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The Influence Of Crop Residues On Plant Phosphorus Uptake

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Abstract

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 a following growth chamber 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. Results showed that residues caused immobilization of soil phosphorus over the short term rather than significantly increasing phosphorus supply rates and plant phosphorus uptake.

Key Words

legume, residue, phosphorus, supply, uptake

Introduction

The role of phosphorus (P) recycling through crop residues in supplying P to plants is often overlooked (Dalal, 1979). In a study by Gares and Schoenau (1995), P uptake and concentration in wheat plants increased with surface wheat straw additions, indicating leaching of soluble P from cereal straw could be an important available P source. Two growth chamber experiments were set up to determine the importance of pulse crop residues in supplying P to a following crop. The influences of pulse crop residue age and type were examined. Plant uptake was included in the rating of residue performance as it has been suggested that the absence of plants in organic matter mineralization studies has led to the belief that P turnover from plant residue is low (Blair and Boland, 1978).

Materials and Methods

Two growth chamber experiments were performed.

In the first growth chamber experiment, fresh pea residues sampled at different growth stages were surface-applied to flats of Haverhill association soil (O-l 5 cm depth sampled out of wheat stubble) at a rate of 5000 kg/ha in the presence and absence of spring wheat plants (var. Columbus). The residues were defined as young: collected 46 days after planting, medium: collected 67 d.a.p. and old: collected 95 d.a.p.

In the second experiment, after harvest pea, lentil and wheat residues were incorporated into Echo association soil (O-l 5 cm depth sampled out of wheat stubble).

Flats of soil (700 g soil / flat) were then placed in a growth chamber and planted to wheat (var. Columbus), canola (var. AC Excel) or left fallow.

Treatments were replicated 3 (experiment 1) and 4 times (experiment 2). All residues were oven dried (50°C for 24 hours) and ground to resemble material that had passed through a straw chopper prior to addition to the soil. Flats received basal applications of nitrogen, potassium and sulfur to meet nutritional requirements and isolate the influence of P on plant growth. Replicates were arranged randomly within the growth chamber and rotated periodically. Soil P supply rate and plant P uptake were used as indicators of residue effects on P availability.

Total P concentrations of the applied residues were determined by sulfuric acid digestion (Thomas et al., 1967). Water soluble content of the residues was determined by shaking 1 gram of residue with 40 ml distilled water for 1 hour and determining P content of the filtrate (Schoenau and Huang, 1991). Potential P supply rate measurements were made initially and after 4 and 8 weeks of plant growth by anion exchange membrane burial for 24 hours (Schoenau et al., 1993). Plants were harvested and weighed after 55 (experiment 1) and 77 (experiment 2) days of growth. In the second experiment, seed and straw were separated prior to analysis. P uptake was determined by sulfuric acid digestion of harvested above ground tissue.

Results and Discussion

Residue Characterization

Table 1. Properties of the applied residues in the first growth chamber experiment.

Residue type	P_{total} µg/g	P_{ws} µg/g	C:P ratio
Young pea	3143	1902	137
Medium pea	2066	1466	208
Old pea	1013	299	416

Table 2. Properties of the applied residues in the second growth chamber experiment.

Residue type	P_{total} µg/g	P_{ws} µg/g	C:P ratio
Pea	740	378	592
Lentil	1437	484	285
Wheat	331	186	1335

P immobilization is postulated to occur when residue C:P ratios exceed 200 (Hannapel et al., 1964). All residues, with the exception of the young pea, had C:P ratios which exceeded 200 (Tables 1 and 2). Based on C:P ratio, young pea, medium pea and lentil residues should have the greatest short term P supply benefit of the residue treatments due to low C:P ratios. Water soluble P (**P_{ws}**) should be most immediately plant available as it is leached from the residues. **P_{ws}** may therefore give a good prediction of residue performance.

The decreased P content of pea residue in the second experiment is associated with overwinter weathering.

