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Effect of Legume Crops Grown Two Years Prior to Barley on Malting Barley Yield and Quality

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Background

- The high costs of inorganic nitrogen fertilizer has generated increased interest in the investigation of cost-effective alternatives.
- Research has shown that some legume crops can achieve high levels of N_2 fixation resulting in yield benefits to cereal crops (Miller et al. 2002; Walley et al. 2007).
- Previous research from the current study indicated that legume crops grown the year prior to canola can increase canola yield and may facilitate reductions in inorganic nitrogen application (O'Donovan et al. 2011).
- Quality requirements for malting barley are strict including a requirement for low protein.
- Thus there is a perception that growing legumes in rotation with malting barley may lead to unacceptable grain protein levels.
- In a previous study, growing malting barley the year following field peas increased yield but did not have a major impact on protein content (Turkington et al. 2012).

Objective

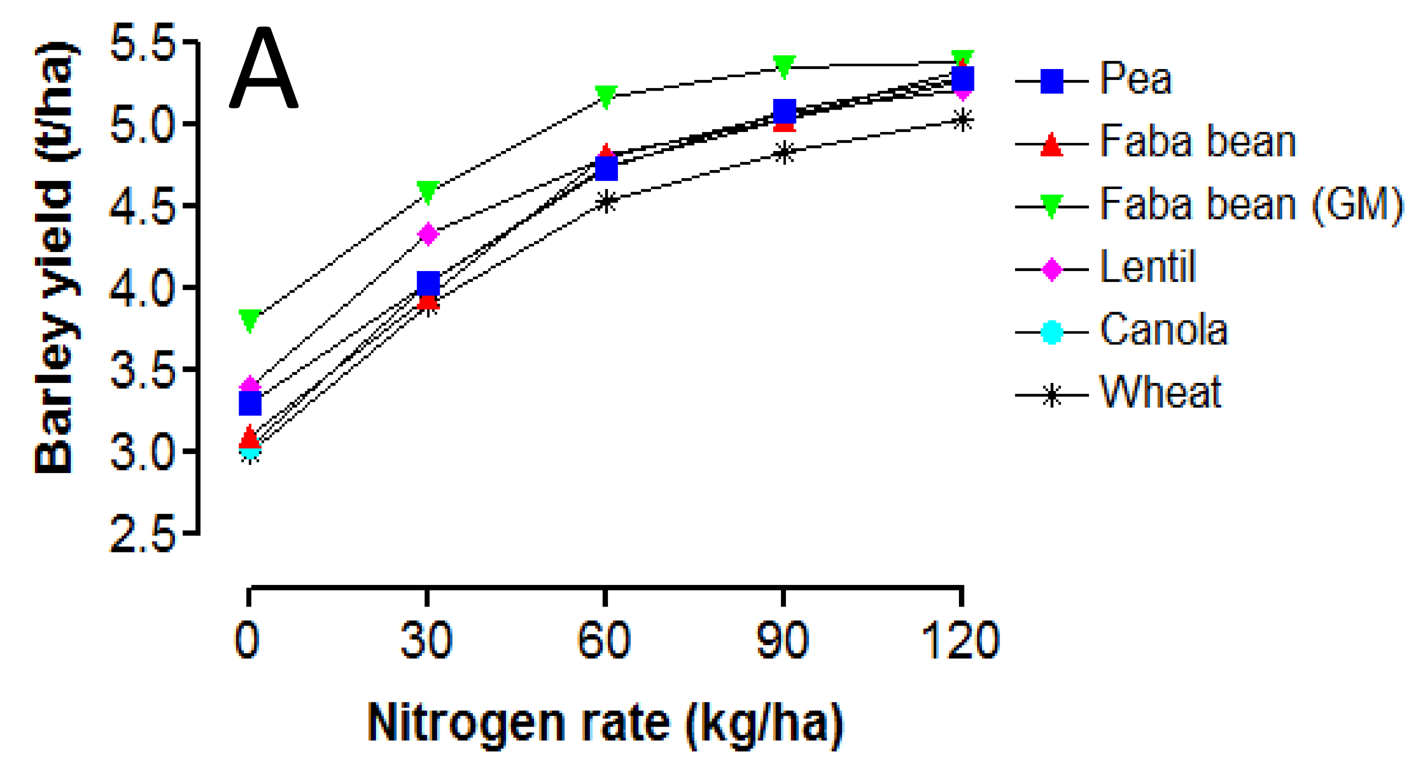
The objective of this study was to investigate the effects of different crop residue (including legumes) on yield and quality of malting barley grown two years after residue establishment.

