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STUDIES ON INTERVENTION OF POTASSIUM IN MAGNESIUM NUTRITION AND ENHANCING NUTRIENT UPTAKE AND YIELD OF TOMATO (*SOLANUM LYCOPERSICUM* L.)

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Abstract

A field experiment on tomato was conducted to study interaction effects of applied Ca, Mg and K on yield, soil and plant nutrient levels in Alfisols of Karnataka. The results showed applied Mg increased yield of tomato up to 100 kg Mg ha^{-1}. The application of K produced significant change in yield. At lower levels of applied K the yield of tomato increased up to 100 kg Mg ha^{-1} and decreased at higher levels of Mg application. But at higher levels of applied K the yield response levels of applied Mg decreased. Magnesium and potassium also have antagonistic relations with respect to availability of one over the other and their effect on crop performance. Increased levels of Mg application increased the K content in plant, but decreased the Ca content in fruit and plant. Interaction effect was however non-significant on soil pH, EC, OC and soil N.

Key words : Tomato, potassium, magnesium, nutrient uptake.

Introduction

The importance of tomato crop is reflected by its large scale cultivation in the world. In the world, an area of 865 thousand ha is under tomato cultivation with a production of 16826 thousand M.T. Indian average productivity is 19.60 t ha^{-1}, which is half of the average of world's productivity. In tomato much area is covered under hybrid variety which gives an average of 3.4 kg fruit yield per plant. For this, soil should supply all the required nutrients for optimal growth. Thus nutrition management is very crucial for achieving higher productivity per unit area. In order to obtain optimum fruit yields, tomato requires at least twelve essential elements. They are N, P, K, Ca, Mg, S, B, Mn, Fe, Cu, Zn, Mo (Upndra *et al*., 2003). Among the secondary nutrients, magnesium plays vital role in fruit yield and quality of tomato.

Secondary and micro nutrient deficiency problems in India increased with application of N, P. and K fertilizers ignoring secondary and micronutrients (Shukla *et al*., 2009). Interpreted the Mitcherlich's law of physiological relationship, which suggests that higher the yield, more sensitive a crop becomes to nutrient imbalances. The intensification of agriculture created nutrient imbalance also increased lead to deficiencies of even the secondary nutrients like Mg. Potassium and Magnesium are cations, dominance of any one of them will decrease the availability of the other and decreases the uptake by the crops. They also had antagonistic relations with respect to availability of one over the other and their effect on crop performance.

Materials and Methods

The experiment was conducted at IIHR Hesaraghatta, Bangalore during the Rabi season of 2011-12. The experiment was laid out in split plot design with three replications. There were four levels of Mg as the main plot treatment and three levels of K as sub-plot treatment. The 12 treatment combinations are presented in table 1.

Tomato crop variety Arka Ananya (F_1) was transplanted at 100 cm × 60 cm after incorporation of fertilizers as per the treatments. The crop was grown up to maturity and fruits were harvested at regular intervals and yields recorded as sum total of all pickings.

Soil analysis

Soil samples were collected from each treated plots. These samples were analysed for pH, EC, OC, N, P, K, Ca and Mg. Analytical methods followed for the analysis of soil samples collected at three different stages are presented in table 2.

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Table 1 : Treatment details of magnesium and potassium interaction experiment.

Treatment	$N:P_2O_5:K_2O$ kg ha^{-1}	Mg (kg ha^{-1})	Equivalent quantity of $MgSO_4$ (kg ha^{-1}) applied	K_2O (kg ha^{-1})	Equivalent quantity of MOP (kg ha^{-1}) applied
T_1	180:150:120	0	0	0	0
T_2	180:150:120	0	0	100	166.66
T_3	180:150:120	0	0	250	416.66
T_4	180:150:120	50	514	0	0
T_5	180:150:120	50	514	100	166.66
T_6	180:150:120	50	514	250	416.66
T_7	180:150:120	100	1028	0	0
T_8	180:150:120	100	1028	100	166.66
T_9	180:150:120	100	1028	250	416.66
T_{10}	180:150:120	250	2570	0	0
T_{11}	180:150:120	250	2570	100	166.66
T_{12}	180:150:120	250	2570	250	416.66

Table 2 : Analytical methods followed for analysis of soil and plant samples.

