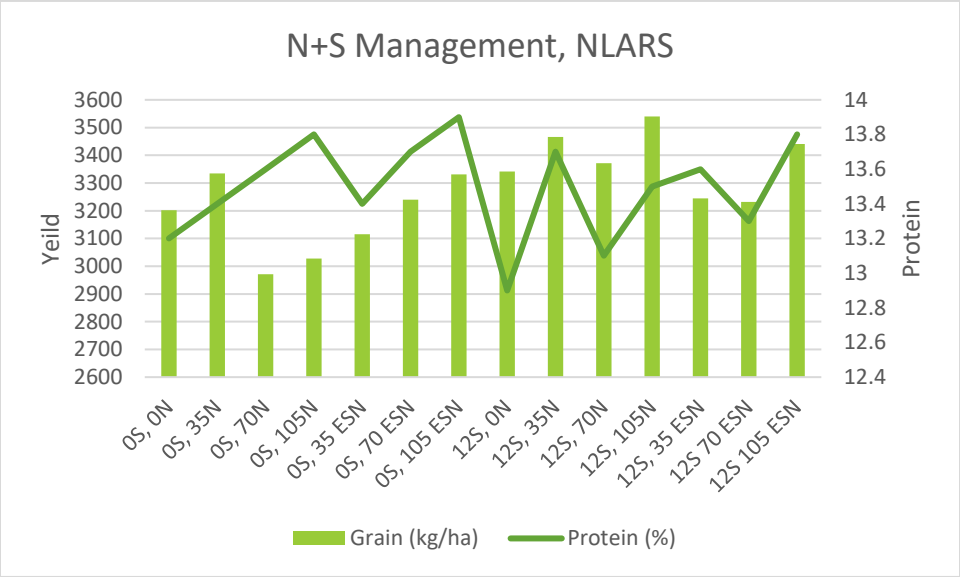

Figure 3. Comparison of nitrogen and sulphur treatments on malting barley yield and protein content at NLARS.

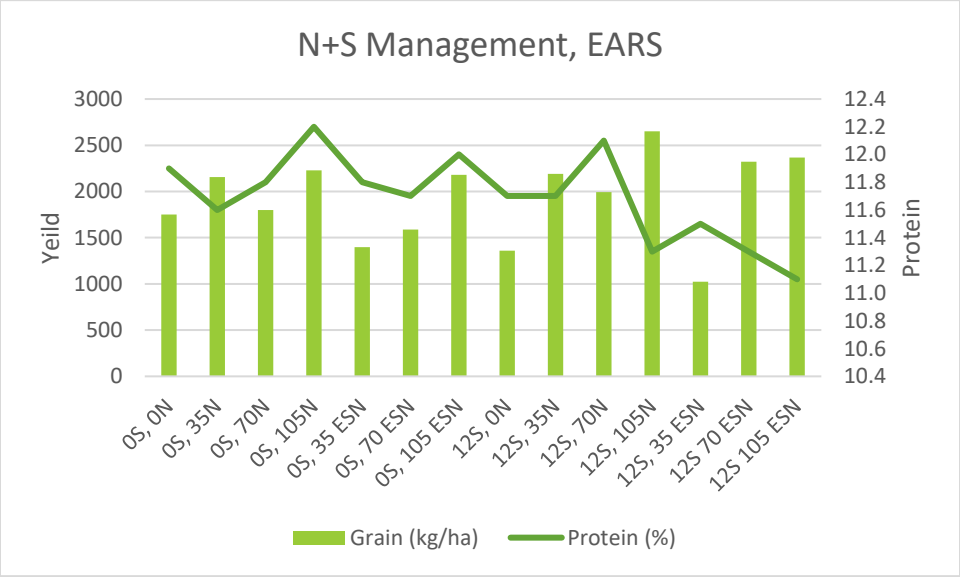

Figure 4. Comparison of nitrogen and sulphur treatments on malting barley yield and protein content at EARS.

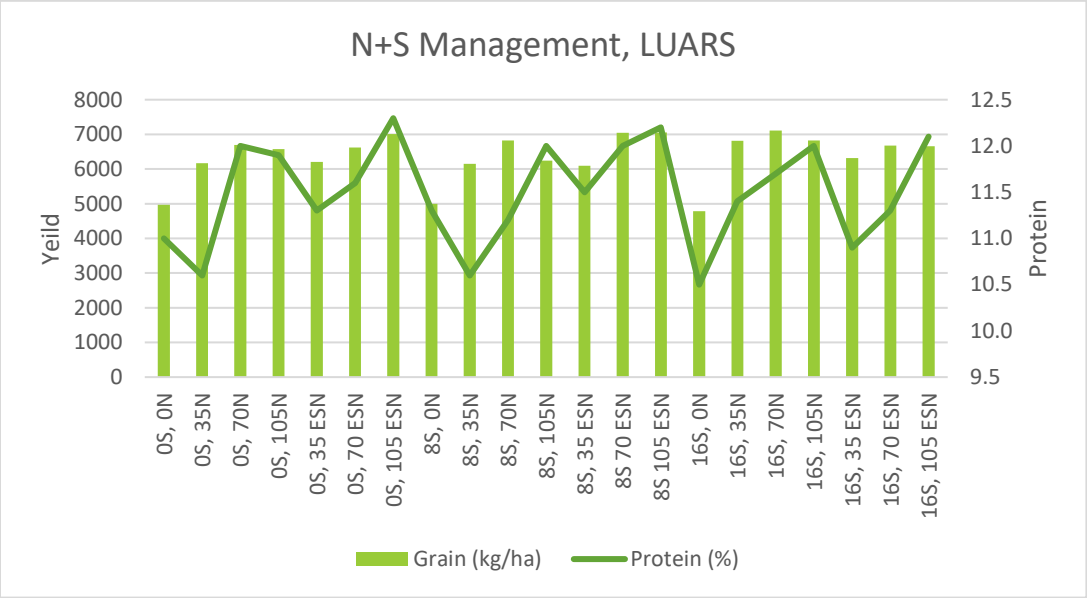

Figure 5. Comparison of nitrogen and sulphur treatments on malting barley yield and protein content at the Laurentian University Agricultural Research Station (LUARS).

