EFFECT OF PHOSPHORUS RATE AND PLACEMENT ON EARLY GROWTH AND NODULATION OF FIELD PEAS (*PISUM SATIVUM L*. CV ALMA)

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Summary. Glasshouse experiments were conducted to test the effects of depth of placement and rate of phosphorus (P) on early shoot and root growth and nodulation of field peas. A P deficient sandy loam soil was used in all experiments. Nodulation was almost completely absent under severe P deficiency and P applied with the seed or 4 cm below the seed increased nodule growth more than the P banded deeper. Nodulation was more sensitive to P deficiency than growth. Roots proliferated only in the immediate vicinity of added P and root growth away from fertiliser zones was the same, regardless of rates of application. Deeper application of P resulted in lower shoot growth and shoot P concentration (compared with placed with the seed and banded 4 cm below seed) even at high rates of P application.

INTRODUCTION

Most agricultural soils in Australia, are deficient in phosphorus for normal plant growth. High grade phosphate rock resources are depleting rapidly and utilising low grade phosphate resources increases P fertiliser manufacturing costs markedly. On the other hand, the efficiency of P fertilisers used by crops is usually low and the absorption rate, in the year of application, does not exceed 20-30% (3, 5). In attempts to increase fertiliser efficiency banding P fertiliser below the seed and comparing this with other methods of application has been studied by several workers under different conditions. The results of these studies have been both favourable (2, 6) and unfavourable (1). This suggests that more work is needed in different soils and with different crops. Research reported here investigated the effects of increasing depth of placement of P fertiliser below seed on growth of field peas in a P deficient calcareous sandy loam under the glasshouse conditions.

MATERIALS AND METHODS

Three glasshouse experiments were conducted with increasing P rates; 0, 15, 45, 90, 135, and 180 mg/pot (Experiments 1 and 2) and 0, 15, 45, 135 mg/pot (Experiment 3). P was placed at different locations within the pot; with seed or banded 12 cm below the seed (Expt. 1), placed with seed or banded 4, 7, or 10 cm below the seed (Expt. 2) and placed with seed or banded 5 or 10 cm below the seed (Expt. 3). In all experiments a virgin sandy loam collected near Avon (South Australia), with a Colwell extractable P of 5 mg/kg and pH = 8.4 (H_2O) was used. Pots were 30 cm in depth and 10 cm in diameter and contained 3 kg of soil each. Basal nutrients were applied as; $CaCl_2.2H_2O$, K_2SO_4, $FeSO_4.7H_2O$, NH_4NO_3, $Na_2Mo_4.2H_2O$, H_3BO_3, $CuSO_4.5H_2O$, $Co(NO_3)_2.6H_2O$, $MgSO_4.7H_2O$, $MnSO_4.4H_2O$ and $ZnSO_4.7H_2O$ and mixed evenly through the soil. P was added as KH_2PO_4 solution to different depths below the seed as pots were progressively filled. Three inoculated pea seeds (*Pisum sativum* cv. Alma) were planted in each pot. Pots were placed in water baths at 12?C for experiment 1 and 2 and 16?C for experiment 3. Glasshouse temperature ranged from 12 to 18?C for experiment 1 and 2 and 21 to 27?C for experiment 3. Pots were watered to field capacity (12% w/w) with deionised water at regular intervals. One harvest was taken in experiment one (4 weeks after sowing), two harvests in experiment two (4 and 6 weeks after sowing) and three harvests in experiment three (3, 5 and 7 weeks after sowing). At each harvest shoot and root dry matter, active nodules, intact root length (Expts. 1 and 2) and root length in 6 different soil layers (0-3, 3-6, 6-9, 9-12, 12-15, 15-27 cm below the seed) (Expt 3) were measured. Shoot and root P concentration was also analysed after all harvests.

RESULTS AND DISCUSSION

The soil used in these experiments was deficient in P for growth of field peas. For example the dry weight of shoots was doubled with high rates of P after only 5 weeks from sowing (Fig. 1).

Nodulation was very sensitive to P deficiency and no active nodules were produced on plants without P fertiliser. In contrast to the conclusion of Robson *et al*. (4), nodulation was depressed by P deficiency before growth effects occurred. Nodulation was also sensitive to the depth of P placement. For example, at early harvests (3 and 4 weeks) P applied with seed (WS) increased nodule growth more than deeper placement. But at later harvests (6 and 7 weeks) P applied a few cm below the seed enhanced nodulation more than the other treatments (Fig. 2).