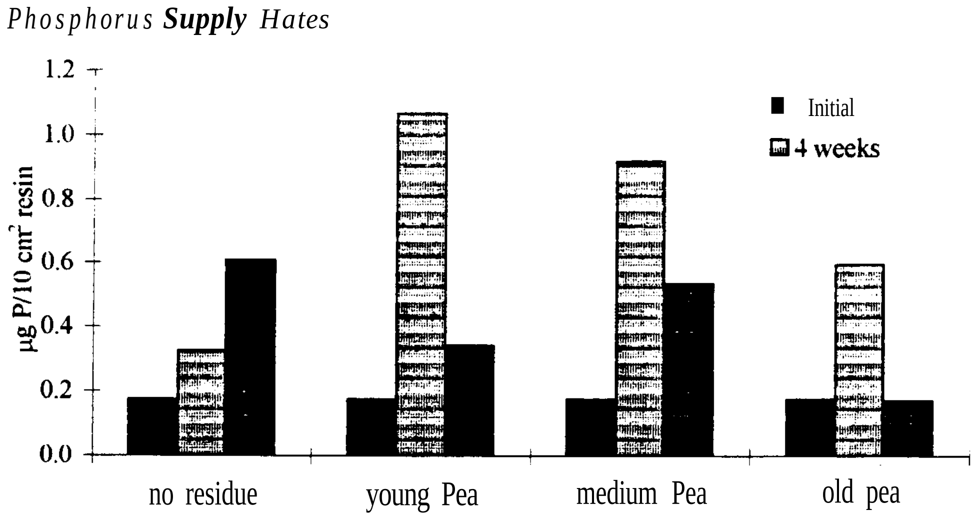

Figure 1. Soil P supply rates in the absence of plants in the first experiment,

In the absence of plants after four weeks, P supply rates were increased by residue addition, possibly due to P_{ws} addition from the residues by leaching. After eight weeks, P supply rates in residue amended treatments were lower, suggesting that immobilization was occurring as more resistant residue components were being decomposed. Mineralization of native soil P occurred over time in the no residue treatment.

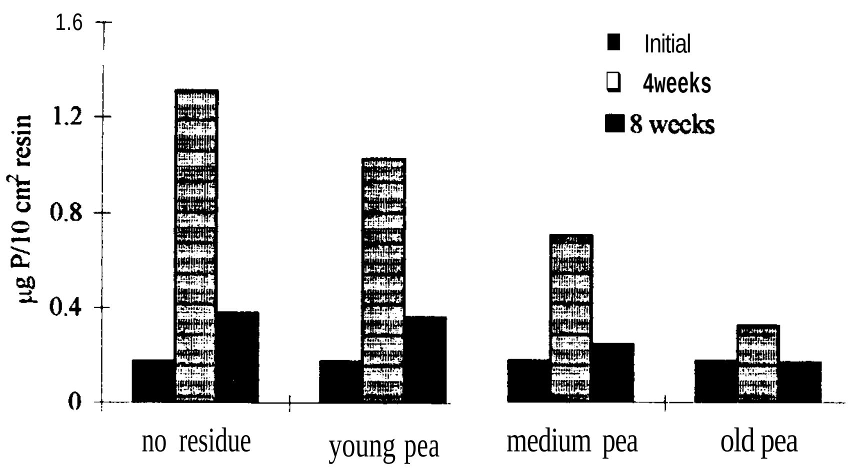

Figure 2. Soil P supply rates under wheat in the first experiment.

Under plant cover, residues caused immobilization of soil P as compared to the no residue control as indicated by lower supply rates in residue amended treatments. Generally, residues of higher P content and lower C:P ratios (younger) provided greater P supply rates. The immediate reduction in P supply rates in residue amended soils with plants growing may reflect greater microbial activity and P immobilization potential as induced in the wheat root rhizosphere.

P supply rates were increased-or maintained with plant growth, despite P uptake, likely due to rhizosphere effects. Due to the small plant : soil ratio (4 plants/700g), all soil was assumed to be rhizosphere soil and therefore strongly affected by root activity.

