PHOSPHORUS AND IRON EFFECTS ON THE EARLY GROWTH OF SOME AUSTRALIAN NATIVE PLANTS

KEVIN A. HANDRECK

CSIRO Division of Soils
Private Bag No. 2
Glen Osmond, South Australia 5064

Abstract. Seeds of 61 native Australian species of the genera *Acacia, Banksia, Grevillea,* and *Hakea* were germinated and grown-on in a pine bark based medium which had been amended with two levels of Fe, added as ferrous sulfate, and five levels of P, added as single superphosphate The species were ranked in groups according to the severity of foliar symptoms

In a second experiment, *Banksia ericifolia* seedlings were grown in a pine bark/peat mix amended with seven levels of Fe, added as ferrous sulfate, and seven levels of P, added as single superphosphate Shoots at 12 weeks ranged in colour from dark green at the highest levels of Fe combined with the lowest levels of P, to yellow and/or dead at the lowest levels of Fe combined with the highest levels of P

Guidelines for interpretation of analytical data for potting media to be used for growing "P-sensitive" plants are given

INTRODUCTION

A number of plants native to Australia and Southern Africa, particularly in Proteaceae and Mimosaceae, have been reported to show foliar symptoms ranging from necrosis and premature senescence of old leaves and chlorosis of whole shoots to general unthriftiness when supplied with even quite modest levels of soluble phosphorus (P). This phenomenon has been observed in the field on sandy soils amended with superphosphate (5), in solution culture (6) and in soilless potting media (2, 4). The observed symptoms have been attributed to uptake by the plants of P in excess of the amounts commonly available to them in natural ecosystems.

The experiments reported here were designed to widen the range of species tested and to investigate the role of iron (Fe) in the response to P in soilless potting media.

MATERIAL AND METHODS

Experiment 1. Seeds of 61 species (Table 1), were germinated in undrained pots of a soilless potting medium comprised of ground *Pinus radiata* bark, German peat (Eurotorf), and siliceous sand (6:3:1). All nutrients except P and Fe had been added in adequate amounts. Half of the medium was amended with sufficient $FeSO_4 \cdot 7H_20$ to give about 19 mg/L Fe (actual 18.6 to 21.2) in a 1:1.5 2 mM DTPA extract (1). Sufficient was added to the other half to give about 34 mg/L Fe (actual 31.8 to 37.8). These concentrations have been found to be insufficient and sufficient, respectively, for a wide range of plants (1). Single superphosphate was added to five subsamples of each of these media to give 3 to 27 mg/L P in 2 mM DTPA extracts. The pH throughout was about 5.5 (water). Foliar symptoms were assessed at appropriate times (6-18 weeks) after sowing.

Table 1. Maximum concentrations of P tolerated by a range of species growing in a soilless potting medium at two levels of extractable Fe

P tolerated in extract at Fe (mg/L)		Species
34	19	
3	<3	*Acacia merrallii, Grevillea leucopteris, Hakea bucculenta, H franciisiana, H. petiolaris*
5	<3	*A imbricata, Banksia benthamiana, B brownii, B lemanniana, B leptophylla, B sphaerocarpa, G banksii, H salicifolia*
5	3	*A baileyana, A decurrens, A. spectabilis, H sericea*
8	7	*A dealbata, A glaucoptera, A ligulata, A lineata, A montana, A myrtifolia, A. retinodes, H laurina*
11	3	*B tricuspis, H rostrata*
11	10	*A argyrophylla, A baileyana* 'Purpurea,' *A burkittii, A calamifolia, A. floribunda, A iteaphylla, A. menzelii, A microcarpa, A. papyrocarpa, A paradoxa, A. rigens, A rivalis, A rotundifolia, A sclerophylla, B aculeata, B laricina, B speciosa, G intricata, G robusta, H suberea*
>20	14	*A cyclops, A fimbriata, A hakeoides, A melanoxylon, A nyssophylla, A pendula, A ramulosa, A sophorae, H. muelleriana*
>20	>25	*A longifolia, A saligna, A truncata, A victoriae, H leucoptera*

Experiment 2. *Banksia ericifolia* seedlings were grown in a soilless potting medium comprised of *Pinus radiata* bark and peat (7:3) contained in undrained pots each holding 260 mL medium. The medium had been amended with the following, in mg/L: $CuSO_4.5H_2O$ (20); $MnSO_4.H_2O$ (20); $ZnSO_4.7H_2O$ (15); $B(OH)_3$ (3.4); K_2SO_4 (200) Subsamples were amended with $FeSO_4.7H_2O$ at eight rates up to 3 g/L and single superphosphate at eight rates up to 444 mg/L (40 mg/L P), in all combinations. All subsamples were adjusted to about pH 5.6. There were 10 replicates of each treatment. Shoot quality was assessed 13 weeks after sowing with pregerminated seeds

RESULTS AND DISCUSSION

Experiment 1. In *Acacia*, symptoms typical of those associated with P toxicity—chlorosis, necrosis, and premature shedding of oldest pinnate leaves—were observed mainly in plants in media having the highest levels of P and lower Fe content. The symptoms in *Banksia, Grevillea,* and *Hakea* were always chlorosis of youngest leaves and were consistent with Fe deficiency. The symptoms tended to be most severe at the lower Fe level and the highest P levels. The range of response is summarised in Table 1.