Growth of roots was stimulated by the addition of P which occurred only in the immediate vicinity of fertiliser P. For example, root length did not improve in any layers below 3 cm in WS treatments with increasing rates of P (Fig. 3). The lowest rate of P application (15 mg/pot) resulted in maximum root growth in the fertiliser band (Fig. 3) despite this level not being sufficient for maximum shoot growth (Fig. 1). Rates of P higher than 15 mg/pot depressed root growth in the fetiliser band but maximised shoot growth.

At early harvests maximum shoot P concentration was obtained when P was applied to seed level. But at later harvests (e.g. 7 weeks after sowing) this difference became insignificant and shoot P concentrations in B4 treatments were the same as in WS treatments. This suggests that field peas can gain as much P from a few cm below seed as from fertiliser placed at seed level. Deeper application of P (B10), however, did not increase the shoot P concentrations to the same degree, even at higher P levels (Fig. 4).

Phosphorus deficiency caused an increase in root growth early but by the end of 6-7 weeks the dry weight of roots in pots without P fertiliser was only 88% of the highest P treatment. (Fig. 5)

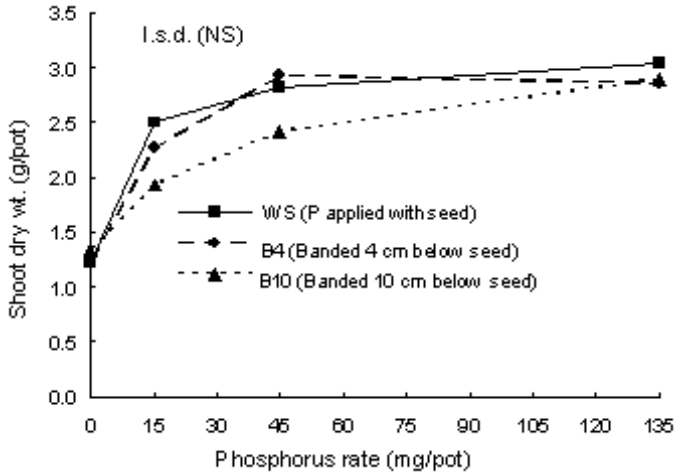


Figure 1. Effect of P rate and placement on shoot dry weight of field peas, 5 weeks after sowing.

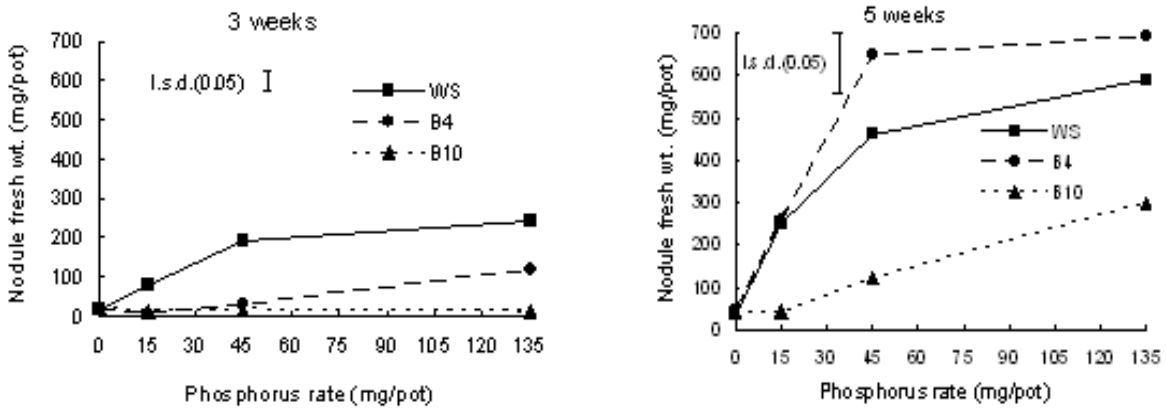
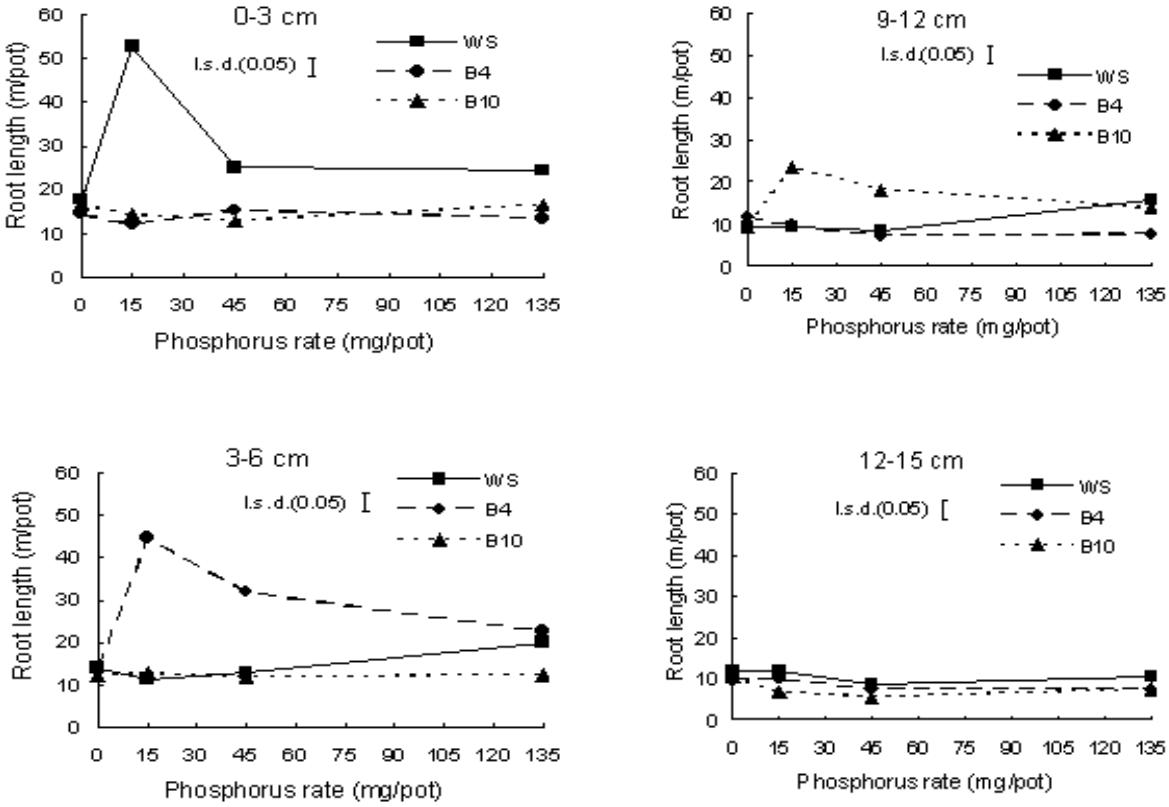