Materials and Methods

- Field experiments were direct-seeded at Beaverlodge, Lacombe and Lethbridge, Alberta, Indian Head, Scott and Swift Current, Saskatchewan, and Brandon, Manitoba.
- In 2009, crop residues were established with faba bean (grown for seed), faba bean (used as a green manure), and pea, lentil, wheat and canola grown for seed.
- No fertilizer was applied to the legume crops in 2009 while wheat and canola were fertilized according to the soil test recommendations.
- In 2010, hybrid canola was seeded across the entire experimental area and N was applied as urea (46-0-0) at 0, 30, 60, 90 and 120 kg/ha actual N.
- In 2011, malting barley was seeded and the same rates of N were applied.
- Protein content was determined with a near infrared reflectance spectrometer, and quality analyses performed according to the standard methods of the American Society of Brewing Chemists.
- The experiment was designed as a split-plot with crop residues (established in 2009) as main plots and N rates (in 2010 and 2011) as sub-plots; treatments were replicated 4 times.
- Data were analyzed using Proc Mixed of SAS and contrasts were used to test for responses to crop residues and N rates; differences were deemed significant at $P < 0.05$.

Results

- The mixed analysis of variance indicated significant ($p<0.05$) effects of crop residue on barley yield and protein at all locations except Scott for barley yield and Scott and Swift Current for protein.
- The effect of N rate was significant ($p<0.001$) at all locations for both yield and protein and a significant ($p<0.05$) N x residue effect for yield occurred only at Lacombe and Beaverlodge.
- Barley yield and protein responses to N for each crop residue type (averaged over locations) are presented in Fig. 1; differences in canola yield (averaged over N rates) between wheat residue and the other crop residues are presented in Table 1.
- Compared to wheat residue, the highest and most consistent barley yield increases occurred with faba bean green manure residues followed by lentil and field pea residues (Fig. 1 A; Table 1 A).
- Barley yield increases with faba bean green manure residues were approximately twice that with lentil and pea residues (Table 1 A).
- The response of barley yield to N rate was generally similar across locations and crop residues; yield tended to increase linearly up to 60 kg/ha N and then level off.
- Kernel protein tended to be highest, and more consistently high, with faba bean green manure and lentil residues than with faba bean seed or field pea residues (Fig. 1 B; Table 1 B).
- Field pea residue had little effect on barley kernel protein content (Fig. 1 B), and, compared to wheat residue, a significant increase in protein was evident at only one location (Table 1 B).
- Overall, inorganic nitrogen application was more likely to result in unacceptably high kernel protein content than legume crop residues (Fig. 1 B).
- At most locations, there were little or no negative effects of any of the residues on malting barley quality as indicated by fine extract concentration, Kolbach index, beta-glucan content or friability modification (data not shown); An exception was lentil residue at Lacombe where a low Kolbach index and high beta-glucan content resulted in poor modification.



