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Estimates of Heritability of Major Malting Quality Traits in Canadian Barley

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As part of the evaluation of potential new cultivars of barley in western Canada, 10 malting quality traits are assessed, at multiple sites in multiple years, on the most advanced malting lines in the co-operative testing system. These traits include thousand kernel and test weight, percent plump (over a 2.3 mm screen), percent crude protein, percent malt extract, percent soluble wort protein, diastatic power, level of alpha amylase and beta-glucans, and wort viscosity. Breeders focus on improvement of these traits, which are under quantitative genetic control and are the major characteristics in the improvement of malt quality (Bertholdsson, 2004).

The above malting traits are under both genetic control and environmental influence. For this reason, breeders estimate the likelihood and rate of genetic gain using (broad-sense) heritability (H^2; Strickberger, 1968). Although H^2 has been estimated for malting quality traits in a wide range of environments (Bertholdsson, 2004), there is little information on heritability of malting quality traits for (western) Canadian malting barley cultivars, including overlapping U.S. cultivars grown in the Northern Great Plains, and tested in western Canada.

Using data from the western Canadian co-operative barley trials from 2001 to 2005, a total of 120 genotypes were assessed for 10 malting quality traits in 32 environments. Broad-sense heritability (H^2) estimates were generated for each trait in each of the 5 years of evaluations (Table 1).

Table 1. Broad-sense heritability (H^2) for 10 malting barley quality traits for 120 genotypes in 32 environments under western Canadian conditions.

	Year							
Trait	2001	2002	2003	2004	2005	Avg.	Range	Std Error
1000 Kernel Weight	72.2	63.7	75.2	65.9	65.3	68.5	8.5	4.4
Test Weight	80.0	70.6	82.7	79.5	72.1	77.0	12.1	4.7
Percent Plump	52.7	75.2	49.9	79.5	61.6	63.8	29.6	11.8
Percent Crude Protein	79.1	53.4	94.0	78.1	82.7	77.5	33.8	13.3
Percent Malt Extract	77.9	87.2	53.2	67.9	75.8	72.4	40.0	11.4
Soluble Protein	72.6	77.1	34.5	79.4	71.8	67.1	44.9	16.5
Diastatic Power	72.1	76.8	42.9	58.0	84.1	66.8	41.2	14.7
Alpha-Amylase Levels	85.6	79.9	60.5	80.5	86.8	78.7	23.6	9.5
Beta-Glucans	64.9	63.7	51.5	60.6	72.8	62.7	21.3	6.9
Viscosity	78.8	49.5	69.8	82.1	63.7	68.8	32.6	11.6

Results in Table 1 show that the most stable traits, over years, are 1000 kernel weight, test weight, alpha-amylase and beta-glucans. Of these, test weight and alpha-amylase also have a high average heritability ($H^2 > 70$). Thus, these two traits are most likely to demonstrate a relatively rapid genetic gain from selection under western Canadian conditions. Crude protein

also demonstrated a high average heritability of 77.5, but was less stable, indicative of a fairly strong environmental influence. Thus, genetic gains would lag behind test weight and alpha amylase. The remaining seven traits had an average heritability value exceeding 62, indicating a positive response for genetic gain and are amenable to genetic improvement under western Canadian conditions, albeit at a slower pace. In addition, four out of the five years of testing were consistent, with respect to H^2, with 2003 being the exception. This indicates that genetic response may not be positive under a certain set of environments (year effect), underscoring the need to maximize multi-site, multi-year testing to realize improvement in malting quality.

References:

Bertholdsson, N.O. 2004. The use of environmentally stable grain characteristics for selection of high extract yield and low b-glucans in malting barley. Eur. J. Agron. 20(3): 237-245.

Strickberger, M.W. 1968. Genetics. MacMillan Publishing, N.Y. pp. 297-298.