S. no.	Parameters	Methodology	Reference
Soil Analysis			
1.	Mechanical Analysis	Hydrometer method	Piper (1966)
2.	pH (1:2.5)	Potentiometer method	Jackson (1973)
3.	Electrical conductivity (EC)	Conductivity method	Jackson (1973)
4.	Organic carbon	Walkley and Black's Wet oxidation	Jackson (1973)
5.	Cation exchange capacity	Leaching with ammonium acetate	Black (1965)
6.	Available nitrogen	Alkaline potassium permanganate method	Subbiah and Asija (1956)
7.	Available phosphorous	Molybdo phosphate blue colour method	Jackson (1973)
8.	Available potassium	Flame photometer method	Jackson (1973)
9.	NH_4OAc extractable calcium (PPM)	Versanate titration method	Black (1965)
10.	NH_4OAc extractable magnesium (PPM)	Versanate titration method	Black (1965)
Plant Analysis			
1.	Nitrogen	Micro Kjeldahl method	Jackson (1973)
2.	Phosphorous	Vanadomolybdo phosphoric method	Jackson (1973)
3.	Potassium	Flame photometer method	Jackson (1973)
4.	Calcium	Atomic absorption spectrophotometer method	Lindsay and Norwell (1978)
5.	Magnesium	Atomic absorption spectrophotometer method	Lindsay and Norwell (1978)

Plant analysis

The plant samples were partitioned into leaf, stem and fruit and washed. Weight of each plant was recorded separately and dried at 60^0C in a hot air oven. Samples were powdered and processed for estimation of nitrogen, phosphorous, potassium, calcium and magnesium using standard procedures. Analytical procedure followed for the analysis of plant samples are presented in table 2.

Statistical analysis

The data on various observations such as, yield, other parameters were tabulated and subjected to statistical analysis (Sundaraj *et al.*, 1972).

Results and Discussion

Fruit yield

Potassium and magnesium are cations, dominance of any one of them will decrease the availability of the other and decreases the uptake by the crops. They also had antagonistic relations with respect to availability of one over the other and their effect on crop performance. The date on yield of tomato hybrid as influenced by four levels of Mg and three levels of K and their interaction is presented in table 3. The combined application of Mg

Table 3 : Tomato (Arka Ananya) yield (t ha^{-1}) as influenced by interaction of effects of magensium with potassium.

Treatments	Yield (t ha^{-1})			
	K_1 (0 kg K ha^{-1})	K_2 (100 kg K ha^{-1})	K_3 (250 kg K ha^{-1})	Mean
Mg_1 (0 kg Mg ha^{-1})	57.71	66.23	66.19	63.38
Mg_2 (100 kg Mg ha^{-1})	74.15	84.39	82.85	80.46
Mg_3 (150 kg Mg ha^{-1})	73.64	79.31	69.01	73.99
Mg_4 (200 kg Mg ha^{-1})	70.73	71.97	64.84	69.18
Mean	69.06	75.48	70.72	71.75
	S. Em±		C.D at 5%	
Mg	2.194		7.593	
K	1.244		3.731	
Mg × K	2.489		7.463	

Table 4 : Interaction effects of different levels of magnesium and potassium on soil nutrients.

