Madras agric. J. 68 (4) : 260—265, April, 1981

Effect of Magnesium Concentration on Uptake of Nitrogen, Phosphorus, Potassium and Calcium by Intact Soybean Plants*

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The effect of a wide range of magnesium concentration (4.10×10^{-6} — 2.49×10^{-4} M) on the uptake and tissue content of nitrogen, phophorus, potassium and calcium in intact soybean (*Glycine max* (L.) Merr. cv. Amsoy) plants was studied under solution culture medium. A stimulatory effect of magnesium on the uptake and content of nitrogen and phosphorus was observed up to 86.5 μM followed by a slight decrease. Magnesium suppressed the uptake and content of calcium and potassium throghout the concentration range studied. A marked decrease was especially noted up to 86.5 μM. These results suggest the importance of balanced fertilization of soybean plants.

It was from the beginning of this century, the relationship between the substrate concentrations of plant nutrients in the external medium and their absorption and translocation by the plants has been considered as one of the prime factors in the study of plant physiological problems. Magnasium is considered to be one of the key factors in plant nutrition since each chlorophyll molecule contains one atom of magnesium. Most of the investigations on the uptake and translocation of divalent cations were concentrated on calcium and only few findings have been reported on magnesium (Leggett and Gilbert, 1969; Madhok and Walker 1969; Fageria, 1973). Many workers have reported that the rate of ion uptake is affected by the nature and level of counter ions present in the nutrient solutions (Fageria, 1973; white, 1973; Classen and Wilcox, 1974).

The vital process of ion absorption by plants necessarily involves the interaction of cations and anions (Leggett and Gilbert, 1969) and a proper balance has to be maintained for proportional uptake of cations as well as anions. However, only less attention has been paid to the study of interaction of several ions in the mineral nutrition of plants and the interactions are not fully undrstood (Epstein and Leggett, 1954; Lazaroff and Pitman, 1966; Rayar and Tang Van Hai, 1977).

The present investigation was aimed to study the inter-relationships between varying concentrations of magnesium ($4.10 \times -^{6}$ —— 2.49×10^{-4} M) in the nutrient solution and

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the uptake and accumulation of N, P, K and Ca by intact soybean plants.

MATERIAL AND METHODS

Seeds of soybean *Glycine max* (L.) Merr. cv. Amsoy) were germinated between paper towels. After three days of germination, five uniform and healthy seedlings were placed in plant support discs which were positioned in black three litre lucite vessels. The nutrient solution (Table) was continuously aerated and renewed every day so as to maintain the level of nutriente as constant as possible. Magnesium in concentrations from 4.10 to 249.10 μM, was added as $MgSo_4$, $7H_2O$. The pH of the nutrient solution was maintained at 5.5 ± 0.2. Growing of plants and the uptake experiments were done in a phytotron under the following conditions; day and night temperature 26 and 20 ± 1°C respectively; relative humidity 75 per cent Thirteen hours day light was provided with phototubes at an intensity of 16,000 lux at 20 cm above the bench level (Joseph, 1976).

When the plants were 20 days old, they were transferred to culture vessels through which the nutrient solution was passed at a flow rate of 110 to 115 ml/h. To determine the rate of uptake of NH_4, P and K, samples of the solution were taken before entering and after leaving the culture vessel, after attaining the equilibrium after 36 hours. The rate of uptake, expressed as $\mu g\ g^{-1}\ h^{-1}$ on root dry weight basis, was calculated as described by Tang Van Hai and Laudelout (1966).

TABLE Composition of the nutrient solution

Salt	Concentration μM
$(NH_4)_2SO_4$	714
KH_2PO_4	32
KCl	510
$CaCl_2.4H_2O$	500
Fe(EDTA)Na	0.9
H_3BO_3	5.0
$MnCl_2.4H_2O$	0.9
$ZnSO_4.7H_2O$	0.8
$CuSO_4.5H_2O$	0.03
H_2MoO_4	0.01

After the uptake experiments, the plants were harvested and dried at 105°C for 36 hours. A representative sample of ground plant material was digested with HNO_3, H_2SO_4 and $HCl\ O_4$ acid mixture (ratio 10:1:4) as described by Jackson (1973). Ammonium concentration in the nutrient solution and total N in the plant material was analysed by Kjeldhal method. Phosphorus concentration in the nutrient solution and in the plant material was determined by the chlorostannous molybdophosphoric blue colour method and that of potassium and calcium by

