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Effect of crop residue, nitrogen rate and fungicide application on malting barley productivity and malting quality

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Introduction

- Opportunities exist to improve malt barley productivity and increase the amount acceptable for malt status
  - Crop production factors can be fine-tuned to improve malt barley yield and kernel quality (Turkington et al. 2012)
    - Planting barley on field pea or canola versus barley residue
      - Reduced leaf disease and increased yield, and improved kernel characteristics
      - Planting into field pea residue did not appear to consistently increase grain protein levels
    - Fungicide application
      - Improved yield and kernel characteristics
        - Typically when the risk of leaf disease was moderate to high
      - Magnitude of impact was less compared with crop rotation
  - Nitrogen fertilizer (N)
    - Increasing the N rate from 50 to 100% of soil test recommendation
      - No effect on leaf disease levels, and only increased yields slightly compared with not planting barley on barley residue
      - Resulted in a significant increase in grain protein
- Agronomic studies on malt barley typically rely on prediction of malt quality from barley kernel quality
  - Can farmer practices impact malting and brewing quality of the harvested malt barley grain

Objectives

- To use malt processing and standard methods of malt quality analysis to ascertain true malt quality and a more accurate determination of how final malt quality was affected by several agronomic practices used by farmers
  - Previous crop residue, fungicide treatment and N rate

Materials and Methods

- To assess the impact of three production factors field trials were conducted at 7 locations across western Canada, 2007 - 2009
  - Alberta: Fort Vermilion, Beaverlodge, Lacombe, Lethbridge
  - Saskatchewan: Scott, Indian Head
  - Manitoba: Brandon
- Experimental design and data collection
  - 4-replicate split-plot design with previous crop residue type (barley, canola or field pea) as the main plot and a factorial combination of nitrogen rate (50 or 100% of soil test recommendation) and fungicide (Tilt® [propiconazole], yes or no) as the subplot, using the 2-row malting barley cv. AC Metcalfe

Materials and Methods

- Constraints on malting capacity and quality analysis limited the number of locations that could be malted and analysed each year
  - In total, three replicates of the 12 treatment combinations were malted across the 9 location/years with a total of 324 samples malted and analysed for quality
- 2 kg subsamples of harvested barley grain from each plot were sent to the GRL CGC for assessment of barley and malting quality
  - Barley was tested for grain protein content, germination energy (4 ml and 8 ml) and plumpness (American Society of Brewing Chemists, 2004)
  - Plump barley (screened over 2.38 mm slotted sieve) was malted (500 g) using a Phoenix Automated Micromalting machine (Adelaide, SA, Australia) according to the following schedule:
    - Wet steep 10 hours, air rest 18 hours, wet steep 8 hours, air rest 12 hours, (steeping at 13°C); germination 96 hours (15°C), kiln 12 hours at 55°C, 6 hours at 65°C, 2 hours at 75°C, 4 hours at 85°C
  - Malt analyses were performed according to the standard methods of the American Society of Brewing Chemists (2004) and included:
    - 1) Malt extract (fine grind), a measurement of the solubility of malt indicating a malt's beer production potential;
    - 2) Kolbach index, ratio of soluble to total malt protein indicating the extent of protein modification;
    - 3) Free Amino Nitrogen (FAN), an indicator of availability of nitrogenous yeast-nutrients;
    - 4) Wort ß-glucan, an indicator of the extent to which cell walls were degraded during malting; and
    - 5) Diastatic power and α-amylase, enzymes that produce fermentable sugars from malt starch during mashing
- Data were analyzed using PROC MIXED of SAS
  - Crop residue, fungicide treatment and N rate were considered fixed effects.
  - Location by year combinations (environments) and their associated interactions with fixed effects were considered random effects, as were replicates nested within environments
  - Each year by location was considered as an environment rather than as a separate main effect
  - For crop residue type and the interactions of crop residue type, N rate and fungicide, means were compared using Fisher's Protected LSD test.
    - All differences were deemed significant at $p < 0.05$

