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Effect of magnesium on plant growth, dry matter and yield in tomato (*Lycipersicon esculentum* L.)

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ABSTRACT

A field experiment was conducted on magnesium nutrition in tomato hybrid Arka Ananya at ICAR-IIHR, Bengaluru, for two years. Graded application of magnesium produced significant difference in fruit yield in tomato among treatments. The yield increased upto 50kg Mg ha^{-1} application, and decreased beyond this dose. Yield parameters like number of fruits per plant and fruit weight recorded results similar as that of yield. Growth parameters like number of branches and plant-height followed a similar trend. Growth and yield parameters were found to be well correlated with yield. Treatment T3 (50kg Mg ha^{-1}) recorded significantly higher plant height, number of branches, fruit number, fruit weight and fruit yield over the Control, T_1, where no magnesium was applied. Yield increase of 29% can be achieved with magnesium application (50kg Mg ha^{-1}) in tomato during winter season.

Key words: Tomato, growth parameters, magnesium, dry matter, fruit yield

INTRODUCTION

The primary cause of low productivity is an imbalanced use of plant nutrients which may deplete mineral elements in the soil (Ganeshamurthy and Hegde, 1980). Nambiar and Abrol (1989) reported that application of N alone increased soil-depletion of other nutrients including Ca, Mg and S. Secondary and micronutrient deficiency in soil increases due to increased application of N, P and K fertilizers (Shukla *et al*, 2009). Further, soil factors like organic matter content, texture, pH, EC and drainage, and, interaction of mineral elements, limit the availability of nutrients. To meet the dietary requirements of a growing Indian population, efforts have been made to increase crop yields per unit area through release of new varieties/hybrids: these require better nutrition management to obtain optimal yields.

Tomato is an important vegetable crop cultivated under open or controlled conditions. It serves as a daily component of our diet and is also an important source of minerals, vitamins, iron and antioxidants (Grierson and Kader, 1986). To obtain high yield levels in new tomato hybrids, advanced precision-farming practices need to be standardized, including nutrient management. Tomato is one of the main crops grown in recent years in peninsular India, where, Alfisols are predominant and are low in pH. Lately, in this region, magnesium deficiency in commercial hybrids of tomato has been found to be a major constraint in achieving desirable yields and quality. Hybrid tomatoes with a high yield potential have a very high demand for magnesium, and, are vulnerable to magnesium deficiency in soil. Reduction in productivity may be due to a reduced biomass production, and lesser biomass allocation to the fruit. Effects of mineral nutrients on biomass partitioning help understand the mechanism of their influence on fruit yield. Efforts have been made to increase quality and yield through adequate supply of secondary nutrients, especially, magnesium and calcium. In general, greenhouse grown tomatoes with 0.4% Mg in leaf dry-matter indicate a critical concentration of this nutrient. Mg deficiency in tomato is first noticed in older leaves (which become abnormally thin), and inter-venal chlorosis starts appearing. In advanced stages of deficiency, leaves become purplish-red and brittle, with a tendency to curl upward. Rockwool grown tomato (50-80 ppm of Mg in the nutrient solution) results in the best yield and quality. In a field experiment, 54kg Mg ha^{-1} increased tomato yield by 27.9% (Osman and Wilcox, 1985). In soils with exchangeable Mg of lower than 0.5c mol (P+) kg^{-1}, magnesium application to soil elicited a good response in many crops (Ganeshamurthy and Hegde, 1980). So as to achieve the high yield potential in tomato hybrids, an attempt has been made in the present study, to assess magnesium requirement in the hybrid 'Arka Ananya'.