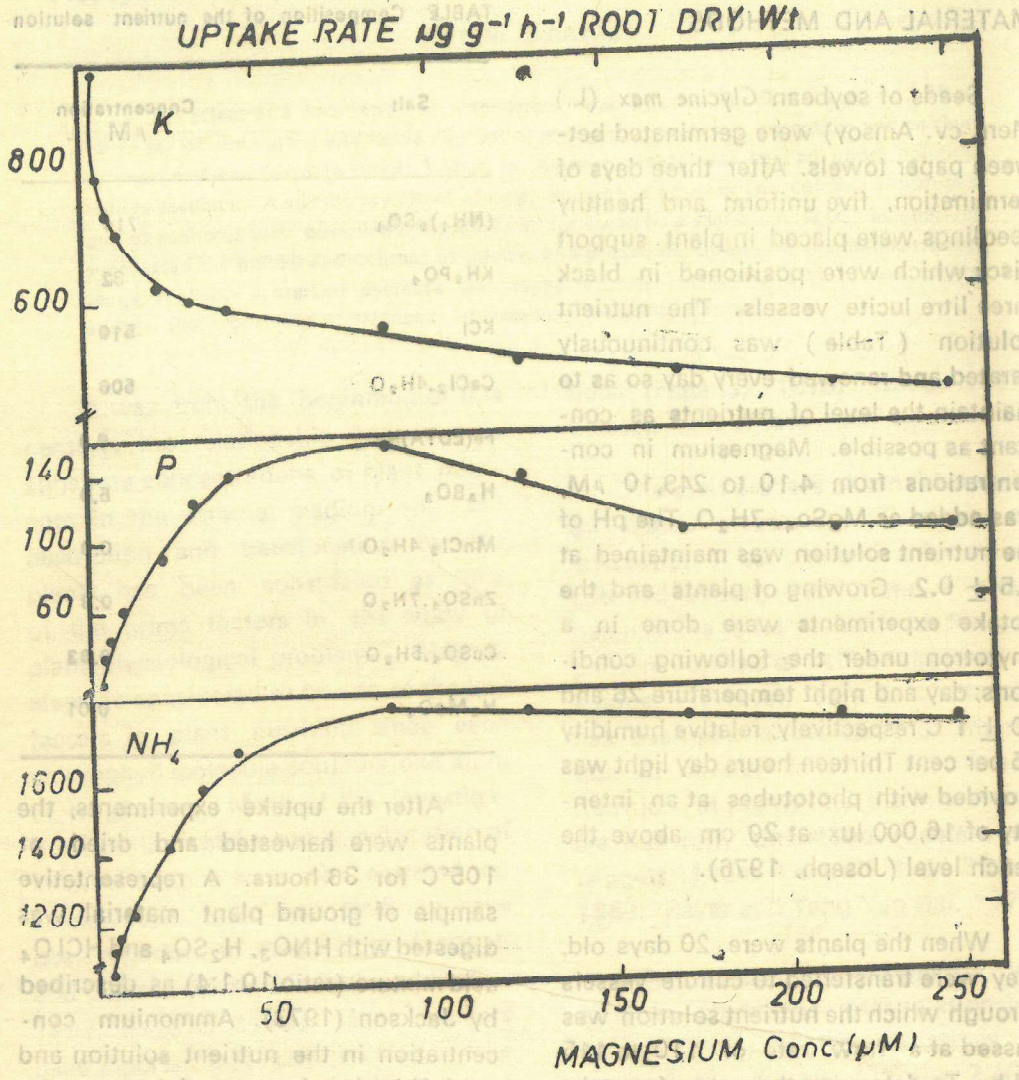

Figure 1 Effect of magnesium Concentration on the rate of uptake of NH_4,P and K by soybean plants.

