The Seed Head
Fact sheet # 18

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Crop rotations with perennial forage seed crops: a beneficial low-cost option for the Peace Region

Red Clover, 2014

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Introduction

Individual crops yield higher when alternated with unrelated species in cropping sequences than when grown continuously in the same field. This rotational or break-crop advantage is evident from many studies around the world. Such yield benefits are attributed to various mechanisms including pest suppression, improved nutrient and water use efficiencies, changes in rhizosphere biology, allelopathy (biochemicals produced by one organism influence another organism's development) or soil structure (Angus *et al*., 2015; Kirkegaard *et al*., 2008).

The preceding crops with more contrasting plant architecture and functional groups produce better rotational effects to the following crops. Table 1 outlines the benefits of crop rotation for wheat and canola found in previous studies. These studies have shown that the break-crop effect not only positively impacts yield but can also decrease incidences of disease.

However, there is lack of studies that evaluate comparative economic and ecological advantage of annual and perennial crops in crop rotations. In 2013 the forage research team at the Beaverlodge Research Farm aimed to bridge the gap in knowledge by initiating a 4-year crop rotation study within the Peace region involving various forages and annual crops. The premise of the study was that the high root to shoot ratio of perennial forages and the nitrogen assimilating properties of forage legumes may provide a means for sustaining productivity and profitability of the cropping systems.

Table 1. Previous study examples of benefits of crop rotation for wheat and canola

Example	Benefits/Improvements
Wheat grown after oats[a]	Mean yield increase of 0.5 t ha^{-1}
Wheat grown after grain legumes[a]	Mean yield increase of 1.2 t ha^{-1}
Wheat grown after other broadleaf crops (e.g. canola, mustard and flax)[a]	Intermediate effects (i.e. between 0.5 and 1.2 t ha^{-1})
Second wheat crop after break-crop effect of legumes[a]	60% of the magnitude of the effect on the first wheat crop
Second wheat crop after break-crop effect of non-legume broad-leaf species[a]	20% of the magnitude of the effect on the first wheat crop
Wheat grown after two successive break-crops[a]	0.1 to 0.3 t ha^{-1} higher yield than after a single break-crop
Canola grown in alternating sequence after two break-crops in rotation[b]	22% increase in yield compared to continuous canola and the wheat-canola-canola rotation as well as up to a 54% reduction in the incidence of blackleg disease and 6% reduction in root maggot damage

a - Angus et al., 2015; b - Harker et al., 2015

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Methods

The study examined six different crop rotations, each of which were then split into three fertilizer scenarios (0, 40 & 80 lbs N/ac applied in the spring at non-legume phases of the rotations):

- Canola (C) -Canola-Canola-Canola
- Creeping red fescue (CF)-CF-CF-C
- Red clover (RC)-RC-Wheat-Canola
- Alsike clover (AC)-AC-Wheat-Canola
- Pea (P)-Barley (B)-Wheat-Canola
- Wheat (W)-Canola-Wheat-Canola

The study looked at cumulative gross margin for the cropping system of each rotation, as well as gross margin for canola and wheat alone, and also measured canola seed yield, wheat seed yield and dry matter. Data on variable cost and gross revenue were also collected in order to calculate cumulative gross margin.

Please note that the figures portrayed in this factsheet are a simplified version of a more detailed portrayal of this study's findings (including standard error details). For more information contact the Beaverlodge Research Farm or the PRFSA.

Gross Margin Calculations

⇒ Input prices (seed and fertilizer) were based on pricing from local suppliers

⇒ Operational costs (seeding, fertilizing, harvesting) were derived from Alberta Agriculture and Forestry survey records

⇒ Commodity values for the forage crops (CF, RC and AC) were obtained from a 2015 Forage Seed News publication from the Manitoba Forage Seed Association and for the annual crops (P, B, W and C) from the Alberta Canola Producers Commission website

Figure 1. Gross margin from canola as the fourth-year crop in different rotations