Phosphorus Uptake

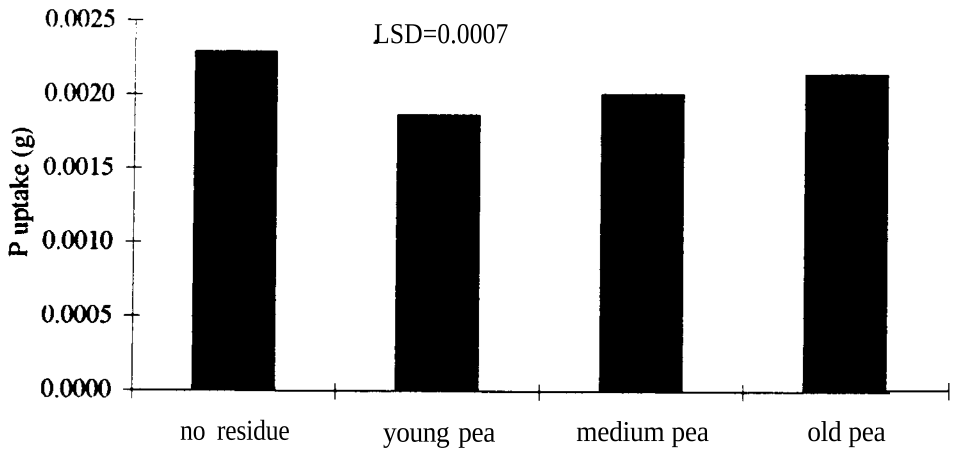

Figure 3. P uptake by wheat plants in the first growth chamber experiment.

P uptake by wheat plants was lower with pea residue addition in the first experiment, indicating P immobilization. P uptake by the wheat plants was not affected by residue age, despite the young residue having a smaller C:P ratio. Neither C:P ratio or P_{ws} predicted the trend observed in the graph of higher uptake under old pea residue than the younger residues which had greater P_{ws} content and lower C:P ratios.

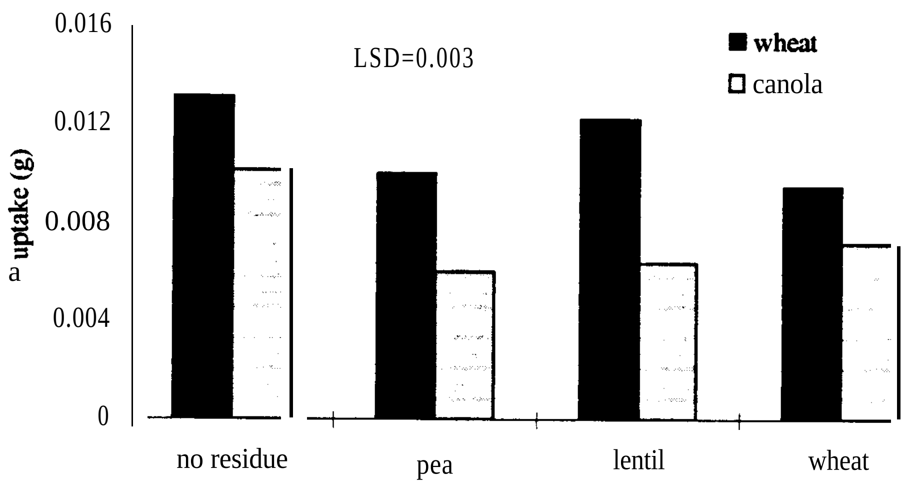

Figure 4. P uptake by plants in the second growth chamber experiment.

In the second growth chamber experiment, P uptake by wheat and canola on residue amended and unamended soils was compared. Overall, residue amended soils gave rise to significantly lower plant P uptake than unamended soils. Under wheat growth, reduction in P uptake induced by residue addition was lowest in lentil residue amended soil, which had the lowest C:P ratio. Residue type did not influence P uptake by canola, however all residues caused significant immobilization.

Among residue treatments, the trend in P uptake by wheat followed residue P_{ws} content more closely than C:P ratio. P uptake in the wheat residue treatment was better than would be predicted by C:P ratio alone. The C:P ratio of the wheat was much greater than that of the other residues, however, differences in P_{ws} content were not as large. Residues of greater P_{ws} content facilitated greater plant P uptake.

Conclusions

In the presence of plants, all crop residues studied (pea, lentil, wheat) resulted in lower soil P availability and plant P uptake when added to the two soils in the growth chamber. The effects of the residue were consistent with C:P ratio, with C:P ratios exceeding 200 resulting in reduced availability due to P immobilization.

While return of P contained in pulse crop residues plays an important role in maintaining long term soil P fertility, the addition of such residues may be associated with short-term immobilization of available P in the microbial biomass.

Increases in P uptake observed in the field in cereal crops following a pulse versus following a cereal are likely associated with a better rooting environment and greater access to indigenous soil P rather than a large direct contribution of available P in the short term from the residue itself

Acknowledgments

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