BMBRI Strategic Goals and Targets for Malting Barley Breeding and Research 2018-2028

The purpose of this document is to provide input and direction from the Canadian malting and brewing industry, and related member customers, outside of Canada, into the upcoming development of the breeding and research funding consortium under "Growing Forward III" and/or other related federal-provincial-industry programs for the period 2018-2028.

Overarching Goals:

- Achieve improved agronomic performance in new varieties, for malting barley to be a profitable cereal choice in rotations with other major crops while also having improved disease resistance and desired quality attributes for selection and use in malting and brewing markets.

- Develop, recruit and train scientists to replace and enhance staff resources at existing or new barley breeding and research centres.

- Invest in laboratory and technological resources and capabilities at Canadian research centres to ensure they have the most up to date scientific equipment needed to efficiently and effectively achieve breeding and research goals and objectives of value chain stakeholders.

- Where possible collaborate with other cereal breeding and research programs on major crosscutting areas of concern so that best use is made of resources and funding investments. An immediate example is the need for investment in Fusarium Head Blight and related micotoxins (DON) breeding and research work to address concerns of both barley and wheat industries.

Specific Breeding and Research Goals and Objectives:
Attached document (Appendix I) details BMBRI's current list of desired traits for breeders and researchers and explains the rationale for and importance of some of these traits. These can be categorized under the following important strategic priority headings and objectives:

A. Breeding and Pre-breeding Research

1. Agronomic Improvement
a) Higher Yield. Target 5% higher yield than current yield check (AAC Synergy) over five years.
b) Improved crop lodging resistance to enhance harvestability
c) Early heading and good head retention to assist ripening and harvesting
d) Ability to withstand range of abiotic stresses in the production areas for which varieties are bred, including early seedling cold tolerance, waterlogging tolerance, drought tolerance, improved resistance to pre harvest sprouting, etc.

2. Disease Resistance/Disease Tolerance Improvement

a) Improved resistance to Fusarium Head Blight (FHB)

b) Reduction of critical field (and storage) Fungi that affect the levels of mycotoxins and quality of beer, and the brewing processes, e.g. DON content, gushing and premature yeast flocculation (PYF)

c) Improved resistance to other important field diseases as identified by the Disease Subcommittee within the Prairie Recommendation Committee for Oats and Barley (PRCOB)

3. Desired malting and brewing traits for specific market steams

a) AS PER ATTACHED BMBRI LIST OF DESIRED QUALITY TRAITS

Note: This LIST includes different protein, FAN , enzyme and other factor target levels for different market streams (adjunct, all-malt craft, etc.,). Breeders are encouraged to keep these in mind when making their breeding selections for pre registration evaluation.

B. Production and Harvest/Storage Best Management Practices for Malt Selection

1. Crop management to allow better harvestability and selectability without the use of any pre-harvest desiccants
2. Research and communicate best management practices for the current range of new malting barley varieties to maximize grower profitability and end-user selectability. Such practices to include seeding rates, nitrogen application rates, other crops in rotation, use of approved agrichemicals , etc
3. Identify best grower management practices and rotations to minimise the incidence of Fusarium Head Blight or other major diseases that can impact selectable malting barley quality
4. Research into best management practices for production of organic or pesticide free malting barley in particular regions for such specific market demand
5. Identify specific best management practices for “local” malting barley production and local craft malting or mainstream malting, including malting barley production in Maritimes and Eastern Canada

Appendix I

BMBRI Desirable Malting Barley Trait Requirements (Current 2016-17 Version)

Research and breeding for improved agronomic performance of malting barley varieties that are competitive with other crops for growers and have improved chances of selection for marketing is a key priority for BMBRI. In addition such varieties should have the quality parameters required for malting and brewing. Quality traits of particular importance to our industry members, as approved by the BMBRI's Technical Committee, are listed and explained below. These traits are separated into those that need to be considered for breeding of new varieties, and those for which further research is required to assist breeding and/or processing. This list is provided as a reference to malting barley breeders and researchers in planning their future work. It is also a reference for parties involved in related breeding and research funding applications.