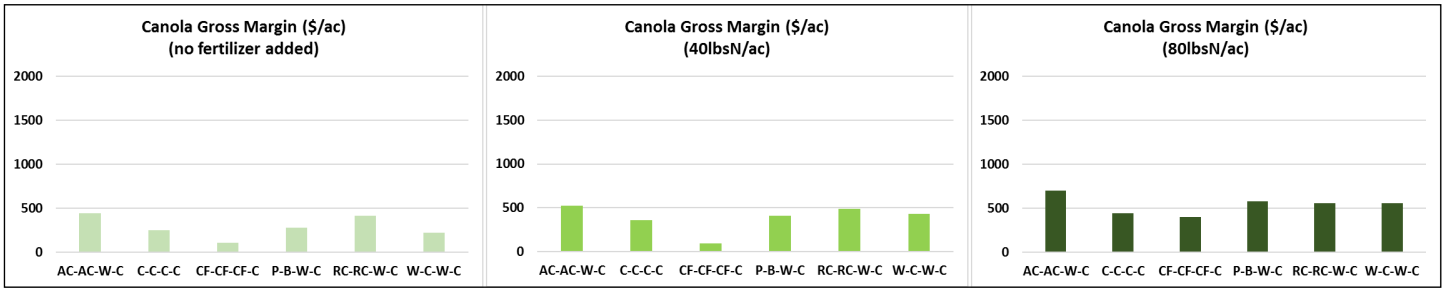


Figure 2. Gross margin from wheat as the third-year crop in different rotations

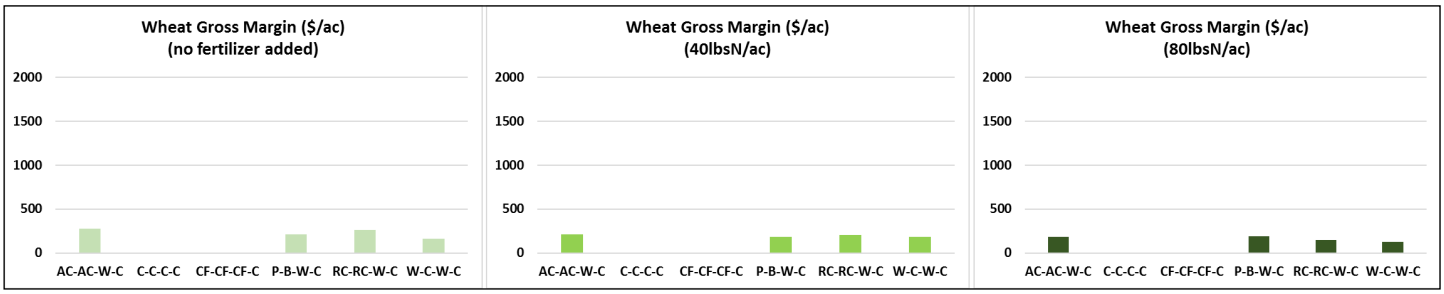
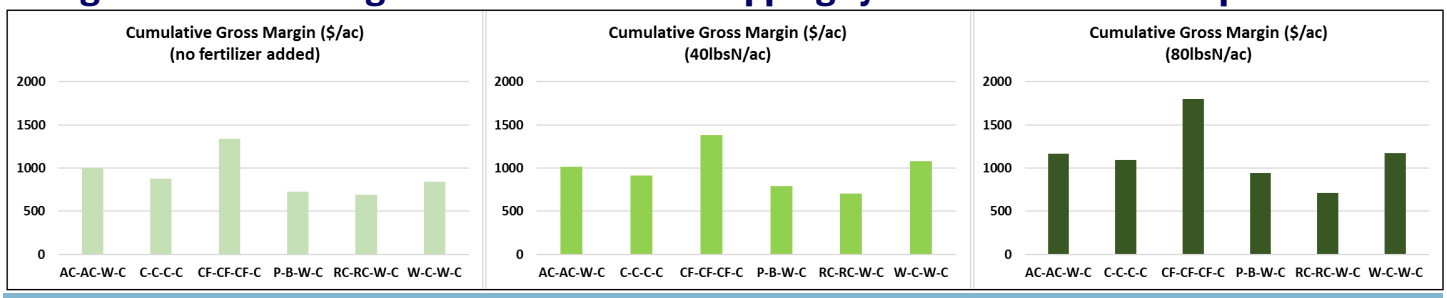


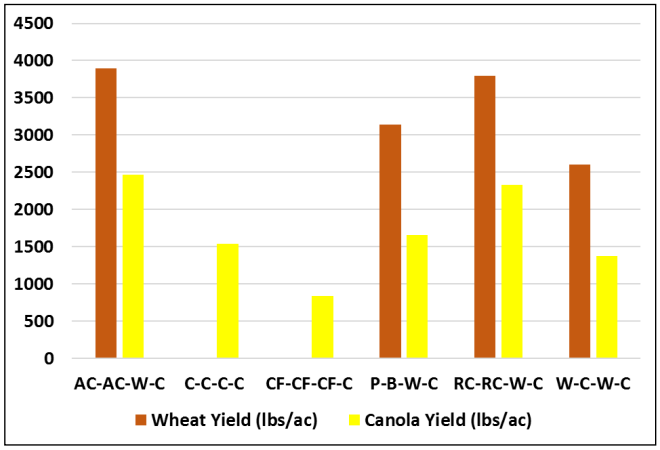
Figure 3. Gross margin from cumulative cropping system for different crop rotations



Results

Gross margin analyses of the 4-year rotation cycles and effect of preceding crops on wheat and canola were performed (Figures 1 to 3). Wheat and canola gross margins tended to be higher in alsike and red clover rotations than in annual rotations, specifically where no or only 40lbsN/ac of fertilizer was applied (Figures 1 and 2). The agronomic benefits of rotations integrating biennial forage legumes for seed production were evident in the succeeding plots of wheat and canola. Replicated field plots of wheat and canola receiving no fertilizer following biennial stand of either red or alsike clover grown for seed produced significantly higher grain yields compared to rotations where those crops were preceded by annual crops such as peas, wheat, barley or canola (Figure 4).

