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Availability of Phosphorus Contained in Pulse Crop Residue to a Subsequent Crop

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Background:

The effect of pulse crop residue on availability of phosphorus (P) to following crops was examined in two replicated growth chamber experiments in 1996 (see 1996 progress report & MacLeod and Schoenau, 1997 p. 564 Proceedings of Soils and Crops Workshop '97 Univ. of Sask.) as the first part of an MSc project in the Dept. of Soil Science at the University of Saskatchewan (Catherine MacLeod). The purpose of the growth chamber experiments was to examine the effect of the residue itself on phosphorus availability to a following cereal or oilseed crop under controlled conditions. Two growth chamber experiments were performed to determine the short term contribution of legume residues to soil phosphorus supplies. In the first experiment, fresh pea residues of different ages were applied to soil in the presence and absence of wheat grown in a growth chamber. In the following study, after harvest pea, lentil and wheat residues were applied to wheat and canola. Residue performance in increasing phosphorus supplies was determined by soil phosphorus supply rates and total phosphorus uptake by plants. The results showed that in the growth chamber, all crop residues (pea, lentil, wheat) when added to the soil caused immobilization of soil phosphorus, consistent with relatively high C:P ratios (>200:1) of the residues. While return of phosphorus contained in pulse crop residues plays an important role in maintaining long term phosphorus fertility, the addition of such residues may be associated with short term immobilization of available phosphorus in the microbial biomass.

In 1997, the effect of a pulse crop and pulse crop residues (field pea) on phosphorus availability was studied in large landscape plots on a farm field at Central Butte, Saskatchewan and at the Swift Current Agriculture and Agrifood Canada Research Centre in plots set up and maintained by Dr. Perry Miller. The results of the work are discussed below.

In 1997-98, the change in phosphorus content and composition of crop residues (wheat, pea, chickpea) from harvest to the following spring is being monitored in the field at the study site at Central Butte. As well, a laboratory tracer study is planned to follow the fate of phosphorus released from crop residues. This work will complete the MSc research component.

Objectives:

The objective of the 1997 field research study was to determine the extent and manner by which soil phosphorus supply, wheat phosphorus uptake and yield are influenced by a pulse crop in rotation the previous year. Possible mechanisms by which legumes could influence phosphorus uptake by a following crop range from direct crop residue phosphorus release to increased root growth due to a better rooting environment and greater access to indigenous soil phosphorus.

Materials and Methods:

Two field experiments were carried out in the summer of 1997.

Central Butte Site:

This site was set up in a level portion of a farm field in the Brown soil zone (mapped as Haverhill loam; same soil as used in 1996 growth chamber studies) and representing a landscape of relatively uniform soil characteristics. The site consisted of 2 main plots that had been managed the same up to 1995 (fallow-wheat) but in 1996 was seeded to pea in one plot and fallowed in the other plot. Within each plot, sub-plots were set up: pea stubble with above ground residue removed; fallow with pea residue added; intact pea stubble; and fallow. Subplots were created by removing the 1996 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). Within each of the four sub-plots, 10 sampling points were selected to represent level landscape positions for measurements. In 1997, spring wheat (Columbus) was seeded across the plots and 100 kg N/ ha added as ammonium nitrate (broadcast and incorporated) after seeding to isolate the influence of phosphorus.

After seeding, in-field measurements of phosphate supply rate were made at every sampling point using anion exchange resin membrane probes four times over the period from the end of May to mid-July. At each measurement interval, the probe was allowed to remain in the soil for a 2 hour period. Sorbed phosphate on the resin probe was measured colorimetrically in the laboratory.

At each sampling point, square meter samples of grain and straw were taken at maturity (mid-August) and used to determine grain and straw yield. Phosphorus concentration of grain and straw was measured and used with the yield data to calculate phosphorus uptake.

Swift Current Site:

The experiment at this site consisted of spring 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. These plots were fertilized according to soil test recommendations with all plots receiving 30 kg/ha of 11-51-0. Wheat stubble plots received 40-0-0-6 at a rate of 103 kg/ha, with 88 kg/ha of this blend applied to chickpea and lentil stubble, 60 kg/ha applied to pea stubble, and fallow receiving 50 kg/ha.

Measurements of soil supply rates of phosphorus were made as described for the Central Butte site. Yield measurements were made on the plots using a small plot combine and phosphorus contents determined.