MATERIAL AND METHODS

The experiment was conducted at ICAR-Indian Institute of Horticultural Research, Hesaraghatta, Bengaluru, for two years during the winter season of 2010-11 and 2011-12. Initial soil-chemical properties and available nutrient status in the field selected for conducting the experiment were: pH 6.14, EC 0.74 dsm^{-1}, OC 0.74, N 119.88 ppm, P 3.51 ppm, K 731.20, Ca 158 ppm and Mg 61.6 ppm. The experiment was laid out in Randomized Block Design, with three replications and five treatments, viz., T_1 - Control (RDF), T_2- RDF+$MgSO_4$ (25kg ha^{-1}), T_3 - RDF+$MgSO_4$ (50kg ha^{-1}), T_4 - RDF+$MgSO_4$ (75kg ha^{-1}) and T_5 - RDF+$MgSO_4$ (100kg ha^{-1}). The recommended dose of fertilizer (RDF) for tomato, 180:150:120 kg NPK kg ha^{-1}, was applied to all the treatments in the form of ammonium sulphate, single super-phosphate (SSP) and muriate of potash, respectively. Full dose of P and K was applied as soil application. Only nitrogen was applied in three splits, viz., 50% RDF at planting, 25% at 25 days after transplanting, and the remaining 25% RDF at 50 days after transplanting. Magnesium dose was applied in the form of magnesium sulphate ($MgSO_4.7H_2O$) (Table 1).

Table 1. Quantity of $MgSO_4$ applied for supplying different doses of magnesium

Treatment	Treatment levels of magnesium (kg ha^{-1})	Quantity of $MgSO_4$.7H2O applied (kg ha^{-1})
T_1 (Control)	0	0
T_2	25	257
T_3	50	514
T_4	75	771
T_5	100	1028

Tomato hybrid *Arka Ananya* was transplanted at a spacing of 100cm x 60cm. Fruits were harvested in 10 pickings, and weight of the fruits from each plant was recorded separately. Growth and yield parameters, viz., plant height, number of branches plant^{-1}, total number of fruits, mean fruit-weight (g fruit^{-1}) and fruit yield (t/ha^{-1}) were recorded.

Total dry matter production was determined by collecting the entire plant; fruits were collected separately at the final harvest-stage. Fresh weight was evaluated and the samples were sun-dried, and then again dried in a hot air oven at 65-70^{0}C. Dry weights of the entire plant and the fruit were recorded individually and expressed as total fresh/ dry matter produced (kg ha^{-1}).

Data on yield and quality parameters were subjected to statistical analysis as per Sundaraja *et al* (1972).

RESULTS AND DISCUSSION

Growth parameters

Plant height and number of branches

Application of different levels of magnesium during the two-year field experiment to tomato resulted in significant changes in plant height and number of branches during all stages of the crop (Table 2). At pre-flowering stage, tallest plants (53.45cm) and maximum number of branches per plant (6.43) were found in T_3 (50kg Mg ha^{-1}), while, the shortest plants (48.98cm) and fewest branches (5.73) were seen in the Control (0kg Mg ha^{-1}) at pre-flowering. Lowest numbers of branches plant-1 (5.54) were observed in the Control plot where no magnesium was applied during the flowing stage. At flowering, maximum plant height (67.88cm) was observed in T_4 (75kg Mg ha^{-1}), and the highest number of branches plant^{-1} (6.10) was found in T_3 (50kg Mg ha^{-1}); lowest values were recorded in the Control

Table 2. Effect of magnesium in tomato hybrid Arka Ananya on two-year mean plant height (cm), number of branches and dry matter (kg ha^{-1}) accumulation at various stages of plant growth

Treatment	Pre-flowering stage		Flowering stage		Harvest stage		Total biomass (kg ha^{-1})	
	Plant height (cm)	Number of branches/ plant	Plant height (cm)	Number of branches	Plant height (cm)	Number of branches	Fresh weight	Dry weight
T_1 (Control) (0kg Mg ha^{-1})	48.98	5.73	62.45	5.54	66.00	4.73	5853.34	958.84
T_2 (25kg Mg ha^{-1})	51.03	6.05	63.53	5.69	67.20	4.88	6752.17	1225.34
T_3 (50kg Mg ha^{-1})	53.45	6.43	66.85	6.10	70.12	5.30	7541.51	1337.50
T_4 (75kg Mg ha^{-1})	50.83	6.08	67.88	6.00	69.12	5.22	6666.67	995.50
T_5 (100kg Mg ha^{-1})	50.054	6.13	67.43	5.97	69.28	4.96	7373.50	1156.34
S.Em±	1.24	0.27	1.77	0.29	1.62	0.29	461.99	100.32
C.D. *(P=0.05)*	4.03	0.89	5.77	0.95	5.30	0.95	1506.94	325.52

