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Yield Advantage and Nitrogen Economy of Annual Crops Following Biennial Forage Legumes in Prairie Cropping Systems

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Introduction

High root to shoot ratio and nitrogen assimilating properties of forage legumes impart a basis for sustaining productivity and profitability of the cropping systems.

A crop rotation study involving various forages and annual crops was initiated in 2013 to evaluate the relative merits of various cropping sequences.

The agronomic benefits of rotations integrating biennial forage legumes for seed production were evident in the succeeding plots of wheat and canola.

This presentation highlights the productivity and profitability of six different crop rotations conducted in western Canada.

Materials & Methods

Location and period of the study: Beaverlodge Research Farm, AAFC (55°N, 119°W); conducted from 2013 to 2016.

Topography & Soil: Gentle east-facing slope with Landry clay-loam (Black Solod, Udic Ustochrept) soil. Soil properties in 2013 at the onset of the study averaged 6.3% organic matter, pH of 5.7, 9.6 kg ha^{-1} NH_4^+, 22.5 kg ha^{-1} NO_3^- and 58.8 kg ha^{-1} phosphorus.

Experimental Design: Split plot design utilizing 4 replicates with main plots of crop **rotation (R)** and sub-plot factors were **nitrogen levels (N)**.

Treatments: started with following 6 crop rotations in 2013, each spilt into 0, 45 & 90 kg N ha^{-1} applied at non-legume phases of the rotations:

1. Canola (C) -Canola-Canola-Canola
2. Creeping red fescue (CF)-CF-CF-C
3. Red clover (RC)-RC-Wheat-Canola
4. Alsike clover (AC)-AC-Wheat-Canola
5. Pea (P)-Barley-Wheat-Canola
6. Wheat (W)-Canola-Wheat-Canola

Crop management: Zero-till air-seeding (CrossSlot™ with Varmax™) on 12"-row spacing; pre-seed and post-emergence herbicide application; treatments at non-legume phase received in-row granular urea during seeding plus perennial grass and creeping red fescue received a Fall broadcast of granular urea.

Observations: Crop biomass, seed yield and soil nitrogen level were recorded every year. Soil quality parameters at onset of experiment and end of 4-year rotation are compared.

Data Analyses: Input price estimates were based on purchase receipts from local suppliers. Operation costs were derived from Alberta Agriculture and Forestry survey records (https://www.agric.gov.ab.ca/app21/infopage?cat1=Statistics&cat2=Farm%20Financial). Commodity values were obtained from Forage Seed News (Vol 22, No 2, Summer 2015, Manitoba Forage Seed Association) and Alberta Canola Producers Commission (http://1albertacanola.com/resource-category/marketing/) retrieved Oct 24, 2016).

Seed yield of wheat and canola, and cumulative dry biomass, gross margin, gross revenue and variable cost of different 4-year rotations and fertilizer levels were statistically analysed by using SAS 9.4 Proc GLIMMIX procedure. Treatment grouping were done by using Least Squares Means (Alpha=0.05).

Results

Four rotations shared a common crop wheat in the third phase and all rotations had canola in the final phase of the first rotation cycle. That allowed yield comparison for these crops.

In the absence of nitrogen fertilizer, the **rotations with alsike and red clover as preceding crops (grown as biennial) had higher seed yield of wheat and canola than the annual crops based rotations** (Figure 1).