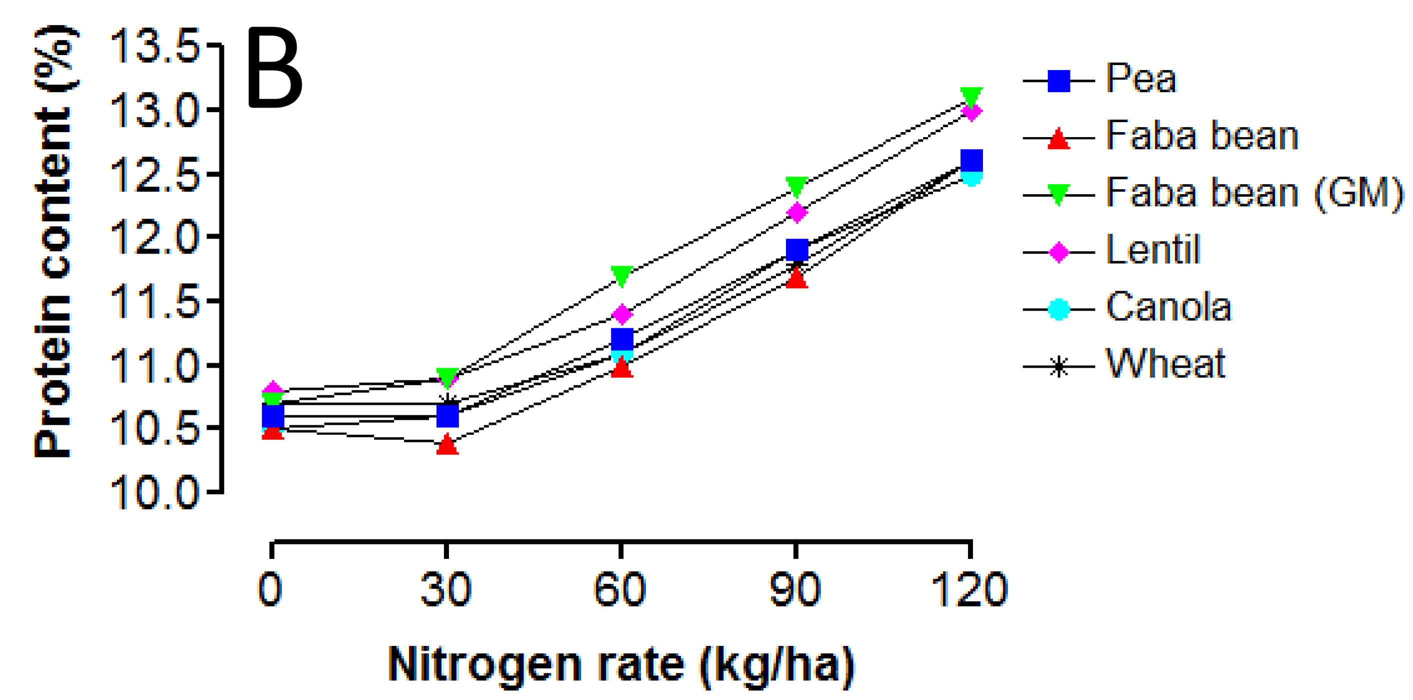


Fig. 1. Response of barley yield (A) and protein content (B) in 2011 to different crop residues established in 2009. Responses represent data averaged over 7 locations

Table 1. The effect of different crop residues on gain or loss of barley yield (A) and barley protein (B) when compared to wheat residue. Means represent differences between barley yields and protein from wheat residue (established in 2009) and each alternative crop residue (averaged over N rates). P values are in parentheses. Means are significant at $P < 0.05$ with green cells indicating crop residues leading to higher yield and protein than wheat, yellow cells indicating crop residues leading to a lower yield or protein than wheat, and white cells indicating no difference.

A Effect of different crop residues on barley seed yield (t/ha) gain or loss compared to wheat residue

Crop residue	Beaverlodge	Lacombe	Lethbridge	Indian Head	Scott	Swift Current	Brandon
Fababean (GM*)	**0.97 (<0.001)**	**0.76 (<0.001)**	**0.86 (<0.001)**	**0.61 (<0.001)**	0.26 (0.090)	0.03 (0.614)	**0.68 (<0.001)**
Fababean (seed)	**0.33 (0.016)**	**0.47 (0.006)**	**-0.02 (0.905)**	0.26 (0.053)	0.16 (0.310)	-0.06 (0.920)	0.08 (0.632)
Pea (seed)	**0.38 (0.006)**	-1.00 (0.997)	**0.47 (0.005)**	0.17 (0.219)	0.06 (0.707)	0.02 (0.724)	**0.42 (0.013)**
Lentil (seed)	**0.46 (<0.001)**	**0.65 (<0.001)**	0.14 (0.404)	**0.43 (0.002)**	0.10 (0.263)	-0.04 (0.508)	**0.41 (0.015)**
Canola (seed)	0.18 (0.192)	0.21 (0.214)	0.19 (0.246)	-0.05 (0.397)	0.27 (0.083)	**0.19 (0.003)**	**0.39 (<0.001)**

B Effect of different crop residues on barley protein (%) gain or loss compared to wheat residue

Crop residue	Beaverlodge	Lacombe	Lethbridge	Indian Head	Scott	Swift Current	Brandon
Fababean (GM*)	**0.543 (<0.001)**	**0.989 (<0.001)**	**0.635 (0.046)**	0.183 (0.278)	0.125 (0.810)	-0.015 (0.856)	-0.029 (0.847)
Fababean (seed)	-0.100 (0.475)	0.204 (0.167)	**-0.521 (0.076)**	-0.312 (0.066)	0.117 (0.822)	0.029 (0.726)	**-0.303 (0.044)**
Pea (seed)	-0.007 (0.961)	0.001 (0.997)	0.223 (0.445)	**0.460 (0.007)**	0.261 (0.615)	0.043 (0.603)	**-0.395 (0.009)**
Lentil (seed)	**0.642 (<0.001)**	**0.818 (<0.001)**	0.348 (0.233)	-0.279 (0.099)	-0.539 (0.300)	**0.201 (0.017)**	-0.027 (0.855)
Canola (seed)	0.074 (0.580)	-0.064 (0.664)	-0.505 (0.085)	**0.351 (0.039)**	0.346 (0.512)	0.024 (0.771)	-0.214 (0.151)

*GM=green manure

Conclusions

- The results indicate that growing legume crops two years prior to malting barley can enhance barley yield and possibly reduce dependence on inorganic N; overall the yield increases with legume residues were not as high or as consistent compared to when canola was grown in 2010 suggesting that the positive impact of the legumes diminishes with time.
- As with canola in 2010, faba bean green manure residue resulted in the the most consistent barley yield increases compared to the other crop residues; however, this would not be economical over the three year period due to loss of crop revenue in 2009.
- The results also suggest that the risks of poor malting barley quality due to high kernel protein may be low if barley is grown two years after a legume crop, especially when field pea or faba bean are grown for seed; increasing inorganic N fertilizer is more likely to result in unacceptable protein levels.
- In the case of field pea, this study and a previous study (Turkington et al. 2012) suggest that malting barley growers could reap significant yield benefits if barley is grown one or two years after field pea without compromising malting barley quality; indeed growing barley in rotation with field pea may improve quality by reducing the requirement for inorganic N.

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