Figure 2. Effect of P rate and placement on active nodule fresh weight of field peas, 3 and 5 weeks after seeding.



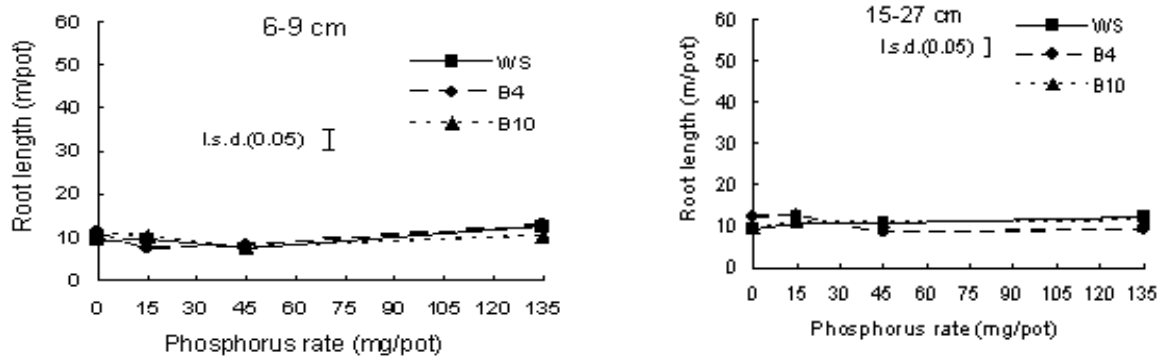


Figure 3. Effect of P rate and placement on root length of field peas in 6 different layers below seed, 7 weeks after seeding.

