Title

Studies on the dynamics of potassium and magnesium in okra (Abelmoschus esculentus Moench.)

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Introduction

Apart from the availability of adequate quantities of nutrients in the soil, it is also important to have a proper balance between the nutrient constituents present both in the soil and the plant. All the essential and other beneficial elements are involved in mutual interactions among themselves. Interaction between nutrient elements can be synergistic or antagonistic and the type of interaction is characteristic of the plant species (Emmert, 1961). Increasing the content of one cation in a plant usually decreases the content of other cations and the total cation equivalents are not greatly changed.

Application of potassium (K) to an inherently potassium deficient soil increases magnesium (Mg) deficiency due to the antagonism between these nutrients in plant and soil. Uptake of nutrients, particularly cations, is seriously influenced by potassium fertilization. Thus K has been shown to affect the absorption, translocation and distribution of other cations (Epstein, 1972). K and Mg also influences many of the processes that are important for the formation of yield in plants such as water economy, synthesis of carbohydrates and the transport of assimilates (Mengel and Kirkby, 1982).

The importance of vegetables in human nutrition is well known as it is a rich and comparatively cheap source of vitamins and minerals. Among vegetables, okra (*Abelmoschus esculentus* Moench.) occupies an important place on account of its tender green fruits. Hence a study was conducted to determine the interactions between K and Mg in plants using okra as the test crop.

Materials and Methods

A pot culture experiment was conducted at the College of Horticulture, Kerala Agricultural University, to study the effect of potassium - magnesium interaction in plants using okra (*Abelmoschus esculentus* Moench) as the test crop. The experiment was conducted on an alluvial soil, sandy clay in texture, acidic (pH 4.9), high in organic carbon, and medium in available P and K contents. The soil contained 2.92 c mol (+) kg^{-1} exchangeable Mg and 44 kg ha^{-1} available S.

The treatments included factorial combinations of four levels of potassium from K_0 to K_3 (0, 15, 30 and 45 kg K_2O ha^{-1} as muriate of potash) and four levels of magnesium from Mg_0 to Mg_3 (0, 10, 20 and 30 kg MgO ha^{-1}). These treatments were imposed on the crop along with the normal recommendation of nitrogen (N) and phosphorus (P) applied uniformly to all the treatments at the rate of 50 kg N and 25 kg K_2O ha^{-1} as per the Package of Practices Recommendations for Crops of the Kerala Agricultural University (KAU 1993). After the application of the treatments plant samples were taken to determine the effect of interactions between K and Mg on the yield and quality parameters of fruit and the nutrient uptake of the plant.

Results and Conclusions

The effects of potassium - magnesium interaction on the dry matter production, yield and quality attributes of the fruit are given in Table 1.

Dry matter production

Application of magnesium (Mg) at the rate of 10 kg ha^{-1} as $MgSO_4$ caused an increase in the dry matter production but a further increase in Mg caused a decrease in dry matter. The increase in the dry matter production by the addition of Mg at the lowest level may be due to an increase in photosynthetic activity induced by the application of Mg (Terry and Ulrich, 1974). But further increasing the Mg levels caused a decrease in the dry matter production. At all K levels combined with Mg application at 10 kg ha^{-1}, an increase was observed in dry matter production, while at higher levels of Mg a decrease was noticed.

Increasing K levels up to K_2 (30 kg K_2O ha^{-1}) significantly increased dry matter production but further increase caused a reduction probably because of the dilution effect due to the increase in fresh weight of the plant caused by an increase in water storage induced by high K levels but the dry matter production remaining low (Loue', 1985). The application of increased levels of K in the presence of low levels of Mg increased the dry matter production significantly but higher levels of Mg decreased the dry matter yield. The initial increase in dry matter production by Mg addition also implies that S assists increased dry matter production since Mg was applied as $MgSO_4$. Higher Mg application decreased dry matter production because above a certain level, growth of the plant is impaired since an excess of sulphur (S) contained in the plant is not metabolized to proteinaceous sulphur (Dhillon and Dev, 1980).

Though high rates of Mg addition markedly decreased the dry matter production, K uptake was not hindered (Table 2). Hence, reduction in growth was directly caused by excessive levels of Mg and not due to a K deficiency induced by excess Mg. Excess Mg may also interfere with the uptake of other nutrients like zinc (Zn) or manganese (Mn) thereby restricting plant growth (Fageria, 1983).

Fruit yield

Addition of Mg at moderate levels (10 kg ha^{-1}) along with K significantly increased the yield of okra fruits when compared to the treatments receiving K alone. Similar to the effect on dry matter production, Mg application only up to 10 kg ha^{-1} significantly increased yield. This effect was more pronounced when K was not added. The decrease in yield at K_0 was overcome by the addition of Mg up to Mg_2 (20 kg ha^{-1}) but further increasing the Mg level reduced the yield significantly. Thus Mg addition at moderate levels increased crop yield in the absence of K, whereas in the presence of each level of K, there was a decreasing trend in yield at higher levels of Mg.