Results

- The effect of crop residue on barley and malt quality
  - The type of crop residue on which barley was grown significantly affected barley quality (data not shown)
    - Barley grown after barley had more intense kernel colour and brighter kernels than barley grown after either canola or peas
    - Kernel weight and diameter were lower for barley grown after barley compared to being grown after either canola or peas
    - Barley grown after barley had greater variability of kernel diameter than when barley was grown after canola
    - There were no significant differences in kernel characteristics between barley grown after canola versus peas
    - Crop residue type had no effect on level of grain protein, germinative energy or water sensitivity

Results

- The type of crop residue on which barley was grown significantly affected malt processing and malt quality (Table 1)
  - Barley grown on barley residue had a higher % of moisture at steepout versus barley on field pea, but not canola
  - The endosperm of barley grown on pea residue was less well modified compared to barley from the other two crop residue types
    - As indicated by lower values for Kolbach index and friability, and a tendency toward higher levels of wort ß-glucan, but differences were not significant
  - Levels of malt extract, wort colour, diastatic power, α-amylase and Calcofluor homogeneity were not affected by crop residue type
  - There were no differences in malt quality for barley grown on barley versus canola residue
- The effect of fungicide application at flag leaf emergence on barley and malt quality (data not shown)
  - Fungicide significantly affected appearance and size of barley kernels
    - When fungicide was applied at flag leaf emergence, kernels had more colour, but had a more intense colour and were brighter
    - Fungicide treated barley had wider and heavier kernels than untreated
    - Grain protein, germinative energy, water sensitivity and variability in kernel diameter and weight were not affected by fungicide treatment
  - Fungicide application only significantly affected steepout moisture
    - Barley grown without fungicide had a higher percentage of moisture at steepout versus no fungicide (46.2 versus 45.8, respectively)
- The effect of nitrogen fertilizer rate on barley and malt quality (data not shown)
  - Grain protein was the only barley quality parameter significantly affected by nitrogen fertilization
    - Higher grain protein was associated with the higher N rate which led to significant effects on malt quality
  - The higher N rate significantly reduced the level of malt extract and friability, but increased levels of the starch-degrading enzymes, diastatic power and α-amylase
- The effect of interactions of crop residue type, N rate and fungicide application on barley and malt quality were limited (data not shown)

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Table 1. Effect of previous crop residue type on malt quality as averaged over nine sites (location by year combinations) distributed across the Prairies, 2007 - 2009.

Variable	Crop residue	Mean	LSD[z]	Variable	Crop residue	Mean	LSD
Steepout moisture (%)	Barley	46.2	A	Friability (%)	Barley	67.3	A
	Canola	45.9	AB		Canola	68.1	A
	Pea	45.8	B		Pea	63.7	B
Malt extract (% dry matter)	Barley	79.7		Calcofluor homogeneity (%)	Barley	83.5	
	Canola	79.9			Canola	84.7	
	Pea	79.8			Pea	82.7	
Kolbach index (%)	Barley	41.4	A	Diastatic power (°L)[y]	Barley	157	
	Canola	41.2	A		Canola	159	
	Pea	40.0	B		Pea	162	
Wort colour (colour units)	Barley	2.24		α-Amylase (DU)[x]	Barley	74.1	
	Canola	2.13			Canola	72.9	
	Pea	2.18			Pea	73.9	
Wort ß-glucan (mg L^{-1})	Barley	179					
	Canola	162					
	Pea	195					

[z]Means within variables followed by different letters are significantly different according to Fisher's Protected LSD test, Proc Mixed, SAS Institute, Inc.; [y] degrees Lintner; [x] Dextrinizing units.

Conclusions

- Controlling disease with crop rotation or fungicides resulted in malt barley with larger kernels, that with slight adjustments to processing, could produce a malt of superior quality
- The quality of malt produced from barley grown on pea residue appeared to be only slightly affected via increased kernel size and perhaps a trend of increased protein
  - Impacts were limited and minor adjustments to processing should produce a malt of commercially-acceptable quality
- In general, farmers using good agronomic practices including: increased seeding rates; avoiding barley as a previous crop; adding field peas and canola to the rotation; using moderate rates of nitrogen fertilizer; and applying fungicides only when needed
  - Can increase yield and kernel quality, and reduce disease and weed pressures
  - While increasing the potential for malt selection all without compromising on quality of the maltster's final product and potentially even improving quality (Edney et al. 2012)

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