Treatment	pH	EC (dsm^{-1} at 25^0c)	OC (%)	Soil N (kg ha^{-1})	Soil P (kg ha^{-1})	Soil K (kg ha^{-1})	Soil Ca ppm	Soil Mg ppm
Mg_1K_1	5.82	0.38	0.64	125.29	7.81	119.3	479.2	124.2
Mg_1K_2	5.83	0.40	0.65	124.60	7.68	114.4	451.6	169.8
Mg_1K_3	5.82	0.39	0.67	125.11	7.46	106.9	438.2	202.9
Mg_2K_1	5.85	0.41	0.68	123.60	7.34	101.8	406.3	227.1
Mg_2K_2	5.83	0.39	0.67	123.82	7.83	122.0	493.0	129.6
$Mg2K_3$	5.84	0.40	0.66	125.36	7.72	118.6	466.4	185.7
Mg_3K_1	5.84	0.42	0.66	125.59	7.50	112.4	421.7	214.5
Mg_3K_2	5.83	0.43	0.67	124.74	7.41	105.9	398.5	241.8
Mg_3K_3	5.81	0.40	0.67	124.24	7.89	125.1	513.8	141.8
Mg_4K_1	5.82	0.39	0.67	126.23	7.81	120.8	475.1	197.6
Mg_4K_2	5.83	0.43	0.68	123.98	7.69	117.1	409.5	229.8
Mg_4K_3	5.84	0.43	0.68	124.32	7.63	111.5	380.4	263.6
S.Em+								
Mg	NS	NS	NS	NS	1.72	1.72	09.8	6.34
K	NS	NS	NS	NS	2.09	2.09	NS	6.80
Mg × K	NS	NS	NS	NS	2.36	2.36	12.1	8.36
CD at 5%								
Mg	NS	NS	NS	NS	5.16	5.16	29.36	19.00
K	NS	NS	NS	NS	6.26	6.26	NS	20.37
Mg × K	NS	NS	NS	NS	7.07	7.07	36.2	25.04

and K significantly enhanced the yield of tomato. The yield of tomato increased with increasing of levels of K application. However at higher levels of K application fruit yield decreases with increased levels of Mg application. The lowest mean yield of 63.38 t ha^{-1} was observed in Mg_1 (0 kg Mg ha^{-1}) application and the highest mean yield of 80.46 38 t ha^{-1} was obtained at Mg_2 (100 kg Mg ha^{-1}). A combination of Mg_2 (100 kg K ha^{-1}) and K_2 (100 kg K ha^{-1}) resulted in recording highest of yield of 84.39 t ha^{-1} on the other hand control plot (0 kg ha^{-1}

Mg and K application) produced lowest yield of 57.71 t ha^{-1}. Ananthanarayana and Hanumantharaju (1992) reported antagonism between Mg and K and stated that it could be due to differences in their ionic mobility. Thus, it is evident that these nutrients need to be applied in certain combination to achieve maximum yield and quality in tomato. Antagonism between K and Mg was also observed by Kolota and Osloeski (1984) wherein they reported good plant growth and highest yield from the plants receiving K_2O and Mg each at 400 mg per plot. Mg had a synergetic effect up to a K concentration of 20 ppm and antagonistic at 40 ppm Mg in cowpea. Similar results were reported by Rani and Jose (2009).

Interaction of Mg and K on soil and plant nutrients

Soil properties

Combined application of Mg and K did not have any significant effect on either soil pH or EC. This is because the levels of both Mg and K used in this study were small to cause any such effect. The Similar results was observed in soil organic matter content also.