Table 1. Dry matter production, fruit yield and quality attributes of okra as influenced by levels of potassium and magnesium

Treatment	Dry matter production (kg ha^{-1})	Fruit yield (kg ha^{-1})	Crude protein (%)	Crude fibre (%)	Ascorbic acid (mg 100 g^{-1})
NPK_0Mg_0	1048	6282	16.6	14.2	18.5
NPK_1Mg_0	1022	7070	19.1	13.9	19.0

NPK_2Mg_0	1073	7210	24.7	13.7	19.0
NPK_3Mg_0	1155	7490	26.5	13.23	19.3
NPK_0Mg_1	873	6720	14.6	13.6	19.1
NPK_1Mg_1	1129	7507	13.0	13.4	19.5
NPK_2Mg_1	1237	7560	16.1	13.4	20.0
NPK_3Mg_1	1244	7682	14.4	13.2	19.5
NPK_0Mg_2	950	6807	20.1	13.2	19.0
NPK_1Mg_2	975	7053	23.0	13.2	19.0
NPK_2Mg_2	987	7210	16.3	13.2	19.2
NPK_3Mg_2	945	6758	18.0	13.0	19.2
NPK_0Mg_3	999	6475	20.1	13.8	19.2
NPK_1Mg_3	1058	7070	12.3	13.7	19.2
NPK_2Mg_3	1122	7210	15.3	13.6	19.1
NPK_3Mg_3	1038	6475	18.3	13.4	19.3
CD**- K x Mg (0.05)	53	423	4.5	0.4	0.7
Levels of K					
K_0	9678	6571	17.9	13.7	19.0
K_1	1046	7175	16.8	13.5	19.2
K_2	1105	7297	18.1	13.5	19.2
K_3	1096	7101	19.3	13.2	19.3
CD-(0.05)	28	212	2.3	0.2	0.35
Levels of Mg					
Mg_0	1074	7013	21.7	13.8	19.0
Mg_1	1121	7367	14.5	13.4	19.5
Mg_2	964	6957	19.3	13.1	19.1
Mg_3	1054	6807	16.5	13.6	19.1
CD-(0.05)	27	212	2.3	0.2	0.35

CD** - Critical Difference

Increasing the level of K from K_0 to K_3 in the presence of low levels of Mg caused a progressive increase in the yield while at higher Mg levels increasing K reduced yield.

Crude Protein

Increased addition of K without Mg significantly increased the crude protein contents. This increasing trend was not observed when different levels of Mg were applied along with muriate of potash. Application of Mg generally decreased the crude protein content of harvested fruits.

Crude Fibre

Addition of Mg as $MgSO_4$ also caused a decrease in the crude fibre content. Increasing the rate of K application also progressively and significantly decreased the crude fibre. The magnitude of decrease was increased in the presence of Mg.

Ascorbic acid

Treatments receiving no fertilizers or only N and P without K significantly decreased the ascorbic acid content. A general increase in ascorbic acid content was observed as K levels increased. At all levels of Mg, as the K application rates increased, the ascorbic acid content also showed a significant increase. It was also noticed that sulphur uptake was positively and significantly correlated with the ascorbic acid content of fruits.

Nutrient uptake

The influence of levels of K and Mg on the uptake of nutrients is given in Table 2. Application of K at K_1 markedly increased the N uptake while a further increase did not show a significant increase. The interaction between K and Mg was found to be significant with the addition of Mg causing a significant increase in the N uptake at each level of K though the magnitude of increase diminished as levels of Mg increased. As the level of Mg application increased without K addition the N uptake was found to decrease.

Addition of increased levels of K increased the uptake of phosphorus. The application of high rates of Mg decreases the favorable effect of K on P uptake and hence Mg is seen to have an antagonistic effect on P uptake. This reduction of P uptake in spite of increased P availability might be due to the interference of sulphate ions on the absorption of P by the plant.

Increasing the rate of K application significantly increased the K uptake. As the level of Mg application increased the K uptake also showed a general increase, contrary to the reports that K and Mg are antagonistic. Thus Mg might have diminished only the solution concentration of K in soil and not the uptake. At higher levels of K, a significant increase in K uptake was noticed as Mg levels were increased.

Thus a positive interaction existed between K and Mg on the uptake of K. This increase in K in the tissue with increasing Mg might be because of the decreased dry matter production associated with high Mg.

Table 2. Nutrient uptake by okra as influenced by levels of potassium and magnesium

Treatment	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Ca (kg ha^{-1})	Mg (kg ha^{-1})	S (kg ha^{-1})
NPK_0Mg_0	25.5	2.3	11.1	26.8	11.7	1.9
NPK_1Mg_0	20.8	2.6	12.5	21.0	12.3	2.2
NPK_2Mg_0	15.9	3.5	12.2	21.5	14.7	1.8
NPK_3Mg_0	26.2	3.2	13.3	21.5	13.3	2.5
NPK_0Mg_1	18.2	1.9	9.2	23.0	19.7	2.1
NPK_1Mg_1	25.5	2.1	11.7	21.8	22.0	2.5
NPK_2Mg_1	23.7	2.5	12.3	21.2	22.0	2.6