Current Hot Topics and Discussion Points (Updated November 2016)

The desired trait lists below are not in order of priority, as BMBRI does not wish to direct breeding and research into any one area. However BMBRI Technical Committee members have recently identified following aspects within the desired trait list as hot topics worthy of note:

- Reduced effects of Fusarium Head Blight (FHB) and related toxins (DON) are a priority for Breeders and Researchers at the levels of improved variety resistance and grower management practices
- Domestic and international market demand has moved primarily to two-row malting varieties both for adjunct brewing and all malt (craft) brewing and away from six-row malting varieties
- There is interest and need for more breeding work and sources for the 'Loxless' trait in future malting barley varieties
- New quality innovations and attributes such as heat stable enzymes are of interest
- Flavour: Understanding and finding objective measurable flavour component attributes are of interest to certain brewers and the ability to transfer such flavour components into breeding programs
- Balanced modification: Recent breeding advances with some new varieties may have now reached the lower required limits for betaglucans while also ensuring balanced modification with required levels of proteolytic modification
- BMBRI guidelines as to some malt quality parameters for the different beer market segments and styles (all malt 2R brewing vs. adjunct 2R brewing vs. adjunct 6R brewing) should be noted in breeding and future variety registration decisions

Characteristic (Not prioritized)	Breeding Target	Research Target
Arabinoxylan measurement		✓
Balanced Modification	✓	
Consistency in barley quality across growing conditions	✓	
Sensory Traits in Barley Varieties	✓	✓
Enzyme Activities	✓See below*	
Extract	✓	
Fermentability		✓
FHB Resistance	✓	
Hull Adherence	✓	
Long Term Germination	✓	
Pre-Harvest Sprout Tolerance		✓
Protein	✓See below*	
Varietal Identification		✓

<u>*Protein/Enzyme Relationship:</u>

There are four main quality profiles which are used to produce commercial malts:

- Moderate protein/High enzymes – high demand for adjunct brewing, e.g. AC Metcalfe
- Moderate protein/Moderate enzymes – high demand for adjunct and general brewing, e.g. AAC Synergy

- Moderate protein/Lower enzymes – moderate demand for low adjunct brewing and blending, e.g. CDC Copeland
- Low protein/Low enzymes – specific demand for all-malt craft beer production with no or limited adjuncts, e.g. Lowe? TBD with further malting.

Protein Range Definition:
Low = < 11% Moderate = 11% – 12.5%

Enzyme Range Definition:
DP- °L: Low = <125 Moderate = 125 – 150 High = >150
Alpha Amylase- DU: Low = <53 Moderate & High = >53

Brewing Market Segment Malt Quality Guidelines
As the international brewing industry has different segments, the following are additional BMBRI guidelines as to the quality needs of these segments. This information is useful for breeders and those involved in decisions on future variety registration recommendations. The general malt quality requirements for all malt beer and adjunct beer production below further illustrate and support the above Protein/Enzyme quality profiles. Individual brewers may have even more refined individual specifications to these. BMBRI advises breeders and researchers to talk directly to such brewers as well.

	***All Malt 2R (Craft) (Increasing)**	****Adjunct 2R**	
Extract, fg, db %	>80 (High as possible)	>80 (High as possible)	
Protein, db%	< 11.5	> 11.5	
Sol. Protein, db%	< 5.0	> 5.0	
KI (S/T), %	38-45	42 – 47	
Enzymes/DP, °L	low/med 100-120 : 120-140	med/high 120-140 : >140	
Beta Glucan, mg/L	Variable, 135 Max	Low as possible	

FAN, mg/L	< 200	> 200	

***All Malt Beer (No Adjunct) Requirements**
Two-row varieties are preferred over six-rows for all malt beer production primarily for higher extract, lower protein and lower enzymes than six rows. A single variety or a blend of more than one variety can be used.

