The influence of pulse crops on phosphorus supply to a subsequent wheat crop

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Abstract

Field experiments were carried out at Central Butte and Swift Current, Saskatchewan, to determine the influence of a previous pulse crop on phosphorus supply to a following wheat crop. It was hypothesized that a portion of the non-nitrogen benefit from a pulse crop in rotation is related to an effect on phosphorus availability. Wheat was planted on pea stubble and fallow at Central Butte; and pea, lentil, chickpea, wheat stubble and fallow at Swift Current. Differences in above and below ground residue effects were measured at Central Butte by removing above ground residue from part of the pea plot and placing it on an equal area of the fallow plot. Soil phosphorus supply rates were measured at various times during early growth using PRS™ anion exchange probes. Yields and phosphorus uptake by the treatments were measured as indicators of effect of the previous crop on P supplied to the next crop.

Key words: pulse crops, non-N benefits, phosphorus supply, phosphorus uptake , wheat

Introduction

Improved cereal yields following pulse crops in rotation have been attributed to both increased soil nitrogen (N) supply – the N benefit – and a net effect in addition to N – the non-N benefit (Baldock et al., 1981). Non-N benefits may include factors such as improved soil structure, aggregation, and infiltration (McVay *et al.,* 1989), or reduced disease and weed incidence (Stevenson, 1996).

Legumes may also increase phosphorus (P) availability in soils (Sask. Ag. & Food, 1995) but few studies have examined this in pulse-cereal rotations on the Prairies. Possible mechanisms by which legumes could influence P uptake by a following crop range from direct crop residue P release to increased root growth due to a more hospitable root environment giving greater access to indigenous soil P.

The objective of this study was to determine the extent to which soil P supply and subsequent plant P uptake are influenced by including a pulse crop in rotation.

Materials and methods

Two field experiments were carried out in the summer of 1997

The first experiment, located at Central Butte, Saskatchewan, consisted of wheat grown in 1997 on pea stubble (1996 crop; treatment = pea) and fallow (treatment = fallow). Subplots were created by removing the previous year's crop residue from the soil surface in

an area of the pea plot (treatment = pea - residue) and then placing this same residue on an equal area of the fallow plot (treatment = fallow + pea residue). Each plot and subplot contained IO sampling points (area = 2 m^2 each) to give a total of 40 points. Nitrogen was added as NH_4NO_3 a rate of 100 kg N ha^{-1} to isolate the influence of P.

The second experiment, located at Swift Current, Saskatchewan, consisted of wheat planted in 1997 on pea, lentil, chickpea, wheat stubble and fallow from 1996. The plots were replicated three times and organized in a randomized complete block design. The plots received 33 kg ha^{-1} of 1 l-51 -0. Wheat stubble plots received 40-O-0-6 applied at a rate of 103 kg ha^{-1}, while 88 kg ha" was applied to chickpea and lentil stubble, 60 kg ha" was applied to pea stubble, and fallow received 50 kg ha^{-1}.

Soil P supply rates were measured at intervals throughout the first half of the season by a 2 hour PRS™ (Western Ag. Innovations, Saskatoon, Saskatchewan) probe burial at each sampling point. Yield measurements were made at harvest. Phosphorus uptake was determined by sulfuric acid digestion of ground harvest samples (Thomas *et al.,* 1967).

Results and discussion

Supply rates between treatments at the same sampling date were not significantly different (figures 1 & 2) with the exception of the fallow treatment at Central Butte, which had significantly higher P supply rates on June 5. Generally, the previous crop had little influence on P supply rates in the soil.

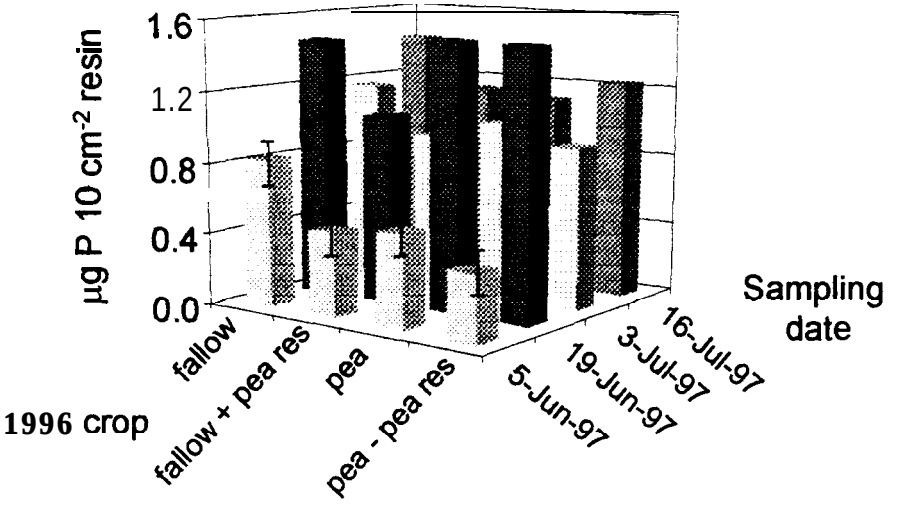

Figure 1. Soil P supply rates under wheat at Central Butte.