plot. At harvest, Control plot recorded minimum plant height (66cm) and number of branches (4.73). On the other hand, T_4 treatment (75kg Mg ha^{-1}) showed maximum plant height (70.12cm) and number of branches (5.30). In general, it was application of magnesium increased plant height and number of branches per plant up to 75kg Mg ha^{-1}, and these were positively correlated to fruit yield. In a pot culture experiment, Agbede and Aduayi (1980) found application of 80ppm Mg as recording maximum plant height. Similar results were found by Jean Aghofack Nguemezi and Tatchago (2010) too (Table 2).

Dry matter production (kg/ha)

Application of graded magnesium to the tomato crop resulted in significant difference in dry matter production (Table 2). Highest dry matter content (7541.51kg ha^{-1}) was found in T_3 (50kg Mg ha^{-1}) while, the lowest (5853.34kg ha^{-1}) was observed in the Control, T_1 (0kg Mg ha^{-1}). Magnesium application recorded increased dry matter production at all the levels over the Control. Similar results in tomato were reported by Xiuming Hao and Papadopoulos (2004).

Yield and yield parameters

Number of fruits and mean fruit-weight

Pooled analysis of data for the two years showed that applied Mg content significantly increased per plant (Table 3). Maximum number of fruits per plant was harvested in T_3 (50kg Mg ha^{-1}) (47.42), while, the lowest number of fruits was harvested in T_5 (100kg Mg ha^{-1}) (39.53). This indicates that with increase in level of Mg up to 50kg Mg ha^{-1}, number of fruits per plant increased significantly. Further increases in Mg level did not influence number of fruits. Pooled analysis of data for the two years on mean fruit-weight showed that applied Mg significantly influenced fruit-weight. Maximum fruit weight was found in T_3 (50kg Mg ha^{-1}) (78.91g $fruit^{-1}$), while, the Ccontrol (0kg Mg ha^{-1}) recorded lowest fruit weight (60.63g $fruit^{-1}$).

Table 3. Effect of various levels of magnesium in cultivation of tomato hybrid Arka Ananya on pooled mean yield attributes

Treatment	Total no. of fruits $plant^{-1}$	Mean fruit weight (g $fruit^{-1}$)	Fruit yield (t ha^{-1})
T_1 (Control) (0kg Mg ha^{-1})	39.66	66.63	60.09
T_2 (25kg Mg ha^{-1})	42.14	75.93	73.92
T_3 (50kg Mg ha^{-1})	47.42	78.91	78.01
T_4 (75kg Mg ha^{-1})	41.68	77.80	68.12
T_5 (100kg Mg ha^{-1})	39.53	76.45	67.80
S.Em±	2.41	1.15	1.93
C.D. *(P=0.05)*	7.86	3.78	6.310

Number of fruits and fruit-weight increased upto application of 50kg Mg ha^{-1}, and then, decreased. These yield parameters correlated well with fruit-yield. Bombita Nzanza (2006) too in a study on Ca , K and Mg nutrition in tomato observed that the number of fruits decreased at a high Ca:Mg ratio, with similar results in fruit-weight as well. Micaela Carvajal *et al* (1999), in a study on Mg nutrition in tomato, also found yield reduction to be associated with number of fruits per plant. Similar results were reported by Cerda *et al* (1970).