Application of Mg and K did not have any significant influence on soil available N. With increasing applied Mg levels the mean available N content did not show any trend, but gave an indication of decrease. The available N content remained at124 kg N ha^{-1} as the level of applied K increased. The lowest available N of 123.60 kg N ha^{-1} was recorded in Mg_2 (50 kg Mg ha^{-1}) K_1(0 kg K ha^{-1}) treatment. Subramanian *et al.* (1976) reported an increase in uptake of N and P and increase in the yield of groundnut. Adams *et al.* (1978) reported maximum yield of tomato when the nutrient content in leaves was 4.5-5.1 per cent N, 4.4-5.6 per cent K and 0.31-0.40 per cent Mg. They found that Mg content of 250 mg l^{-1} was fully adequate for obtaining optimum yields. The soil available P content was significantly influenced by the application of Mg and K. Interaction effects of applied Mg and K resulted in decreasing the soil available P from 7.81 kg P ha^{-1} in Mg_1 (0 Mg kg ha^{-1}) K_1 (0 K kg ha^{-1}) to 7.34 kg P ha^{-1} in Mg_2 (50 kg Mg ha^{-1}) K_1(0 kg K ha^{-1}) treatment. Subramanian *et al*. (1976) showed that as the level of Mg is increased the uptake of N and P increased the yield in groundnut. The application of Mg and K together had significant influence on soil available K. The available K content decreased with increasing level of application of Mg. The lowest available K of 101.8 kg K ha^{-1} was recorded in Mg_2 (50kg Mg ha^{-1}) K_1 (0kg K ha^{-1}) treatment on the other hand the highest available K of 125.1 kg K ha^{-1} was recorded in Mg_3(100kg Mg ha^{-1}) K_3(250kg K ha^{-1}) treatment. These results indicate an antagonism between Mg and K availability in the soil. As level of Mg is increased then Mg will try to occupy exchangeable K from the soil surface and vice versa. As reported by Ananthanarayana and Hanumantharaju (1992), antagonism between Mg and K could be due to differences in their ionic mobility. Higher K concentration in nutrient solution resulted in Mg deficiency in plant tissue (Jones, 1999) and also vice-versa. Kirkby and Mangel, (1976) reported that high Mg concentration in soil or plant is due to poor status of K in soil. Sonneveld (1987) observed on tomato that Mg deficiency symptoms reduced due to high and low K/ Ca elements in the nutrient solution. A high K level was effective in reducing in Mg content of spinach when Mg level was high, but no effect when Mg level was low (Hohlt and Maynard, 1966). This suggests that cation interactions are more intense at high concentrations than at low ones.

Combined application of Mg and K resulted in non significant change in soil Ca was observed by the application of different combinations of Mg and K. But the trend indicated that with increasing applied Mg levels the exchangeable Ca content decreased. The combined application of Mg and K resulted in decreasing the soil exchangeable Ca from 479.2 ppm in Mg_1(0kg Mg ha^{-1}) K_1(0kg K ha^{-1}) to 380.4 ppm in Mg_4 (250kg Mg ha^{-1}) K_3 (250kg K ha^{-1}) treatment. Similar to calcium, magnesium also have antagonistic relationship with potassium The combined application of magnesium and potassium resulted in significant change in the soil magnesium content. The control plot where no K and Mg was applied given 124.2 ppm soil magnesium, on the other hand Mg content of 263.6 ppm was recorded by Mg_4 (250kg Mg ha^{-1}) K_3 (250kg Mg ha^{-1}) K_3 (250kg K ha^{-1}) combinations. At very high concentration, Mg^{2+} will suppress K^+ uptake at the exchange site. Research has shown that a K-Mg imbalance can be corrected by increasing the concentration of the deficient nutrient. Additions of potassium on cotton, in high magnesium and sufficient potassium soils, give a positive growth response. He also noted that high potassium fertility can reduce plant magnesium in low magnesium soils (Bhargava and Raghupathi, 1997). Grape leaves with a potassium magnesium ratio of 1:3 were scorched and dying while leaves with a ratio of 1:1 showed significantly less symptoms. Research with coffee has shown that antagonism can be cultivar dependent (table 4).

Interaction of Mg and K on plant nutrient content

Applications of combined levels Mg and K showed significant changes in plant nutrients (table 5). In fruits in general plant N content decreased with increased level of Mg and K application. The interaction of Mg and K

Table 5 : Interaction effects of different levels of magnesium and potassium on plant nutrients.