Results and Discussion:

Soil Phosphorus Supply Rates

At the Central Butte site, at the first measurement interval, the soil phosphorus supply rates were significantly ($p<0.05$) higher in the fallow than in the fallow plus pea residue treatments (Fig. 1) suggesting that the pea residue itself was responsible for some immobilization of phosphorus. This is consistent with the relatively wide C:P ratio (563:1) of the pea residue and the observations made in the 1996 growth chamber experiments in which added above-ground residues resulted in phosphorus immobilization. However, there was no significant difference in phosphorus supply rates between the intact pea stubble and the pea stubble where the surface residue was removed. At Swift Current, there was no significant difference in phosphorus supply rates among the different crop stubble types (Fig. 2). Generally, it appears that the previous crop had relatively little influence on the potential supply of available phosphorus in the soil the following spring. Overall, phosphorus supply rates were greater at Swift Current compared to Central Butte, reflecting the past history of phosphorus fertilization and the addition of phosphorus fertilizer at the Swift Current site in 1997. The phosphorus supply rates increased after the first sampling period at both sites, likely in response to warmer soil temperature, greater soil microbial activity and the presence of a crop rhizosphere which would enhance phosphorus availability, as was observed in the 1996 growth chamber experiment.

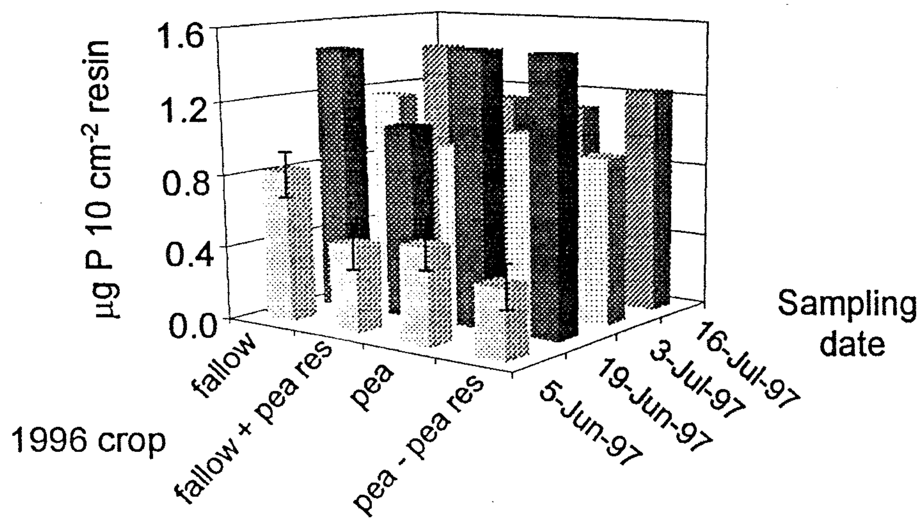

Figure 1: Soil phosphorus supply rates under wheat at Central Butte

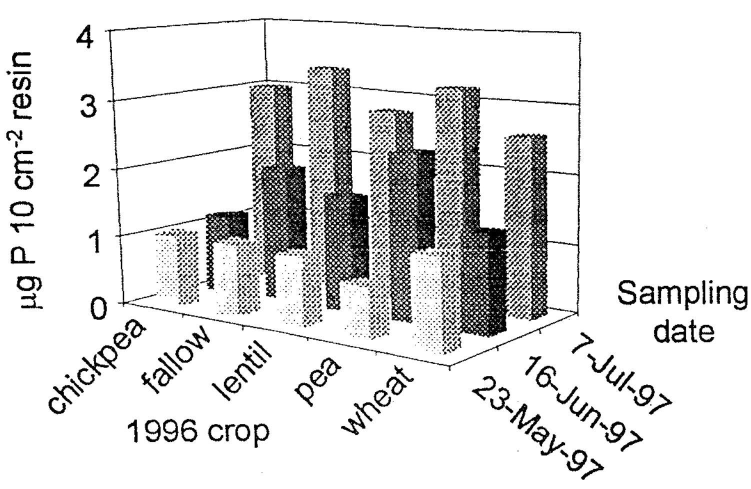

Figure 2. Soil phosphorus supply rates under wheat at Swift Current.