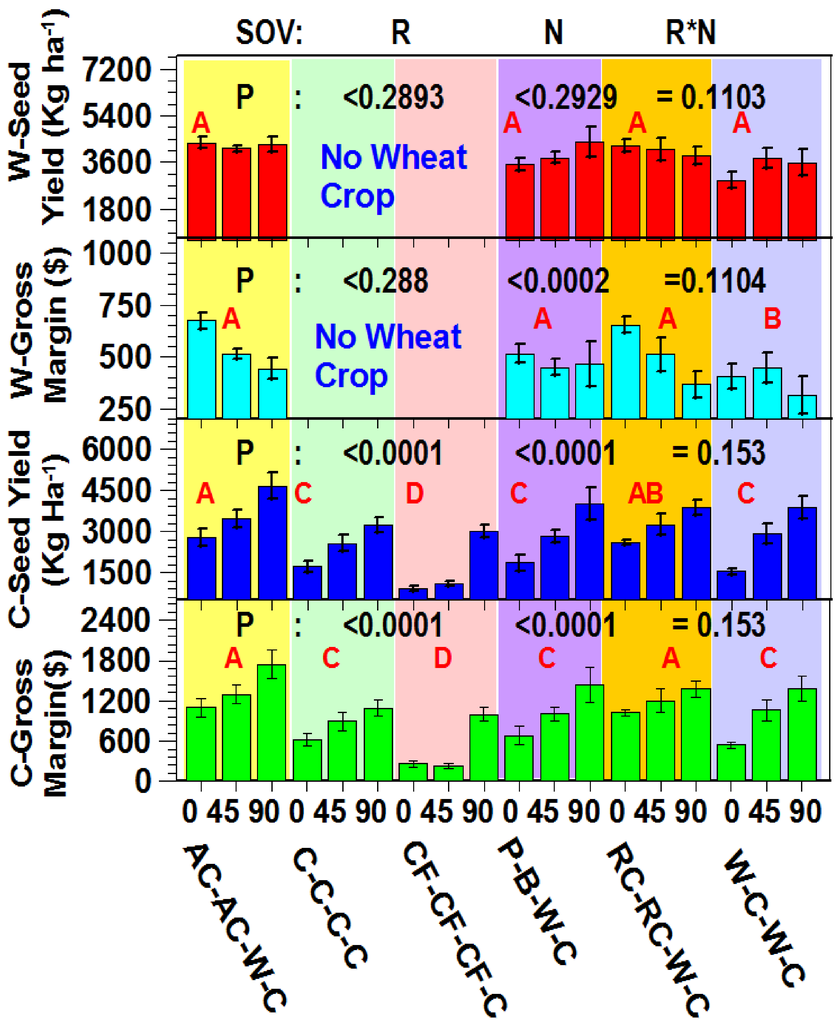

Figure 1: Seed yield and gross margin of wheat and canola in third and fourth phases of the crop rotation cycle. There was no wheat crop in C-C-C-C and CF-CF-CF-C rotations. The error bars are standard errors.

In the absence of a supplemental nitrogen application, wheat plots preceded by biennial stand of red clover produced yield increases of 21% and 45% compared to wheat plots preceded by pea-barley and wheat-canola sequences respectively.

Similarly, without supplemental nitrogen, wheat plots preceded by biennial stand of alsike clover produced yield increases of 24% and 49% compared to wheat plots preceded by pea-barley and wheat-canola sequences respectively.

The biennial legume seed crops of red and alsike clovers replaced the nitrogen fertilizer requirement for succeeding wheat crop by about 90 kg N ha^{-1}.

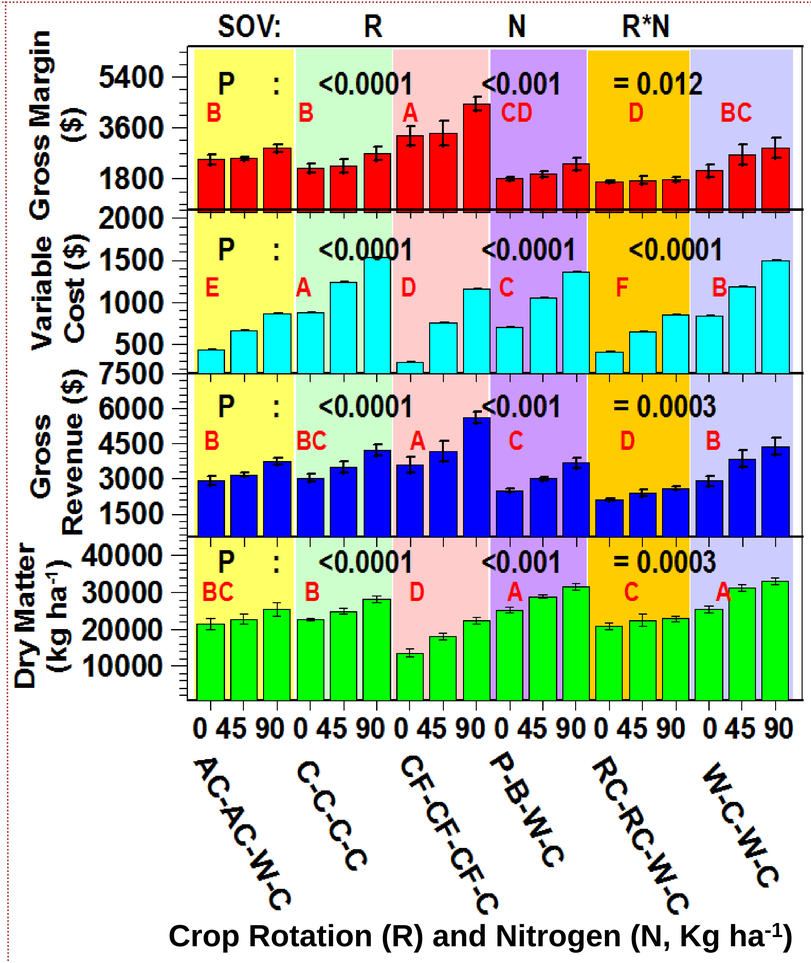

Figure 2: Cumulative cropping systems productivity and profitability of crop rotations with various annual crops and perennial forage seed crops**.** The error bars are standard errors.

Based on cumulative gross margin analysis of the 4-year rotations, **creeping red fescue (CF)**-based rotation produced highest profit followed by **alsike clover (AC)**-based rotation. **Red clover (RC)**- based rotation was the least profitable. Annual crops-based rotations had intermediate profitability (Figure 2).

Differential input requirements for different crop species and the output prices offered for the commodities were major determinants of the gross margin.

Conclusions

In terms of cropping systems productivity and profitability, biennial and perennial forage based rotations are comparable to annual crop based rotations including canola, peas, wheat and barley.

Agroecological sustainability imparted by biennial and perennial forage crops will be evaluated in terms of changes in the soil physical and chemical properties compared to those planted to the annual crops.

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