Experiment 2. The first signs of foliar symptoms—chlorosis of youngest leaves—began to appear about 5 weeks after sowing seeds. Chlorosis appeared first and was most severe in media with no added Fe. Amendment with increasing levels of Fe delayed or totally eliminated tip chlorosis but, at every level of added Fe, increasing P gave increasing severity of chlorosis. Severe chlorosis was followed by necrosis of leaf tips and sometimes death of shoot tips.

Quality score data at harvest recorded in Table 2 clearly show the effects of Fe and P and the extent of interaction between them. The data indicate desirable levels of extractable Fe and P for optimum visual quality of this species.

Table 2. Quality score of *Banksia ericifolia* seedlings growing in a soilless potting medium amended with Fe and P The scale is from dead plants = 0 to the greenest = 11 Plants with a score of 8 were *just* of acceptable commercial quality, but lower-scoring plants were too chlorotic

Fe in 2µM DTPA ext	P in 2 µM DTPA extract mg/L							
mg/L	0 4	1 0	2.6	3 6	6 7	8	8 5	11 1
7 7	4.2	1 8	1 9	2 2	1 7	2 0	1 2	2 7
13	6 6	4 2	2 3	3 1	2.3	2 6	2 2	1 8
20	7 2	6.5	6 6	5 4	4 3	4 3	4 5	3 6
25	8 1	8.1	6.6	6.6	4 3	5 2	4 7	4 2
43	9 1	8 9	8 2	8 0	7 0	6.3	6 2	5.4
45	10 1	10 2	9 9	9 4	8 4	8 2	7 6	6.8
49	10 0	10 5	10 0	9 6	8 6	9 3	8 8	7 2
70	10 6	10 4	10 2	10.6	9 7	9 9	9 9	8 9

It is clear that in this species the observed foliar symptoms were those of Fe deficiency. At low levels of added P this deficiency was due to an absolute shortage of Fe in the medium, but at higher Fe even modest levels of extractable P interfered with the use of Fe by the plant.

IMPLICATIONS FOR PLANT PROPAGATORS

Potting media for plants known to be sensitive to even modest levels of P should be very well endowed with Fe. When ferrous sulfate is the source of Fe it is desirable to add enough to give at least 40 mg/L Fe in a 1:1.5 volume 2 mM DTPA extract. This is provided by about 1 to 1.3 g/L $FeSO_4 \cdot 7H_2O$ if the medium is mainly pine bark and its pH about 5.5. At pH 5, sufficient Fe may be provided by 0.7 g/L $FeSO_4.7H_2O$.

Including FeEDDHA in the mix may be necessary if some species are to be free from Fe deficiency symptoms.

It is also essential for very sensitive species to keep the P content of the propagation medium to a low level. A 1:1.5 volume 2 μM DTPA extract of the medium should contain no more than about 2 mg/L P at potting. The concentration might be extended to about 7 or 8 mg/L if the Fe concentration in the extract is over about 65 mg/L, but management is easiest if the P concentration is kept below 2 to 3 mg/L. As little as 0.1 g/L single superphosphate provides this. The only safe way to be sure is to have the medium analysed.

Most of the Nutricote range of controlled release fertilizers are safe to use, as are low-P Osmocotes (8 to 9 month, 1.6% P or less). There is anecdotal evidence that Osmocote Plus formulations containing up to 3.5% P, used at up to about 3 g/L, should be safe to use (3).

LITERATURE CITED

1 Handreck, K A 1989 Assessment of iron availability in soilless potting media *Commun Soil Sci Plant Anal* 20 1297-1320

2 Handreck, K A 1990a Available phosphorus in potting media extractants and interpretation of extract data *Commun Soil Sci Plant Anal* 21 (in press)

3 Handreck, K A 1990b Safe fertilizers for phosphorus-sensitive plants *Austral Hortic* (1) 62-64

4 Nichols, D G , D L Jones, and D V Beardsell 1979 The effect of phosphorus on the growth of Grevillea 'Poorinda Firebird' in soilless mixtures *Sci Hortic* 11 197-205

5 Specht, R L 1963 Dark Island heath (Ninety-Mile Plain, South Australia) VII The effect of fertilizers on composition and growth, 1950-60 *Austral Jour Bot* 11 67-94

6 Specht, R L and R H Groves 1966 Comparison of the phosphorus nutrition of Australian heath plants and introduced economic plants *Austral Jour Bot* 14 201-221