INFLUENCE OF POTASSIUM AND MANGANESE ON GROWTH AND UPTAKE OF MAGNESIUM BY SOYBEANS (GLYCINE MAX (L.) MERR. CV. BRAGG)

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KEY WORDS
K supply  K Mg uptake  Mn nutrition  Soybean  Short-term  Water culture

SUMMARY
Soybean (Glycine max (L) Merr. cv. Bragg) seedlings were grown in nutrient solutions to evaluate the response to manganese nutrition as affected by potassium supply. In solutions containing 275 μM manganese, increasing the solution concentration of potassium from 1 mM to 10 mM alleviated symptoms of manganese toxicity, decreased manganese concentrations in the leaves and increased dry matter yields of the plants. The reduction in manganese toxicity was brought about by a reduced rate of root absorption of manganese at high potassium supply levels.

Increasing the supply of either potassium or manganese decreased the leaf concentration of magnesium although there were no apparent symptoms of magnesium deficiency in any treatment. The reduced concentration of magnesium in the leaves was due to effects of potassium and manganese on the rate of root absorption of magnesium.

Under manganese deficiency conditions, growth was reduced and manganese concentrations in plant parts were very low; there was no effect of potassium supply when manganese was absent from the nutrient solution.

INTRODUCTION
In soybean growing areas, manganese can either be available in insufficient amounts to support optimal growth2,11,18 or present in high levels sufficient to induce toxic symptoms and reduce growth5,6,14. The uptake of manganese by plants is a function of soil properties and can be altered by the addition of certain fertilizers10,22. As soybeans require large amounts of potassium, some of the most striking results to fertilization have been obtained by addition of potassium fertilisers12. Little is known about the effects of potassium on manganese uptake and distribution in soybeans. There have been reports that increasing potassium increased manganese concentration in both tops and roots of tobacco20 and in

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leaves of barley plants, while Bolle-Jones reported an effect of K on manganese transport in potatoes. It is therefore possible that addition of potassium may accentuate manganese toxicity by increasing the uptake of manganese.

The aim of this experiment was to examine, in a water culture experiment, the interaction between potassium and manganese on growth and chemical composition of 'Bragg' soybeans. Previous studies showed that this cultivar was susceptible to high manganese supply.

**MATERIALS AND METHODS**

Soybeans (*Glycine max* (L.) Merr. cv. Bragg) seedlings were grown in a modified Hoaglands No. 2 solution in 6 liter polyvinyl chloride containers. The basal solution consisted of 6 mM KNO₃, 4 mM Ca(NO₃)₂·4H₂O, 2 mM MgSO₄·7H₂O, 0.5 mM NH₄H₂PO₄, 2 μM H₃BO₃, 0.3 μM ZnSO₄·7H₂O, 100 μM FeEDTA, 0.12 μM H₂MoO₄, 0.008 μM Co(NO₃)₂·6H₂O. The macronutrient solutions were purified with dithizone (0.02% w/v) in carbon tetrachloride. Deionized water was used throughout and the pH maintained at 5.5 ± 0.3 by addition of NaOH or H₂SO₄. The solutions were aerated twice per hour for 15 min and changed every week.

The experiment was conducted in an air conditioned glasshouse where the mean maximum temperature was 25°C and the mean minimum 17°C during winter in the southern hemisphere (latitude 34°S).

The soybeans were germinated in acid washed sand moistened with 10 mM CaSO₄ and transferred to solutions when 10 days old. Eight seedlings were supported by foam plastic plugs in grey polyvinyl chloride covers over the solutions. The photoperiod was maintained at 16 h by incandescent lights providing a light intensity of 5.5 Wm⁻².

There were four treatments of Mn (as MnSO₄·H₂O) at 0, 1.8, 90 and 275 μM, and three levels of K (1, 6 and 10 mM). The experimental design was a 3 (potassium) x 4 (manganese) factorial with three replications. Additional potassium was added as KNO₃ and no attempt was made to keep the total nitrate concentration constant between treatments. However, the effects of varying KNO₃ levels are considered to be due to potassium alone because the basal level of nitrate (supplied as Ca(NO₃)₂) was 8 mM. Manganese additions to the basal solution were made one day after transplanting seedlings. Harvests were made at 14, 21 and 28 days after transplanting. Plants were separated into individual leaves (L₁, L₂ etc.), petioles, and stems and roots. Leaves were numbered from the bottom unifoliate (L₁) to the uppermost trifoliate. Hypocotyls were included in root dry weights and chemical analyses. Roots were immediately desorbed after harvest for 15 min in a solution of 0.1 M Ca(NO₃)₂ adjusted to pH 1.3 with HCl.

Plant material was dried in a forced-draught oven at 70°C for 48 h, digested in nitric/perchloric acid and analysed by atomic absorption spectrophotometry.

**RESULTS**

*Symptoms and growth*

Symptoms of toxicity (crinkle leaf and chlorosis) appeared on plants grown in 275 μM Mn solutions five days after application of high levels of Mn, irrespective of K supply. A significant reduction in dry matter yield in a solution of 275 μM Mn solutions.