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Effect of increasing nitrogen fertilization on barley protein content and endosperm modification during malting

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Introduction

Only about 25% of barley is selected for malting in western Canada annually due to strict quality specifications, including acceptable levels of grain protein. While application of nitrogen fertilization can increase yield, it can also impair quality by increasing protein to undesirable levels. Our previous research has indicated that malting barley varieties respond differently to nitrogen in terms of protein accumulation and overall modification and quality. For example CDC Copeland accumulated less protein than the more widely grown AC Metcalfe (Edney et al. 2012; O'Donovan et al. 2012). Barley with high grain protein content is difficult to modify and limits the amount of potential extract. The objective of this study was to determine the responses of four relatively new malting barley cultivars (AAC Synergy, CDC Kindersley, Voyageur, and Cerveza) to increasing nitrogen rates compared to the response of AC Metcalfe, the most commonly grown malting cultivar in Western Canada.

Methods

Five Canadian malting barley varieties (AC Metcalfe, AAC Synergy, CDC Kindersley, Voyageur, and Cerveza) were grown with different nitrogen application rates (0, 30, 60, 90, and 120 kg/ha) in a factorial design that was randomized in a complete block with three replications. Field trials were conducted during the 2013 growing season in Lacombe, Alberta.

Barley protein was determined using a near infrared transmittance whole grain analyzer.

Plump barley, retained over a 6/64" slotted sieve, was malted in a Phoenix Automated Micromalting System (Adelaide, Australia) designed to process twenty-four 500g samples per batch. Samples were steeped with water at 13°C using alternating periods of immersion and air rest as follows: 8 hours wet, 16 hours air, 8 hours wet, 12 hours air. Steeped barley was then germinated for 96 hours at 15° C and 100% relative humidity. Kilning was carried out over 24 hours as follows: 12 hours at 55°C; 6 hours at 65°C; 2 hours at 75°C; 4 hours at 85°C.

Malt modification by friability was determined on a 50g portion of malt using the Pfeuffer Friabilimeter (ASBC Malt-12). Fine extract was measured following the Congress mashing procedure (ASBC Malt-4). High molecular weight β-glucan content of wort was determined on a segmented flow analyzer) by fluorescence using Calcofluor (ASBC Wort-18B).

Data were analyzed using PROC GLM of SAS. ANOVA was used to test for significance of main effects and interactions.

Results

The analysis of variance indicated significant effects of increasing nitrogen fertilization rate on barley protein content (Table 1). Increasing rates of nitrogen resulted in an increase in barley protein content (Figure 1). There were no differences in average protein content among varieties. While there was no significant interaction effect between variety and nitrogen rate on barley quality, AAC Synergy, CDC Kindersley and Voyageur tended to have lower protein contents at the higher nitrogen rates than AC Metcalfe.

Increasing nitrogen rates had a negative effect on cell wall modification as demonstrated by decreasing malt friability (Figure 2), and increasing levels of wort β-glucan (Figure 3). The amount of fine extract also decreased at the higher nitrogen rates (Figure 4).

There was a significant variety by nitrogen rate interaction for malt friability. Although malt friability decreased as nitrogen rates increased, the decrease in friability was not as dramatic for AAC Synergy as for other varieties, especially for Cerveza at the Lacombe location (Figure 2).

A significant variety by nitrogen rate interaction was also observed for β-glucan content in wort. AAC Synergy and CDC Kindersley produced wort samples with relatively low levels of β-glucan that were relatively independent of the increasing N fertilization rates (Figure 3). The levels of β-glucan in wort from Cerveza were the highest among the tested varieties and also increased with increasing N rates.

While there was no statistically significant variety by nitrogen fertilization rate interaction observed for malt extract, it was noticed that AC Metcalfe had the highest extract at the lowest nitrogen rate, whereas AAC Synergy had the highest extract at the highest nitrogen rate (Figure 4).

Conclusion

Preliminary results suggest that varieties differ with respect to their ability to resist the negative effects of increasing rates of nitrogen, resulting in smaller reductions in friability and malt extract than the check cultivar, AC Metcalfe. This indicates that the need to restrict application of nitrogen fertilizer in order to achieve acceptable grain protein levels, which has a detrimental effect on yield, can be overcome with specific variety choices.