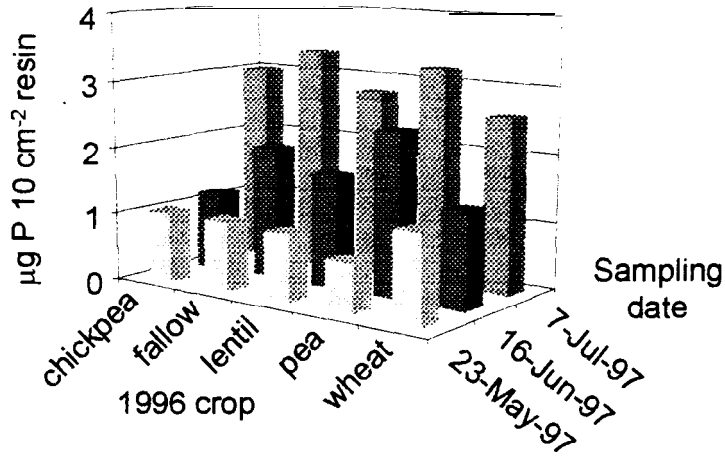

Figure 2. Soil P supply rates under wheat at Swift Current

At Central Butte, wheat grain yields on pea stubble were significantly greater than on fallow (figure 3) indicating that the growth of the previous crop had a beneficial effect on the cereal. In the presence of above ground residue, slightly lower grain yields (although statistically insignificant) suggest P immobilization caused by a residue C:P ratio of 563. Residue C:P ratios above 200 result in immobilization (Hannapel *et al.*, 1964). At Swift Current (figure 4) any P influence on yield created by pulse crops was likely masked due to P fertilization and overall high inherent soil P levels as can be seen in figure 2.

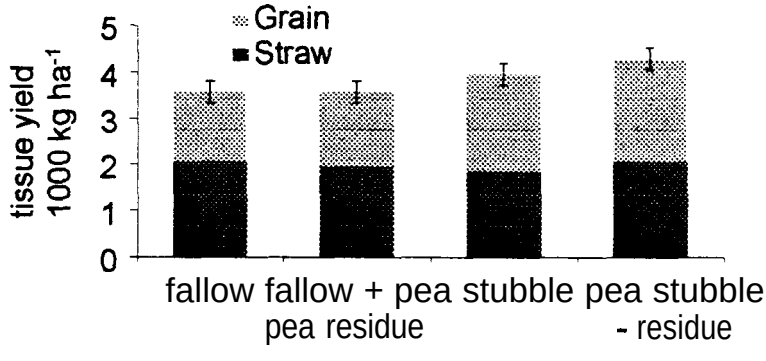

Figure 3. Wheat yields at the Central Butte site.

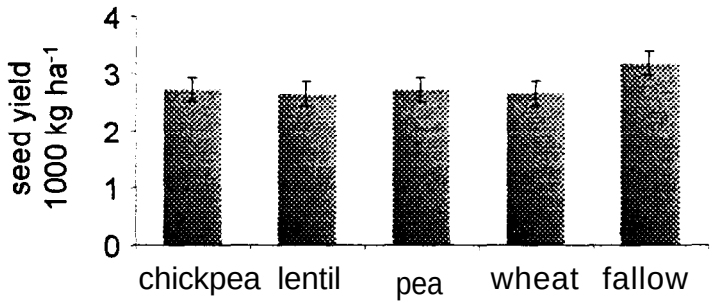

Figure 4. Wheat yields at the Swift Current site.

In addition to yield, P uptake (figure 5) was also significantly greater on the pea stubble plots at Central Butte, indicating the previous pea crop had a positive influence on growth and P uptake by the following wheat crop. There were no significant differences in P uptake at the Swift Current site (data not provided).

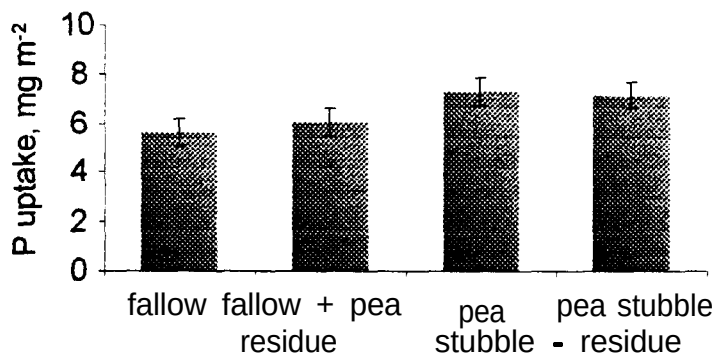

Figure 5. Phosphorus uptake by wheat at the Central Butte site.

Conclusions

The previous crop had little influence on soil P supply rates to the subsequent wheat crop. Wheat yields and P uptake at Central Butte were greater following peas compared to fallow. Results suggest that including pulse crops in rotation will likely influence subsequent crop P uptake through factors such as enhanced plant and root growth allowing access to a larger indigenous soil P pool rather than having a large effect on increasing P availability in the soil itself.

Acknowledgments

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