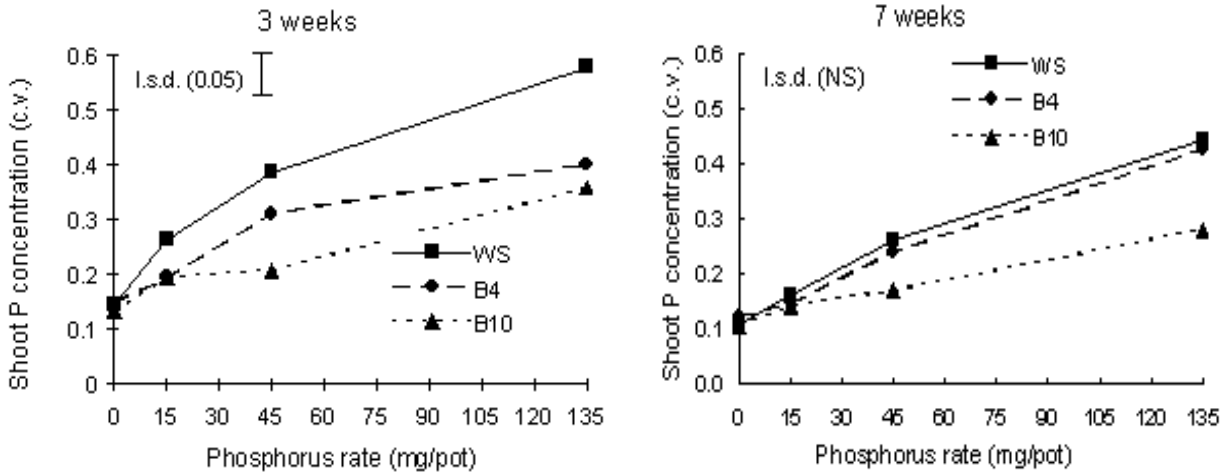


Figure 4. Effect of P rate and placement on shoot P concentration in field peas.

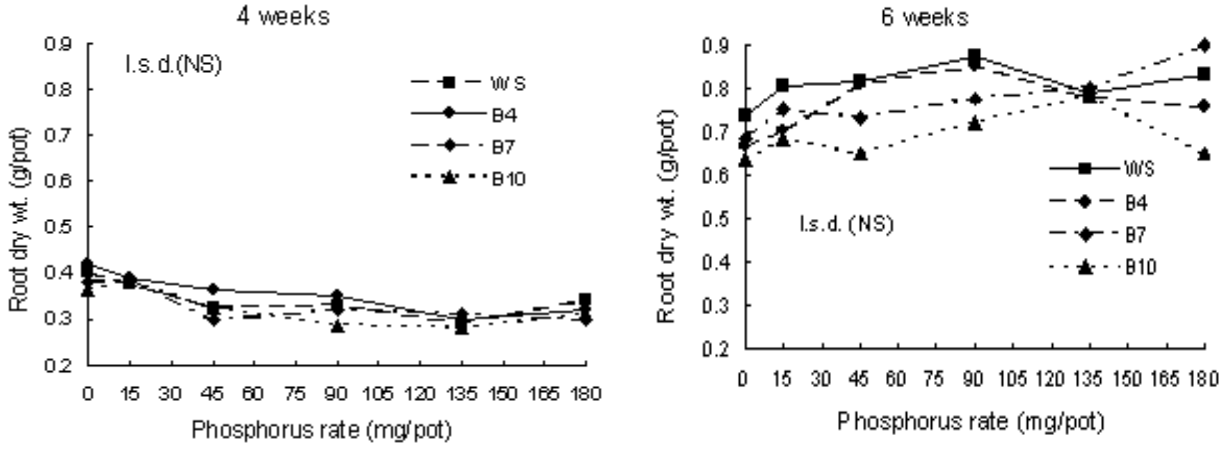


Figure 5. Effect of P rate and placement on root dry matter of field peas, 4 and 6 weeks after seeding.

CONCLUSION

These results suggest that placing P fertiliser under the seed rows of field pea crops at depths up to 5 cm will be as effective as placing the fertiliser with the seed after the first few weeks of growth. However placing the fertiliser below the seed has two advantages which may be realised under certain conditions. The first is a reduced risk of decreased germination due to P toxicity from high rates of P fertiliser near the seed. The second is increased availability of the fertiliser under dry conditions because fertiliser placed close to the soil surface may not be available to the crops due to the dry soil conditions.

REFERENCES

1. Jarvis, R.J. and Bolland, M.D.A. 1990. Fertiliser Res. 22, 97-107

2. Jarvis, R.J. and Bolland, M.D.A. 1991. Aust. J. Exp. Agric. 31, 357-366.

3. Mc Laughlin, M.J. 1988. Aust. J. Soil Res. 26, 323-331.

4. Robson, A.D., O'Hara, G.W. and Abbott, L.K. 1981. Aust. J. Plant Physiol. 8, 427-436.

5. Russell, E.W. 1988. In: Soil conditions and Plant Growth. (Ed A. Wild) (John Wiley and Sons: London). 734 pp.

6. Scott, B.J. 1973. Aust. J. Exp. Agric. Anim. Husb. 13, 705-710.