Phosphorus and the Proteaceae

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Macadamia seedlings were grown at several phosphorus (P) levels (0, 0.5, 1, 2,4 and 8 mg l^{-1} in a constant liquid feed) at the pHs (4.7, 5.6 and 6.4) in a soilless potting media. The seedlings responded strongly to P at the lowest pH. Increasing pH reduced growth and response to P. Possible reasons for the growth reductions are discussed.

LITERATURE REVIEW

The practice of preplant incorporation of superphosphate into container media containing soil was continued after the introduction of soilless container media which did not "fix" the phosphate in water-insoluble form. Yeager and Wright (1982) showed that following incorporation of superphosphate into soilless potting media the phosphorus (P) concentrations can be as high as 248 mg/liter in the weeks following potting. This level is likely to cause problems of iron deficiency for most plants. Handreck (1990) has stated that soluble P in a 1 : 1.5 D.T.P.A. extract should not exceed 3 ppm for young plants of a sensitive species. This is equivalent to 15 ppm in the water in a container. He has since confirmed this for *Banksia* species (Handreck 1991).

Following from the work of Grundon (1972) and Nicholls and Beardsell (1981) there developed in the nursery industry the idea that most Australian native plants and particularly the Proteaceae did not require any phosphorus fertilizer. Manufacturers of slow-release fertilizer responded by developing products with either no P or very low levels of P.

Recently Bowden (1987) challenged the concept that Proteaceae should not be supplied with phosphorus and concluded that Proteaceae did respond to phosphorus. What should be said is that plants in the Proteaceae family are sensitive to phosphorus when it is applied in the wrong form and at the wrong concentration.

Because growing macadamia seedlings is a large and important industry in the Alstonville area, we initiated a project to look at the response of macadamia to both phosphorus and pH in an effort to improve growth rates.

MATERIALS AND METHODS

Macadamia seed from the variety H2 (Hinde) were germinated in sand. At the four-leaf stage they were transplanted into a 5 litre planter bag containing a soilless potting mix consisting of 35% composted hardwood sawdust, 35% composted pine bark fines and 30% coarse river sand. It was amended with slow-release fertilizer with no P at 2 kg/m^3 and Micromax at 1 kg/m^3. The slow-release fertilizer was

applied every 3 months. The mix had a pH of 4.7. Two additional pH treatments were created by adding 100 g and 400 g of dolomite to each 30 liters of mix. This produced pHs of 5.6 and 6.4 (1 : 1.5, by volume in water).

The phosphorus treatments were applied as phosphoric acid (H_3PO_4) at the following levels: 0, 0.5, 1.0, 2.0, 4.0, and 8.0 mg/liter in 500 ml of water applied every second day. This replenished the soil solution and flushed the pots, keeping P levels constant. There were five replications and the plants were grown in an evaporatively cooled glasshouse.

Plant height was measured monthly and at harvest which was after 9 months of growth. At the conclusion, the plants were cut and dried and root, stem and leaf weights recorded.

RESULTS AND DISCUSSION

Growth was significantly increased by P at the lowest pH while increasing pH both reduced growth and limited the response to P (Fig. 1).

Plants growing in the P_0 treatment developed characteristic symptoms on the lower leaves which we now believe to be phosphorus deficiency symptoms. These appeared initially on the oldest leaves as interveinal purpling on the upper surface. This progressed through the leaf, eventually becoming necrotic and coalescing.

Clearly macadamia seedling growth is promoted by P, provided it is not applied at excessively high rates. The P level at which growth would have been reduced was not indicated in this experiment. However, in a further experiment using rates up to 64 mg/liter of P, which is not yet complete, chlorosis appeared at and above 32 mg

