Effect of Forage Legumes on Phosphorus Availability to the Following Wheat Crop in a Black Chernozem

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Abstract

Including forage legumes in rotation with annual crops could increase phosphorus (P) availability to the annual crop due to their deep roots and intensive mycorrhizal infection. However, the benefit of forage legumes to increase soil P availability to the subsequent crop has gained less attention in the western Canada. The aim of this study was to investigate the impact of short rotation forage legumes on P availability to the following crop. Forage legumes evaluated in this study were red clover and alfalfa in comparison to an annual legume (pea) and non-legume (flax). The study was conducted at four sites across Saskatchewan. This poster reports on the results at one site near Melfort, SK. In this experiment, two-year alfalfa rotation produced the highest ($P = 0.015$) biomass yield. Inclusion of short rotation forage legumes had positive impact on wheat grain yield ($P < 0.001$) , but it did not affect wheat straw P uptake ($P = 0.76$). The amounts of soil P fractions extracted from all treatments were generally similar. The results suggested that a two year rotation of legumes may be too short a time period to significantly enhance in soil P availability to the following crop.

Key Words: Forage legumes, Phosphorus availability, Wheat, Black Chernozem

Introduction

Most prairie soils generally have lower levels of available P than is required for optimum crop yields (Malhi, 2010) as considerable amounts of P are present in insoluble forms. Application of P fertilizer is usually required to sustain high yield (Condron 2004), but crop rotation may also be employed as a tool to access insoluble native soil P reserves.

Legumes are reported to have the ability to solubilize P from less labile P pools in the soil (Hassan et al. 2012). Inclusion of forage legumes in rotation for two years with annual crops may increase P availability to the annual crops and increase the crop growth and production.

Objectives

To investigate the impact of short rotation forage legumes on P availability to the following crop. Forage legumes evaluated were red clover and alfalfa in comparison to an annual legume (pea) and non-legume (flax). The study is conducted at four sites across Saskatchewan. This poster reports on the results at one site near Melfort, SK.

Material and Methods

The field experiment was conducted near Melfort, SK on a loamy Black Chernozem. The experimental design is an RCB Design with four replications. After two years of crop rotation (Figure. 1), spring soil samples were collected in April, 2012. Wheat grain and straw was harvested in September, 2012.

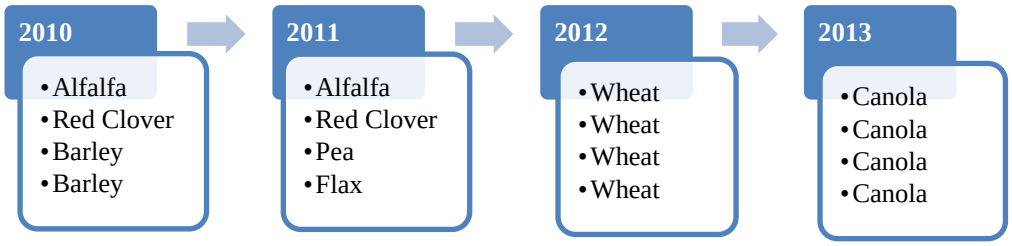

Figure. 1 Description of crop rotations

- Plant samples were analysed for total P using acid (H_2SO_4+H_2O_2) digestion (Thomas et al. 1967).
- Soil samples were extracted sequentially to determine distinct pools of soil P as described by Tiessen and Moir (1993):

1. Readily plant-available P (resin Pi, $NaHCO_3$-Pi, and $NaHCO_3$-Po) were extracted sequentially by using deionized water, anion exchange membrane and $NaHCO_3$;
2. Moderately available P (NaOH-Pi and NaOH-Po) was removed by NaOH;
3. Slowly available P (HCl-Pt) was extracted with HCl;
4. Residual P was determined using acid (H_2SO_4+H_2O_2) digestion (Thomas et al. 1967).

Inorganic P in various soil extracts was measured using ascorbic acid reduction method (Murphy and Riley, 1962).

Results and Discussion

Biomass (Straw+Grain) Yield

Biomass yield was greatest (P = 0.015) in the two-year alfalfa rotation (Figure. 2). The rotation with barley followed by one year of peas produced the lowest wheat straw yield compared to other rotations.

Grain Yield

Wheat grain yield was significantly increased (P < 0.001) with the inclusion of forage legumes (Figure. 2). The highest grain yield was in the two-year alfalfa rotation. Including a two-year alfalfa and red-clover crop increased (P < 0.001) the grain yield by 45% and 35%, respectively in comparison to the non-legume rotation.

Wheat Straw P Uptake

Short rotation forage legumes did not (P = 0.76) significantly increase the P uptake in the straw of the wheat crop (Figure. 3). This suggests that improvements in wheat growth are mainly caused by enhanced soil nitrogen (N) nutrition or other factors apart from phosphorus.