Malt Quality

Quality samples that tested within acceptable protein ranges underwent further testing for malt quality, identifying traits necessary for brewing different kinds of beer. These traits include:

- Moisture content – the closer a malt is to 1.5%, the less it risks mold growth and it loses less flavor and aroma over time. The upper limit for acceptable moisture in any malt is 6% and colored malts should never be over 4% MC.
- % DBGF – anything lower than 78% is considered substandard. This percentage indicates the maximum soluble yield possible for malt, the higher the percentage, the more soluble the material and the less husk and protein.
- % DBCG – indicates the amount of yield a brewer can target, based upon the degree of starch modification that the grain underwent during malting. These values typically need to be reduced by 5% - 15% to reflect actual yields obtained in a brewhouse since they are less efficient than the lab.

Since all the samples from NLARS exceeded protein levels, they did not undergo malt quality testing. All varieties in LUARS and EARS had moisture content levels below 6%, with CDC Bow (5.8%) having the highest MC at LUARS and AAC Synergy (5.8%) having the highest MC at EARS. All varieties had moisture levels at 4% or higher. With nitrogen and sulphur management, moisture content levels varied between 4.4%-4.9% at LUARS and 3.9%-4.8% at EARS.

Both OAC 21 (76.5%) and CDC Copeland (77.2%) fell below the limit for % DBGF at EARS. OAC 21 (73.8%) also fell below the limit for % DBGF at LUARS. With nitrogen and sulphur management, % DBGF fell between 80.6% - 83.2% at LUARS and 79% - 80.7% for EARS.

AAC Connect (80.3%) had the highest % DBCG and OAC 21 (75%) had the lowest % DBCG at EARS. Lowe (81.3%) had the highest % DBCG and OAC 21 (70.6%) had the lowest % DBCG at LUARS. With nitrogen and sulphur management, % DBCG fell between 77.7% - 79.7% at EARS and 79.4% - 82% at LUARS.

When assessing the overall malt quality from both stations, all varieties were too dark except for OAC 21. Only AC Newdale, CDC Kindersley and Lowe had acceptable levels of betaglucans, high levels of which makes it harder for barley to absorb water during the malting process. These levels are affected by the timing of rain in the summer and feed barley is typically bred to have higher levels of betaglucans. Plumpness, indicative of the valuable part of the harvest, was above the threshold for AAC Synergy, Bentley, CDC Bow and CDC Fraser. The amino acids in wart (flavor of the beer) were all too high, which results in compounds that lead to spoilage in beer (can't ship long distance and has a short shelf life). This is also affected by nitrogen levels. Finally, malt protein was acceptable in all varieties except OAC 21 and Bentley. Table 4 shows a breakdown of malt quality based on CMC's analysis for each malting barley variety tested.

Table 4. Malt Quality Summary Based on CMC Analysis

Variety	Protein	Plumpness	Color	Betaglucans	Amino Acids
Bentley		OK			
AAC Synergy	OK	OK			
AAC Connect	OK				
Newdale	OK			OK	
Lowe	OK			OK	
CDC Bow	OK	OK			
CDC Copeland	OK				
Kindersley	OK			OK	
Fraser	OK	OK			
OAC 21			OK		

Considerations Moving Forward

Results from the first year were likely impacted by weather, with a wet spring causing delays in planting and washouts of seedings in some plots, a hot, dry summer leading to higher protein levels, and a wet harvest, impacting the quality of malting barley in some locations.

Early planting and high yields usually result in lower percentage protein. Excessive rates of nitrogen fertilizer will increase protein levels, but the application of nitrogen, based on soil tests, to obtain optimum yields will normally have only a minor effect on the protein content of the grain. Good production practices that increase yield will generally tend to reduce protein levels.

The farmer, maltster and brewery are concerned with different considerations. The farmer needs to consider Deoxynivalenol (DON) and protein and needs to have low chitting. The maltster is concerned about low betaglucans and protein and the brewery needs low colour, high extract and low protein.

Timing is essential for a good harvest of malt barley. Extremely high values for chitting or pre-harvest sprouting (anything over 5%) are enough to impact the entire harvest. Due to the high-level enzymes in malt barley compared to feed barley, it is common in eastern Canada to take off the barley at 18-20% moisture and use forced air in the grain bin to get the moisture down. It has been said that “nothing good happens after physiological maturity”. High chitting numbers can correlate with high numbers of peels and broken kernels, mildew, etc.

Beta-glucans are going to be an issue for eastern Canada. These levels are very high, and most varieties in this first year illustrated this. This is largely governed by the grain filling period and there is little that that can be done other than try to grow varieties that genetically have lower levels of beta-glucan.

These trials will be repeated in 2019 and 2020, at which point an overall data summary, economic analysis and best practices will be produced.

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