Acknowledgments

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Figure 1. Effect of increasing nitrogen fertilization rates on protein content of barley varieties compared to AC Metcalfe grown in Lacombe.

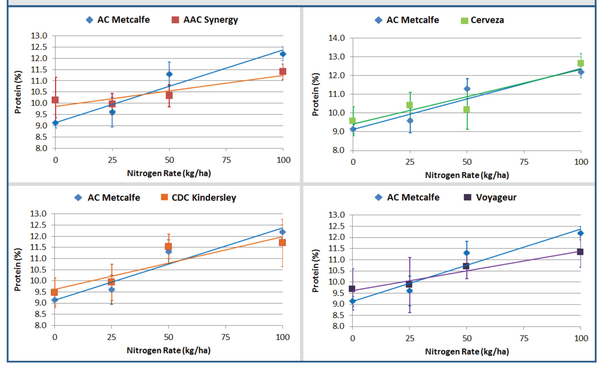


Figure 2. Effect of increasing nitrogen fertilization rates on friabilty of malt from barley varieties compared to AC Metcalfe grown in Lacombe.

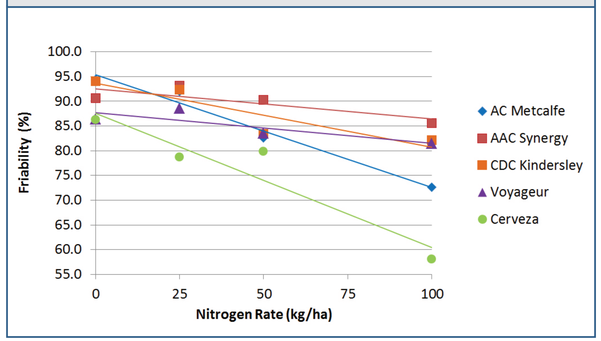


Table 1 - P values form the ANOVA for the effects of nitrogen rate and variety and their interaction on quality of malted barley grown at Lacombe

Effect	Grain Protein	Friability	Fine Extract	β-Glucan
Variety (V)	0.858	**<0.001**	**0.003**	**<0.001**
Nitrogen Rate (N)	**<0.001**	**<0.001**	**<0.001**	**<0.001**
V X N	0.225	**0.028**	0.147	**0.001**

[1]Values in bold are significant at the 95% confidence level

Figure 3. Effect of increasing nitrogen fertilization rates on wort β-glucan content of malt from barley varieties compared to AC Metcalfe grown in Lacombe.

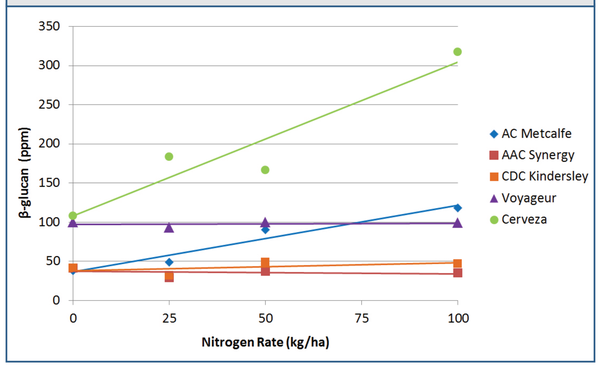
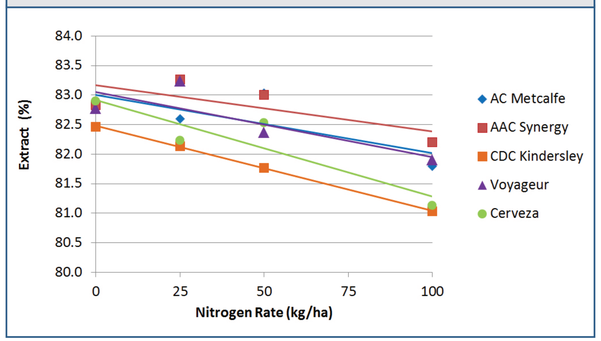


Figure 4. Effect of increasing nitrogen fertilization on the amount of extract produced from malt of barley varieties grown in Lacombe.



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