****Adjunct Beers**
Both two-row and six-row (now to a much lesser extent) varieties are used in this category, either as single varieties, blends of two-row varieties, blends of six-row varieties, or blend of two-row and six-row varieties. Generally, for brewing with solid adjuncts, high extract is required as well as higher enzymes and higher FAN for efficient fermentation. But for brewing with liquid adjuncts, more moderate enzyme levels are acceptable and will vary based on each individual brewer's requirements. Use of six-row varieties is declining while use of two row varieties is increasing for this category.

Explanations:

Arabinoxylans measurement: One type of non-starch polysaccharide found in the cell walls of the starchy endosperm and aleurone layer are arabinoxylans. If the cell walls are insufficiently degraded during the malting process, these molecules may have adverse effects during filtration in the brewing process and may contribute to haze formation. At the same time, arabinoxylans may have positive effects in regards to the sensory profile and foam stability in beers. In order to have a better understanding of arabinoxylans role

in beer production and quality, a universal measurement technique would be useful to end users.

Balanced Modification: The term "modification" encompasses all the changes which happen within a barley kernel as it becomes malt. Two key measures of these changes are the breakdown of beta glucan molecules into smaller molecules, and the partial degradation of the barley protein. Ideally varieties would deliver low beta glucan levels, for optimum lautering and filtration during brewing, without excessive breakdown of the protein fraction, which can be detrimental to beer characteristics such as foam stability. "Balanced" refers not to a mid level for both beta glucan and soluble protein, but to an ideal level of each without compromising the level of the other. Better understanding of beta glucanase activity.

Consistency in barley quality across growing conditions: Some malting barley varieties have acceptable malt quality when grown across diverse growing areas and across crop years. Varieties which give consistent malt quality have a better chance of becoming widely grown and accepted for malting and brewing purposes. For example, Harrington has been grown in several countries under varying conditions and has been consistently selected for malting. Consistency across all malting barley quality traits is an important characteristic in itself.

Sensory Traits in Barley Varieties: There is a desire for researchers and breeders to come up with screening methods to identify differences between lines for some important malt and beer sensory characteristics. The ultimate aim would be to develop future public varieties that have sensory characteristics that are of benefit to brewers. Examples would include, Dimethyl Sulphide (DMS) and its Precursors; low lipid oxygenase varieties (low LOX); research if positive flavor components exist or not in older varieties.

- Dimethyl Sulphide (DMS) and DMS Precursors: DMS adds a characteristic flavour in beers. It arises from precursors that are formed during grain germination. These can be controlled to the desired level during kilning of the malt or during boiling in the brew house. DMS at the required levels in kilned malt would be desirable. This may allow for energy cost savings at the boiling stage in the brewery. Research is needed to examine if there is tendency for DMS variability between varieties. A tool for breeders to identify any such variability is also desirable.

- Low Lipid Oxygenase Enzyme (Low LOX): There is an interest in low LOX varieties among brewers because of potential improved beer shelf life and other associated benefits.

- Flavor Components in Older Varieties (Research only): Imported malt from older European varieties is being used in the craft brewing segment of the North American brewing industry, in part because of claims of specific positive flavor components in

these older varieties. There is a need for researchers to investigate methods to identify and validate if such variety specific flavor components exist before deciding whether any future breeding effort is necessary for interested brewing market segments.

Enzyme Activities: Typical North American malts have relatively high enzyme levels when compared with European and Australian malts. This is one of the advantages of our malting barley varieties. The enzymes active during the malting process ensure the appropriate levels of beta glucan and protein breakdown. The enzymes in finished malt ensure that the starch from both malt and any adjuncts which may be used in the brewing process are broken down into fermentable sugars. Enzyme levels can be too high, however, leading to a lack of control in the brewing process. Current levels are appropriate for meeting most malt specifications. There may be some interest in malting barley varieties which have lower enzyme levels for some malt markets, but there is not a significant demand at this time. In addition to measurement of Alpha Amylase (AA) overall Diastatic Power (DP), it would be desirable to provide information on the levels of Limit Dextrinase (LD) in breeding lines currently under development.