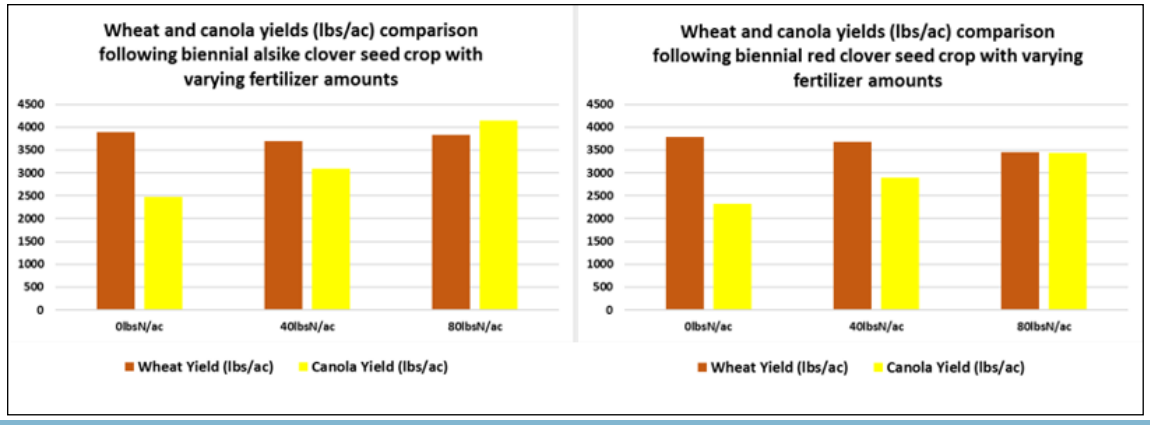
Figure 4. Wheat and canola seed yield comparison for third and fourth years of crop rotation cycles (no fertilizer added)



In the absence of a supplemental nitrogen application, wheat plots preceded by biennial stand of red clover produced yield increases of over 45% and 21% compared to wheat plots preceded by wheat-canola and pea-barley sequences respectively. Similarly, wheat plots preceded by biennial stand of alsike clover produced yield increases of over 49% and 24% compared to wheat plots preceded by wheat-canola and pea-barley sequences respectively. Substantial carryover effect of forage legumes in rotation was also observed on canola crop following wheat. Without nitrogen fertilizer application, canola yield from forage legumes-based rotations were 40 to 70% higher than those from annual crop sequences. The carryover effect diminished in magnitude as the application rate of nitrogen increased. The biennial legume seed crops of red and alsike clovers replaced the nitrogen fertilizer requirement for succeeding wheat and canola crops by at least 80 and 40 lbs N/ac, respectively (Figure 5).

Based on cumulative gross margin analyses of the 4-year rotations, the creeping red fescue-based rotation produced the highest profit followed by the alsike clover-based rotation (Figure 3). The red clover-based rotation had lower profitability due to the low sale price of the red clover seed. Annual crops-based rotations had intermediate profitability. Differential input requirements for different crop species and the output prices offered for the commodities were the major determinants of the gross margin from different crop rotations.

Figure 5. Comparison of wheat and canola yields and fertilizer use (crop rotations AC-AC-W-C and RC-RC-W-C)



At a glance:

- 6 different rotations and 3 different fertilizer scenarios were studied for a total of 18 different observation sites
- canola and wheat gross margins tended to be higher in rotations where either red or alsike clover seed crops were grown prior to wheat and canola, and where either no fertilizer or only 40lbsN/ac was used
- wheat and canola grown without fertilizer after either red or alsike clover seed crops produced significantly higher grain yields compared to rotations where the preceding crop was peas, wheat, barley or canola
- red and alsike clover seed crops replaced the need for a nitrogen fertilizer in the case of wheat crops grown after these biennial legume crops
- the creeping red fescue-based rotation produced the highest profit overall, largely due to the high value of the CF seed and the lower input and operational costs
- cumulative gross margin was largely affected by input requirements for the different rotations as well as by current commodity values

Wheat in the AC-AC-W-C rotation, 2015

Alsike clover root with nitrogen-fixing nodules, 2014

Looking to the future

This short-term crop rotation study shows that the biennial and perennial forage-based rotations have comparable productivity and profitability to annual crop-based rotations including canola, peas, wheat and barley. This study will continue long-term with the hopes that the agro-ecological benefits brought about by biennial and perennial forage crops through the soil physical and chemical properties can be better understood, particularly when compared to annual cropping systems. This study is particularly significant to the Peace River region where land used for the production of forage seed crops is declining in favour of annual crop production, likely reducing soil organic matter which is crucial to the resiliency of the cropping systems.

References

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