Treatment	Plant N (%)		Plant P (%)		Plant K (%)		Plant Ca (%)		Plant Mg (%)	
	Fruits	Leaf & stem	Fruits	Leaf & stem	Fruits	Leaf & stem	Fruits	Leaf & stem	Fruits	Leaf & stem
Mg_1K_1	2.54	2.10	0.16	0.09	4.63	1.37	2.44	2.70	0.39	0.94
Mg_1K_2	2.63	2.52	0.19	0.13	4.57	1.32	2.02	2.69	0.42	0.97
Mg_1K_3	2.70	2.14	0.17	0.19	4.40	1.29	1.56	2.56	0.46	1.19
Mg_2K_1	2.54	2.43	0.18	0.18	4.10	1.05	1.14	2.32	0.48	1.22
Mg_2K_2	2.46	2.47	0.18	0.13	4.85	1.49	2.07	2.68	0.34	0.88
$Mg2K_3$	2.47	2.19	0.20	0.15	4.66	1.53	1.86	2.58	0.40	0.90
Mg_3K_1	2.64	2.43	0.18	0.10	4.60	1.81	1.40	2.51	0.42	1.11
Mg_3K_2	2.40	2.35	0.19	0.10	4.31	2.10	1.05	2.26	0.42	1.06
Mg_3K_3	2.58	2.35	0.19	0.13	5.06	1.86	1.70	2.51	0.31	0.84
Mg_4K_1	2.53	2.51	0.17	0.13	4.94	1.92	1.41	2.54	0.36	0.85
Mg_4K_2	2.52	2.69	0.16	0.14	4.88	2.03	1.22	2.42	0.41	1.06
Mg_4K_3	2.36	2.10	0.17	0.11	4.59	2.26	1.01	2.14	0.38	1.02
S.Em+										
Mg	0.060	0.053	0.003	0.003	0.126	0.058	0.127	0.059	0.054	0.019
K	0.045	0.041	0.006	0.005	0.113	0.031	0.170	0.053	0.029	0.016
Mg x K	0.092	0.086	0.012	0.010	0.226	0.062	0.340	0.106	0.058	0.033
CD at 5%										
Mg	0.211	0.186	0.013	0.013	0.436	0.200	0.442	0.205	0.189	0.066
K	0.140	0.125	0.018	0.016	0.340	0.093	0.510	0.159	0.087	0.050
Mg × K	0.276	0.258	0.036	0.032	0.680	0.186	1.020	0.319	0.174	0.101

resulted in lowest fruit N content of 2.36 per cent in Mg_4 (250kg Mg ha^{-1}) K_3(250kg K ha^{-1}) treatment. Similar trend was seen in leaf and stem N content also. With increasing applied Mg levels the fruit and plant P content showed increasing trend. The interaction of Mg and K resulted in lowest fruit P content of 0.16 per cent in Mg_4 K_2 and Mg_1 K_1 treatments and maximum 0.19 per cent was observed in three combinations. Magnesium is found to increase the uptake of N and P and increase the yield in groundnut as reported by Subramanian *et al.* (1975), Adams *et al.* (1978) studied in tomato on a peat substrate and found that maximum yields were obtained when the nutrient content in leaves was 4.5 – 5.1 per cent N, 4.4-5.6 per cent K, 0.31 – 0.40 per cent Mg. It was focused that Mg content of 250 mg l^{-1} was fully adequate for obtaining optimum yields.

Plant K, Ca and Mg showed a negative interaction, with increasing one element leading to decrease of the other. Application of K increased the K content of fruits and plant. The lowest fruit K of 4.10 per cent was recorded in Mg_2 K_1 treatment. On the other hand, the highest fruit K of 5.06 per cent was recorded in Mg_3K_3 treatment. In plant K content varied between 1.05 to 2.26 per cent. In fruit calcium content varied between 1.01 to 2.44 per cent. As the level of Mg and K application increased plant Ca content decreased . similar trend was observed in leaf and stem. In fruit lowest magnesium content was observed 0.31 per cent Mg_3K_3 treatment and the highest of 0.48 per cent was found in Mg_2K_1 treatment. The same trend was observed in plant Mg content.