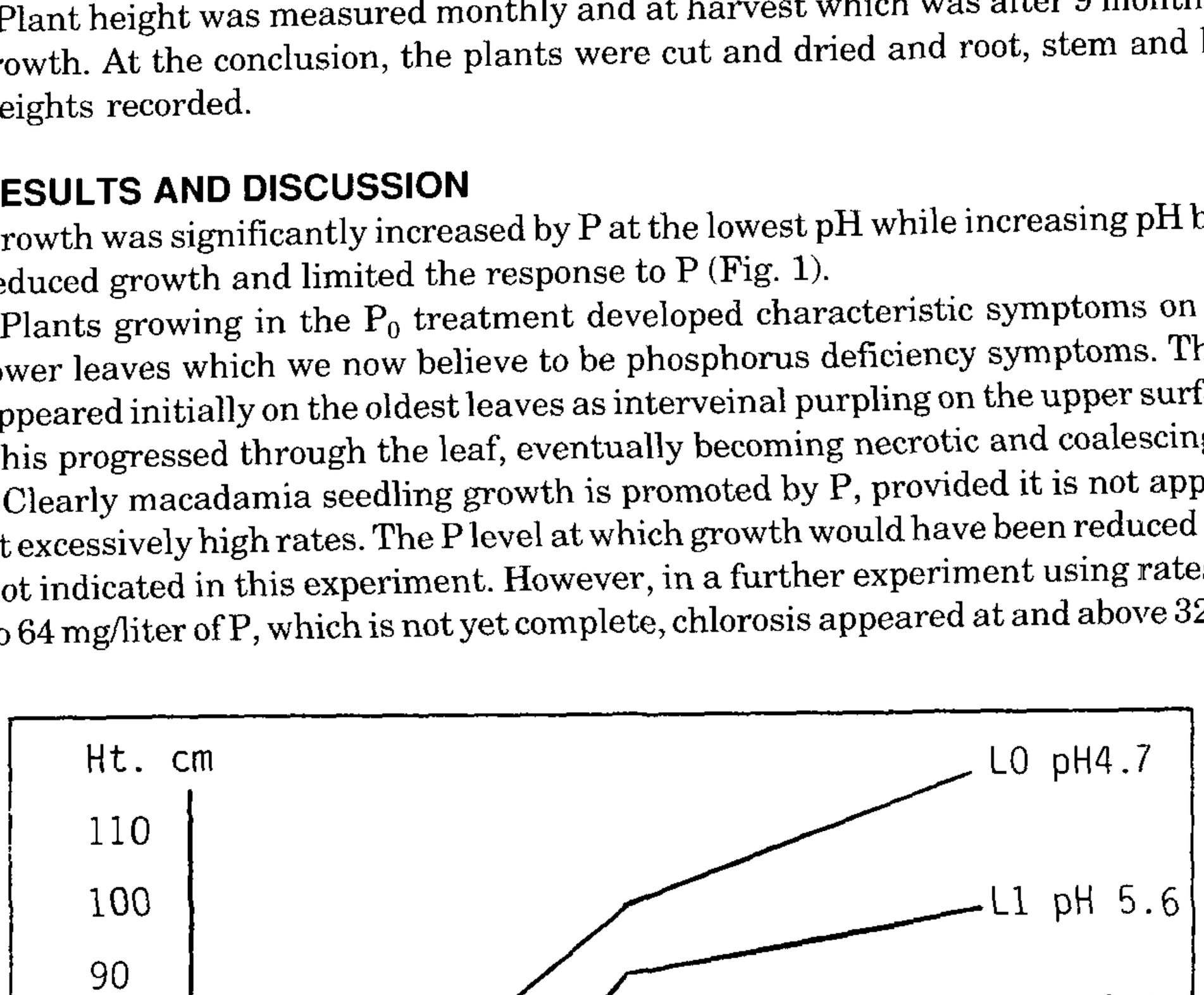

Figure 1. Effect at harvest of P and three lime rates on plant height.

at a pH of 4.7 and at 16 mg at a pH of 5.6 and 6.4. At the highest pH chlorosis is severe and growth is reduced. The reasons for the reduced growth and P response at the higher pHs are less clear. When plant analyses are completed it may be possible to state what caused the growth depression.

Aitken et al. (1990) in Queensland have demonstrated with macadamia that nut production and seedling growth are reduced at soil pH >5.5 (measured in water) which they ascribe to induced micronutrient deficiencies. The availability of iron is greatly reduced as pH is increased and increasing phosphate levels also reduce the availability of iron. Therefore, it is possible that the growth reduction resulted from iron deficiency, although the plants were not chlorotic.

We would like to suggest that members of the Proteaceae have an inefficient iron uptake mechanism and thus small changes in pH or P level can result in phosphate-induced iron deficiency which is more common than phosphate toxicity itself. Wright and Niemiera (1987) indicate that in soilless media the optimum pH range for maximum nutrient availability is 4.0 to 5.2 as manganese toxicity is unlikely.

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