Fruit yield

Total mean-yield of tomato fruits differed significantly among treatments during the two years of experimentation (Table 3). Mg applied as $MgSO_4$ @ 50kg ha^{-}1 significantly enhanced fruit yield. Application of higher levels of Mg decreased fruit yield, but yield levels here were significantly higher than in plots without Mg application (T_1-Control). Lowest tomato yield was observed in the Control treatment (60.09t ha^{-1}). On the other hand, highest yield was observed in T_3- RDF+$MgSO_4$ 50kg ha^{-1} (78.01t ha^{-1}), which was on par with T_2-RDF+$MgSO_4$ 25kg ha^{-1} (73.92t ha^{-1}), followed by T_4-RDF+$MgSO_4$ 75kg ha^{-1} (68.12t ha^{-1}) and T_5-RDF+$MgSO_4$ 100kg ha^{-1} (67.80t ha^{-1}).

Tomato responded significantly to Mg applied in terms of fruit yield, number of fruits and fruit-weight. As the level of Mg applied increased, total yield, number of fruits $plant^{-1}$ and mean fruit-weight increased, attaining a maximum

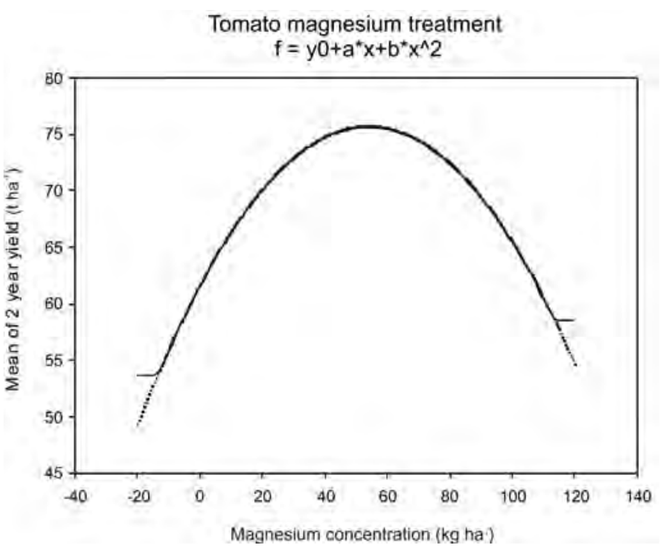

Fig. 1. Two-year mean yield in tomato as influenced by magnesium levels in soil

$Y = 61.624 + 0.5217 X - 0.0048 X^2$ $R^2 = 0.8598$

at 50kg Mg ha^{-1}. It then declined. Regression equations were developed between Mg applied and yield. The best fit equation ($Y = 61.624 + 0.5217 X – 0.0048 X^2$, $R^2 = 0.8598$) is presented in Fig. 1. From this regression equation, it is found that the tomato crop yields maximum at 54.2kg ha^{-1} applied Mg @ 75.6t ha^{-1}. From this study, it is found that application of 50kg Mg ha^{-1} results in increase of tomato fruit yield up to 29% in low-pH sandy soils. Upendra *et al* (2003) observed that application of Mg was essential, along with other major nutrients, to obtain economic yields in tomato. Osman and Wilcox (1985) also obtained significantly higher yields at 56kg Mg ha^{-1} on acidic soil. Bose *et al* (2006) reported tomato yield to increase when potassium and magnesium sulphate (K_2SO_4 and $MgSO_4$) were applied, compared to the use of just potassium chloride. Hao and Papadopoulos (2004) found that for greenhouse grown tomatoes to attain higher yields, application of 80ppm Mg was essential. From our present study, it is found that application of 50kg Mg ha^{-1} results in an increase in tomato fruit yield up to 29% in low-pH sandy soils.

Application of magnesium to tomato increased the yield significantly over the Control. Further, it was observed that yield of tomato increased up to 50kg Mg ha^{-1}. Application of higher levels diminished growth parameters like plant height, and number of branches per plant. Dry matter showed a similar trend and was very well correlated with fruit yield. Yield parameters, viz., number of fruits per plant and fruit weight, also showed a similar trend. It can be concluded, therefore, that magnesium application @ 50kg ha^{-1} to low acidic Alfisols can enhance fruit yield in tomato significantly.

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