Wheat Yields and Phosphorus Uptake

At Central Butte, wheat grain yields and phosphorus uptake on pea stubble were significantly greater than on fallow (Fig. 3 and Fig. 4). Greater yield and uptake of phosphorus by wheat on the pea stubble compared to the fallow can be attributed to a rotational benefit of the pea as phosphorus supply rates were actually higher in the fallow plots compared to the pea stubble. Visual observations of wheat rooting systems under pea compared to fallow indicated a better root system under pea, which would enable the wheat crop to access more indigenous phosphorus. At Swift Current, seed yields and phosphorus uptake were not significantly different among the crop stubble types (Fig. 5). However, yield was significantly higher under fallow, probably as a result of more stored soil moisture in spring.

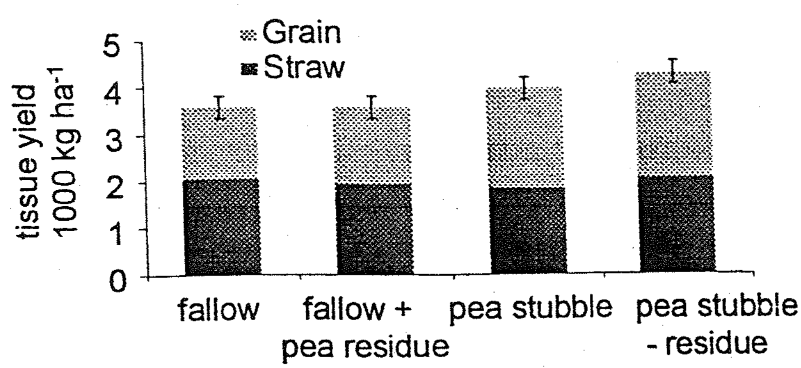

Figure 3. Wheat yields at the Central Butte site.

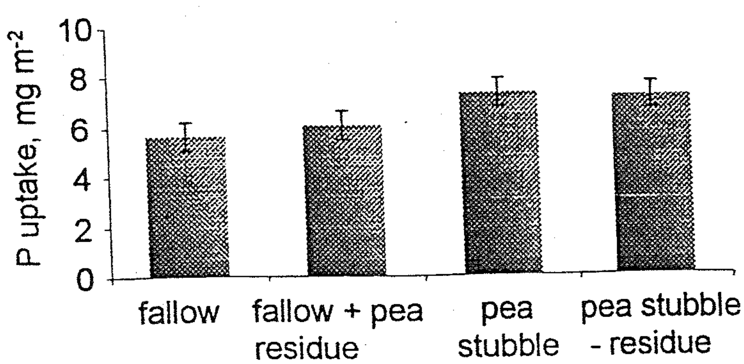

Figure 4. Phosphorus uptake by wheat at the Central Butte site.

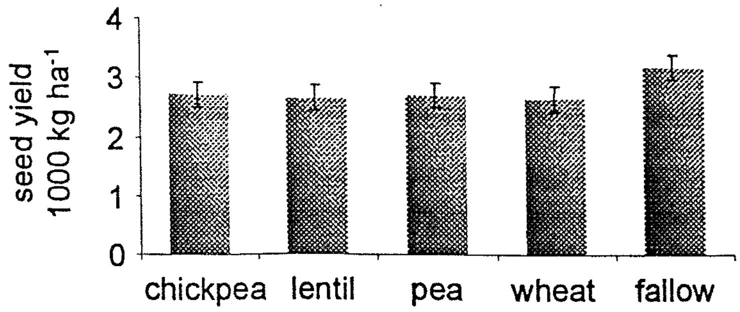

Figure 5. Wheat yields at the Swift Current site.

Conclusions:

The results of the 1997 field study corroborate the results obtained in the 1996 growth chamber studies. Above ground pulse and cereal residues can reduce the initial supply of available phosphorus through immobilization if the C:P ratio is high enough and decomposition coincides with the time of crop demand. The results indicate that including pulse crops in rotation will likely influence subsequent crop phosphorus uptake through factors such as enhanced plant root growth which allows greater access to soil phosphorus in the rooting zone, rather than having a large effect on the amount of phosphorus available per unit volume or weight of the soil. This suggests that after several years of a pulse-cereal rotation without phosphorus fertilization, the soil phosphorus fertility may decline more rapidly than in a cereal-based rotation.