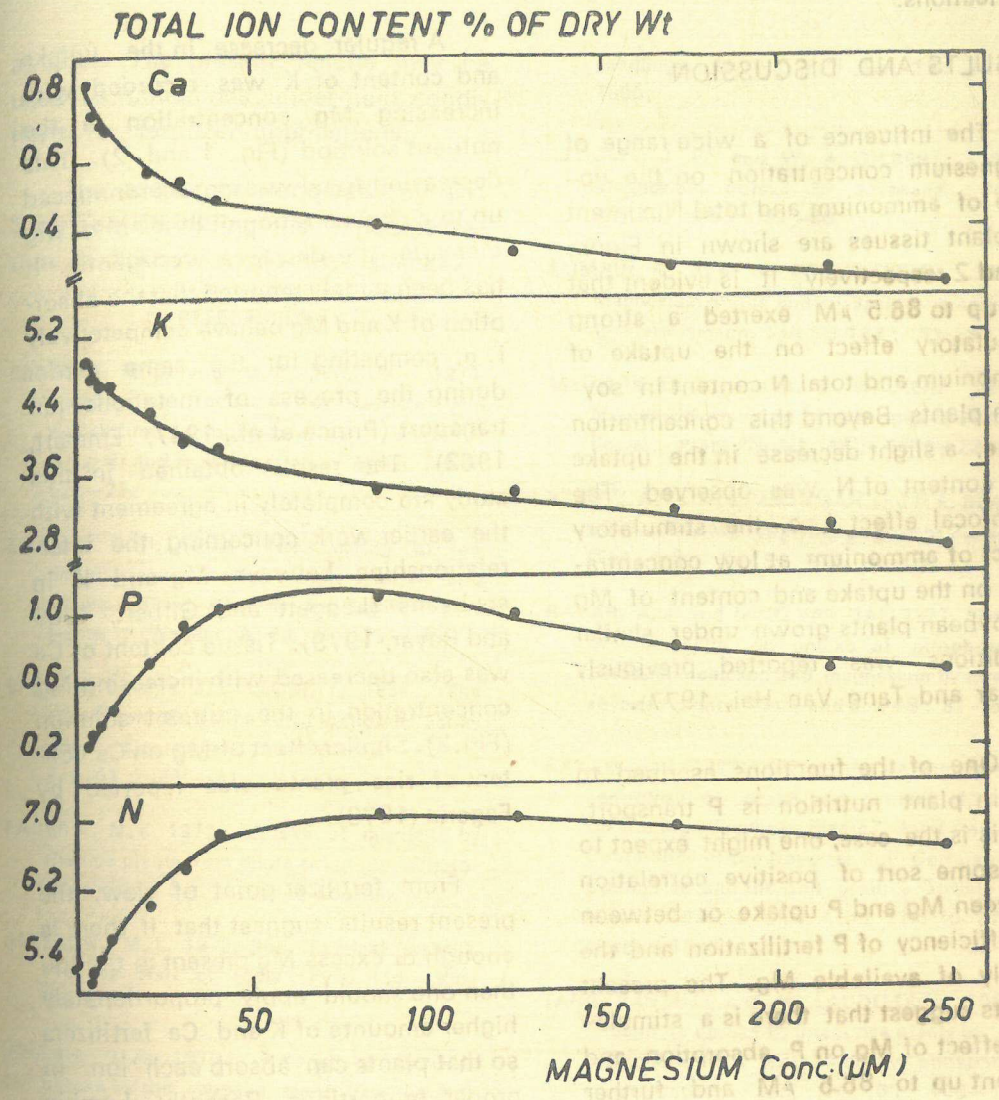

Figure 2 Effect of magnesium concentration on the content of N,P,K and Ca in soybean plants.

atomic absorption spectrophotometry. The results are the means of three replications.

RESULTS AND DISCUSSION

The influence of a wide range of magnesium concentration on the uptake of ammonium and total N content in plant tissues are shown in Figure 1 and 2 respectively. It is evident that Mg up to 86.5 μM exerted a strong stimulatory effect on the uptake of ammonium and total N content in soybean plants. Beyond this concentration range, a slight decrease in the uptake and content of N was observed The reciprocal effect i, e. the stimulatory effect of ammonium at low concentration on the uptake and content of Mg in soybean plants grown under similar conditions was reported previously (Rayar and Tang Van Hai, 1977).

One of the functions ascribed to Mg in plant nutrition is P transport. If this is the case, one might expect to find some sort of positive correlation between Mg and P uptake or between the efficiency of P fertilization and the supply of available Mg. The present results suggest that there is a stimulatory effect of Mg on P absorption and content up to 86.5 μM and further increase in Mg results in a decreasing trend (Fig.1 and 2). However, Fageria (1973) has reported a stimulatory effect of Mg up to 41.5 μM on the absorption and content of P in rice plants grown under similar conditions. Apparently this influence may be explained by the differences in plant species.

A regular decrease in the uptake and content of K was recorded with increasing Mg concentration in the nutrient solutiod (Fig. 1 and 2). This decreasing trend was more pronounced up to a concentration of 86.5 μM of Mg thereafter the decrease was gentle. It has been widely reported that the absorption of K and Mg behave competetively i. e. competing for the same carrier during the process of metabolic ion transport (Prince et al., 1947; Emmert, 1962). The results obtained in this study are completely in agreement with the earlier work concerning the interrelationships between Mg and K in soybeans (Leggett and Gilbert, 1969 and Rayar, 1979). Tissue content of Ca was also decreased with increasing Mg concentration in the nutrient solution (Fig,2). Similar effect of Mg on Ca content of rice plants was reported by Fageria (1973).

From fertilizer point of view, the present results suggest that if there is enough or excess Mg present in the soil then one should apply proportionately higher amounts of K and Ca fertilizers so that plants can absorb each ion in proper proportions. Recently, Lombin and Fayemi (1976) have also demonst rated that the availability of soil cations to crops may depend not only on the absolute quantities of these cations in the soil medium but also on their activities in soil solution relative to one

another. The present results may be used as guidelines under field conditions for fertilizer applications.

The assistance rendered by Dr. Tang Tan Hai during the experimentation is acknowledged with thanks.

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