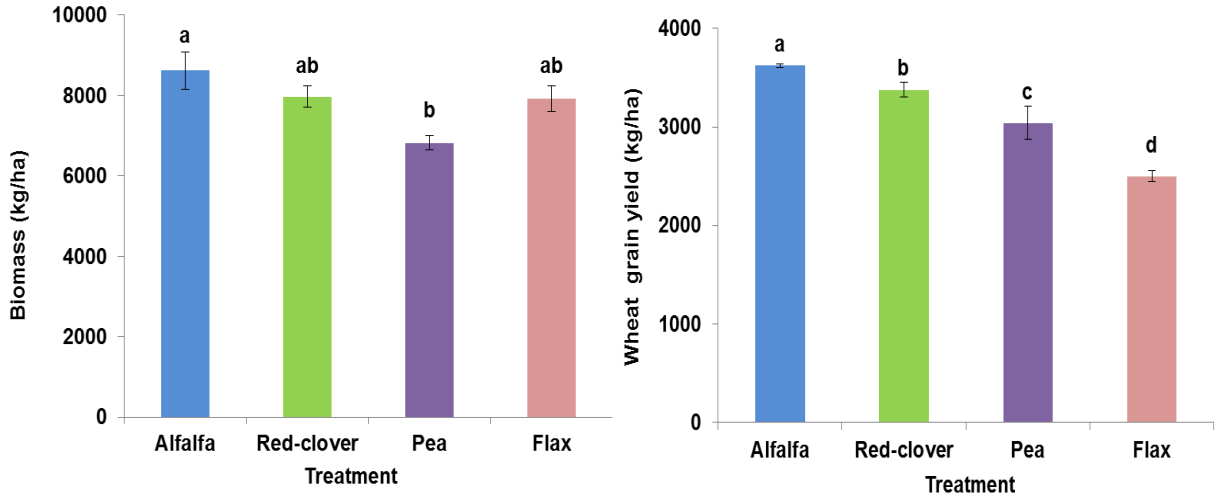

Figure. 2 Effect of forage legumes on wheat biomass and grain yield

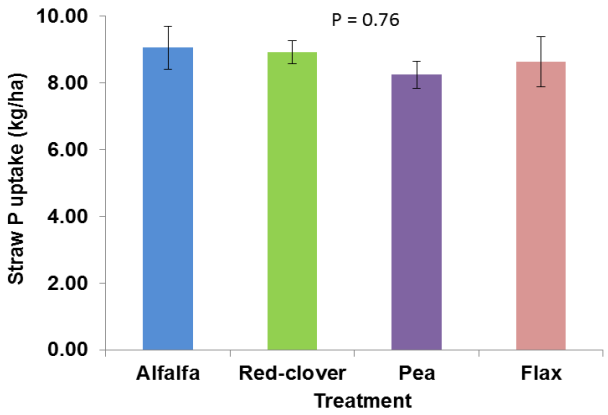

Figure. 3 Effect of forage legumes on P contained in wheat straw.

Soil P Availability

The amounts of soil P fractions extracted from all treatments were generally similar (Table 1). There were no significant treatment effects on both labile and stable P fractions except for $NaHCO_3$-Po pool. The $NaHCO_3$-Po concentration was lower (P = 0.09) in the legume rotations compared with the non-legume (flax). The depletion of $NaHCO_3$-Po in the legume treatment may be related to greater removal of soil P by the forage legume during the two years it was in the rotation (Nuruzzaman et al. 2005).

Table 1. Concentrations of soil inorganic (Pi) and organic phosphorus (Po) in different pools

Variables	Treatment				SEM	*P*-value
	Alfalfa	Red-clover	Pea	Flax		
Resin - Pi	39.6	39.6	44.7	41.8	6.75	0.94
$NaHCO_3$ - Pi	47.0	61.9	60.0	58.6	6.82	0.44
$NaHCO_3$ - Po	22.2 ^{b}	22.8 ^{b}	22.9 ^{b}	35.2 ^{a}	3.82	0.09
NaOH - Pi	175.3	188.6	188.8	186 .0	18.75	0.95
NaOH - Po	523.2	423.4	441.9	553.8	58.66	0.37
HCl - Pt	298.4	325.5	337.0	310.2	18.89	0.50
Residual - Pt	509.9	496.5	569.5	561.4	34.53	0.38

Note: Means with the different superscript letter in the same row are significantly different ($P \leq 0.10$).

Conclusions

1) Including two years of forage legumes in rotation showed a positive effect on wheat crop growth, but the growth improvements appeared to be related to factors other than phosphorus nutrition. The effect on a canola crop grown in the second year will be assessed in 2013.

2) A two year rotation may be too short a time period for measurable solubilisation of stable P in soil and significant enhancements in soil P availability to the following crop to be observed.

Acknowledgements

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