Conclusion

The results showed applied Mg increased yield of tomato up to 100 kg Mg ha^{-1}. The application of K produced significant change in yield. At lower levels of applied K the yield of tomato increased up to 100 kg Mg ha^{-1} and decreased at higher levels beyond 100 kg. Interaction was also negative between Mg and K only at higher levels of Mg and K and at lower levels it was synergistic. Magnesium and potassium also has antagonistic relations with respect to availability of one over the other and their effect on crop performance. Combined application and Mg and K did not have significant effect on pH, EC, OC and soil N content and significant differences were found in soil P, K and Mg contents. Different combinations of K and Mg application resulted in significant differences in plant and fruit content of N, P, K, Ca and Mg. It is evident from the study antagonism exists between K, Ca and Mg thus optimum quantity of these nutrients to be added to soil for obtaining better fruit yield in hybrid tomato.

References

Adams, P., J. N. Davies and G. W. Winsor (1978). Effects of nitrogen, potassium and magnesium on the quality and chemical composition of tomatoes grown in peat. *J. Hort. Sci.*, **53 :**115-122.

Ananthanarayana, R. and T. H. Hanumantharaju (1992). *Interactions of Ca and Mg with other plant nutrients*. In: H.L.S Tandon (Ed).

Black, C. A. (1965). Methods of soil analysis part-II. Agronomy Monograph, *Amer. Soc. Agron.,* Maidson, Wisconsinn, USA Soil Analysis.

Bhargava, B. S. and H. B. Raghupathi (1997). Current status and new norms of magnesium for grapevines. *J. Indian Soc. Soil Sci*., **45** :120-123.

Hohlt and Maynard (1966). Magneisum nutrition of spinach. *Proc. Amer. Soc. Hort. Sci.,* **89** : 478-482.

Jackson, M. L. (1973). *Soil chemical analysis*. Prentice Hall of India Private Limited, New Delhi, pp: 498.

Jones, J. B. (1999). *Tomato plant culture: in the field, green house and home garden*. CRS Press, LLC Florida, pp: 11-53.

Kirkby and Mangel (1976). The role of magnesium in plant nutrition. Pflanzenerth. *U. Bodenkde*, **2** : 209-222.

Kolota and Osloeski (1984). The influence of potassium and magnesium fertilization on growth yield and mineral nutrition of green house tomatoes. *Biuletyn Warzywniczy*, **27** : 301-315.

Lindsay and Norwell (1978). Development of a DTPA Soil test for zinc, iron, manganese and copper. *Soil Sci. Soci. of American J.*, **42** : 421-428.

Piper, C. S. (1966). *Soil Chemical Analysis*, Prentice Hall of India Pvt. Ltd., New Delhi.

Rani and Jose (2009). *Studies on the dynamics of magnesium and potassium in okra*. On proceedings of the international plant nutrition colloquium XVI paper 1255. University of California USA.

Shukla, A. K., B. S. Dwivedi, V. K. Singh and M. S. Gill (2009). Macro role of micronutrients. *Indian J. Fert*., **5** :11-30.

Sonneveld (1987). Magnesium deficiency in rockwool-grown tomatoes as affected by climatic conditions and plant nutrition. *J. Plant Nutrition*, **10(9-16)** : 1591-1604.

Subbaiah, B. V. and G. L. Asija (1956). A rapid procedure for the estimation of available nitrogen in soils. *Curr. Sci*., **25** : 259-260.

Subramanian, R. M., T. S. Manickam and K. K. Krishnamoorthy (1976). Studies on the effect of magnesium on the yield and quality of groundnut (pol 1) on two red soils of Tamil Nadu. *Madras Agril. J*., **63** : 81-84.

Sundaraja, N., M. N. Nagaraju, Venkataramu and M. K. Jaganath (1972). *Design and analysis of field experiments*, U.A.S. and Biostat-I.I.H.R., Bangalore .

Upendra, M., Sainju Ramdane Dris and B. Singh (2003). *Mineral nutrition of tomato Training Report*, Thailand, Pp:325-327.