Extract: When brewers buy malt they are buying extract. It contains all the soluble components of the malt, primarily carbohydrates and proteins and their breakdown products, as well as colour and flavour compounds. The extract provides the source of fermentable sugars, the enzymes necessary for starch conversion, and proteins needed for yeast nutrition. Extract levels in current commercial varieties are at acceptable levels. Increases beyond the current levels which are derived from increased soluble protein are not desirable.

Fermentability: While extract refers to all components of a malt which are solubilized during the mashing stage of brewing, only the fermentable sugars in the wort can be converted into alcohol by the yeast. Not all of the starch in malt gets broken down into fermentable sugars and not all starch breakdown products can be used by the yeast. A variety of processing parameters can affect fermentability, but there also appear to be varietal differences. Increased fermentability means getting more out of the malt during the brewing process, in a controlled and predictable way. The development of a measurement for fermentability that is accepted by end users is required to better understand this dynamic phenomenon.

FHB Resistance: Agronomic performance in general, including disease resistance, is recognized as being as important as malting quality in new malting barley lines; however, it is particularly urgent that lines with improved FHB resistance be developed. Susceptibility to FHB and the presence of DON in barley directly impacts the quality of both the malt and the beer which can be made. It is also of critical importance in terms of maintaining and regaining production acres in the Red River Valley and, increasingly, across the Prairies.

Hull Adherence: This remains an important target for improvement in Canadian malting barley varieties. Hull adherence in both malting barley and the resulting malt impacts the quality of the malt and the beer produced from it in several ways: the hull physically protects the embryo end of the kernel and, in doing so, helps to ensure vigorous germination; the hull also provides some degree of insulation during the kilning stage of the malting process, moderating the effect of the heat on the enzymes in the green malt; the hulls are also important during the brewing process as a filter bed during lautering. For all these reasons, hulls that adhere firmly during the handling of barley and malt are important contributors to overall quality.

Long Term Germination: The problems associated with germination of Canadian malting barley has gained considerable attention over the past couple of years, in particular with respect to the performance of Canadian malting barley overseas. Reliable germination is just as important to the production of malt domestically. While it is clear that pre-harvest sprouting and storage conditions have a significant effect on germination behavior, it is not yet clear to what extent different varieties are susceptible to these problems. The challenge is to ensure that malting barley maintains its germination, but without introducing prolonged dormancy. It is also desirable that barley not be water sensitive.

Pre-Harvest Sprout Tolerance: Some malting barley varieties have a greater propensity to germinate than others under wet conditions during crop maturation through harvest. This compromises the likelihood of this crop being selected for malting purposes. Although the barley is still alive, once pre-harvest germination has occurred, the barley will never perform optimally in the malt house, compromising malt quality. While long term dormancy is not desirable, it is recognized that some resistance to pre-harvest sprouting is required to ensure barley quality under a wide range of harvest conditions. A procedure to determine a variety's propensity to sprout would be very beneficial to the development of new barley lines.

Protein: The protein content of malting barley is affected by many factors, especially the growing conditions. Fertilizer application may also impact the final protein level. The protein level of new lines is measured relative to standard check varieties grown at the same location under the same conditions, and lines which have a tendency to regularly have higher or lower protein than the checks are noted. The protein level is important because it will affect the rate of water uptake during the steeping stage of malting, affect the extract level in the finished malt (higher protein dilutes the starch available for conversion to fermentable sugars), and provide the enzymes and soluble proteins needed in the finished malt. Protein levels can be too low (inadequate enzymes) and too high (inadequate extract; excessive enzymes and soluble protein). Varieties which tend to maintain a moderate protein level under a range of growing conditions are desirable.

Varietal Identification: Malting is done on a varietal basis, with conditions particular to each variety being used during processing to produce malt with the required specifications. Blending is only done with finished malt, and is done to a brewer's specifications. There is a very real need for the means by which to accurately, quickly and affordably determine the varietal composition of barley samples, using a subjective method. This is becoming increasingly important as the number of registered varieties proliferates. Visual identification of varieties is no longer adequate.