NPK_3Mg_1	19.2	2.5	13.4	20.2	20.4	2.5
NPK_0Mg_2	19.7	2.0	10.1	19.9	21.1	2.1
NPK_1Mg_2	23.3	2.5	13.0	22.7	19.6	2.3
NPK_2Mg_2	22.5	2.3	14.5	18.5	20.5	2.4
NPK_3Mg_2	19.4	2.4	15.7	18.1	20.5	2.3
NPK_0Mg_3	19.4	2.4	9.6	21.3	21.8	2.2
NPK_1Mg_3	21.3	2.7	14.1	20.3	23.0	2.4
NPK_2Mg_3	27.8	2.6	14.9	18.9	21.1	2.4
NPK_3Mg_3	22.9	2.5	15.6	17.1	22.4	2.4
CD**- K x Mg (0.05)	3.4	0.3	1.5	3.4	2.4	0.3
Levels of K						
K_0	21.0	2.2	10.0	22.7	18.6	2.1
K_1	22.7	2.4	12.8	21.4	19.2	2.4
K_2	22.5	2.8	13.5	20.0	19.8	2.3
K_3	22.0	2.6	14.2	19.2	19.2	2.4
CD-(0.05)	1.7	0.15	0.8	1.7	1.2	0.2
Levels of Mg						
Mg_0	22.1	2.8	12.3	22.7	13.0	2.1
Mg_1	21.7	2.3	11.4	21.5	21.0	2.4
Mg_2	21.5	2.3	13.3	19.8	20.4	2.3
Mg_3	22.9	2.6	13.6	19.4	22.3	2.3
CD-(0.05)	1.7	0.15	0.8	1.7	1.2	0.2

CD** - Critical Difference

Calcium (Ca) uptake was significantly reduced with increasing K levels especially in the absence of Mg. Similar results were reported by Fageria (1983) who found an antagonistic effect of K application on Ca uptake. When applied with high levels of Mg, though higher levels of K caused a reduction in the Ca uptake, no significant decrease was generally obtained. Addition of increasing levels of Mg remarkably decreased the Ca uptake. The high Mg levels must have hindered the absorption of Ca by the plant due to the action of the Ca- Mg antagonistic effect. Such antagonism of Mg on the uptake of Ca was also reported by Kumar *et al*. (1981). It is also seen that the antagonistic effect of increased levels of Mg occurred only in the absence of K. The decrease in tissue concentration and uptake of Ca with increasing concentration of Mg is presumably due to the replacement of Ca by Mg for the neutralization of negative charges within the vacuole and on the exchange sites in the apoplast of the plant cell (Ananthanarayana and Rao 1979).

Though Mg uptake increases with its level of application, the presence of K especially at higher levels was found to decrease uptake by the crop. This may be because of an induced reduction in availability of Mg to the crop by the excess application of K, leading to less absorption of Mg by the plants. Thus, at higher Mg levels, by supplying additional excess levels of K, the antagonism of additional K is great enough to repress Mg absorption regardless of the Mg level. Thus at low soil K and sufficient exchangeable Mg levels, uptake of Mg is not hindered.

Increased addition of K and Mg generally increased the uptake of S. In the presence of a particular level of Mg, increasing the K levels did not bring about a significant variation in the S uptake.

References

Ananthanarayana, R. and Rao, B.V.V. 1979. Studies on dynamics of magnesium in soils and crops of Karnataka: II. Magnesium nutrition of groundnut. *Mysore J. agri. Sci.* **13**: 420- 425

Dhillon, N. S. and Dev, G. 1980. Studies on S nutrition of soybean (*Glycine max L.*) as influenced by S fertilization. *J. Indian Soc. Soil Sci*. **28**: 361-365

Emmert, F. H. 1961. The bearing of ion interactions on tissue analysis results. In *Plant Analysis and Fertilizer Problems*. *Am. Inst. Bio. Sci.* Washington, D. C. pp. 231- 243

Epstein, E. 1972. *Mineral nutrition of Plants-Principles and Perspective. John Wiley and Sons. Inc. New York.*

Fageria, N. 1983. Ionic interaction in rice plants from dilute solutions. *Pl. Soil* **70**: 309-316

KAU, 1993. *Package of Practices Recommendations- Crops*. Directorate of Extension, Kerala Agricultural University, Thrissur, Kerala, India.

Kumar, V., Bhatia, B. K. and Shukla, U. C. 1981. Magnesium and Zinc relationship in relation to dry matter yield and the concentration and uptake of nutrients in wheat. *Soil Sci.* **131**: 151- 155

Loue', A. 1985. Potassium and the sugarbeet. *Pot. Rev*. *11*: 30. International Potash Institute, Berne, Switzerland.

Mengel, K. and Kirkby, E. L. 1982. *Principles of Plant Nutrition* IPI, Switzerland p. 427- 453

Terry, N. and Ulrich, A.1974. Effect of magnesium deficiency on photosynthesis and response of leaves of sugar beet. *Plant Physiol*. **54**: 379- 381