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# Effect of applied magnesium on yield and quality of tomato in Alfisols of Karnataka

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## ABSTRACT

**Field experiments were conducted for two years on Alfisols to assess the effect of applied magnesium on fruit yield and quality parameters in tomato. Magnesium was applied at four levels ranging from 0 to 100 kg/ha in the form of $MgSO_4$. Applied Mg significantly enhanced fruit yield up to 50kg /ha during the two years of experimentation. Tomato quality parameters *viz*., total titrable acidity, content of lycopene, total carotenoids and ascorbic acid differed significantly among treatments. Applied Mg significantly improved quality. Highest lycopene content, carotenoids and ascorbic acid in the fruit was recorded in Recommended Dose of Fertilizers (RDF) + $MgSO_4$ @ 50Kg/ha followed by RDF + $MgSO_4$ @ 75 kg/ha. Lowest values for the above parameters were observed in the treatment receiving RDF alone in both the years.**

**Key words:** Tomato, titratable acidity, lycopene, total carotenoids, ascorbic acid, yield

## INTRODUCTION

According to a panel of Nobel laureates, of the top 10 priorities selected for advancing global welfare using methodologies based on theory of welfare economics, in Copenhagen Consensus, 2008, five were in the area of nutrition " nutrient supplements, nutrient fortification, biofortification, de-worming and other nutrient programmes at the school and community levels. Agriculture in general and horticulture in particular, are of paramount importance for overcoming the malady of mineral nutrient deficiency and malnutrition. Attempts to enhance mineral content in food automatically enhanced quality and yield of the crops, especially in horticulture.

Secondary nutrient deficiency in soils and crops is now emerging as a major problem for maintaining balanced nutrition and quality in horticultural crops. This is mainly due to use of straight fertilizers devoid of secondary nutrients particularly, Mg and S. Further, intensive cultivation of high yielding varieties/hybrids and the ensuing multifold increase in yields have lead to mining out of these nutrients from soil (Shukla *et al*, 2009). Magnesium deficiency in soil not only limits horticultural crop quality and production but also has a negative effect on human nutrition and health. Apart from human suffering due to morbidity and mortality, malnutrition, in general, and mineral nutrient deficiencies in particular entail a high economic cost. Solanaceous crops like tomato, potato and cole crops respond well to applied Mg (Bhargava and Raghupathi, 1997).

Tomato is extensively cultivated on Alfisols in south India, particularly, in south and south interior Karnataka. These soils are generally deficient in available Mg and crops in the field frequently show symptoms of Mg deficiency that seriously affect yield and quality in tomato. Hence, the present study was undertaken to understand effect of applied Mg on yield and quality in tomato grown on Alfisols in southern Karnataka.

## MATERIAL AND METHODS

The experiment was conducted at Indian Institute of Horticultural Research, Hessaraghatta, Bangalore, for two years during the winter season of 2010-11 and 2011-12. The experiment was laid out in Randomized Block Design in triplicate with five treatments, *viz.*, $T_1$ - Control (RDF-[180:150:120 NPK kg $ha^{-1}$]), $T_2$ - RDF+$MgSO_4$ (25kg $ha^{-1}$), $T_3$ - RDF+$MgSO_4$ (50kg $ha^{-1}$), $T_4$ - RDF+$MgSO_4$ (75kg $ha^{-1}$), $T_5$ - RDF+$MgSO_4$ (100kg $ha^{-1}$). Fifty per cent of nitrogen and the, full dose of phosphorus and potassium were applied at transplanting, as per treatment, in the form of ammonium sulphate, Single Super Phosphate (SSP) and muriate of potash. The whole quantity of ammonium sulphate 857kg/ha, SSP- 938 kg/ha and muriate of potash-200 kg/ha were applied through soil application. Only nitrogen was applied

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in three splits *viz*., 50% at planting, 25% at 25 days after transplanting, and 25% at 50 days after transplanting. Magnesium was applied in the form of magnesium sulphate ($MgSO_4$ $7H_2O$). Quantity of magnesium applied as magnesium sulphate is given in Table 1.

**Table 1. Quantity of $MgSo_4$ applied for supplying different doses of magnesium**

| Treatment levels of magnesium (kg $ha^{-1}$) | Quantity of $MgSo_4$ applied (kg $ha^{-1}$) |
|---|---|
| 25 | 257 |
| 50 | 514 |
| 75 | 771 |
| 100 | 1028 |

Tomato hybrid Arka Ananya was transplanted at a spacing of 100cm x 60cm. Tomato fruits are harvested in 7 pickings. Fruit samples were drawn after II & IV picking for quality analysis. Samples were immediately washed and stored in a refrigerator until analysis. Fruit quality parameters *viz*., total titratable acidity, lycopene level, total carotenoids and ascorbic acid were analyzed by the following methods.

### Titratable acidity (%)

Titratable acidity of tomato was analyzed using the procedure outlined by Mazumdar. Acidity was expressed as per cent (%) citric acid. A known amount of tissue sample (by weight) was taken. This was extracted with distilled water by thorough crushing. The extract was then filtered, and the filtrate was made up to a known volume with distilled water. A few drops of phenolphthalein solution were added to this and shaken well. Titration was determined by appearance of a pink colour. Titratable acidity (%) was quantified using the following formula:

### Calculation

In terms of citric acid

Percentage of total titratable acidity in the sample as equivalent of citric acid

$$= \frac{\text{Average burette reading for sample (ml)} \times 0.0064 \times \text{Volume made upto with distilled water (ml)} \times 100}{\text{Weight of sample (g)} \times \text{Volume of aliquot taken for examination (ml)}}$$

where, 0.0064 refer to 1 ml of 0.1 N NaOH neutralises 0.0064g of citric acid

### Lycopene and Total carotenoids content (mg/100g)

Lycopene and total carotenoids content of tomato was analyzed using the procedure outlined by Lichtenthaler (1987). Five grams of the fruit sample was blended with the help of a clean mortar by adding 20ml acetone. The acetone extract was transfer to a separating funnel. Carotenoids were extracted with (10x2) ml of hexane, 50ml of distilled water and a pinch of NaCl. The volume was then made upto 25ml. To this were added 5-6 grams of sodium sulphate to remove water. Absorbance was read using spectrophotometer at 470nm for total carotenoids, and 503nm for lycopene estimation and quantified using the formula:

$$\text{Lycopene (mg/100g) (503 nm)} = \frac{\text{OD} \times \text{Std. value} \times \text{Total volume} \times 100}{\text{Weight of the sample (g)} \times 1000}$$

Std. value = 1 OD = 5.375 µg

$$\text{Total carotenoids (mg/100g) (470 nm)} = \frac{\text{OD} \times \text{Std. value} \times \text{Total volume} \times 100}{\text{Weight of the sample (g)} \times 1000}$$

Std. value = 1 OD = 7.306 µg

### Ascorbic acid

Ascorbic acid was estimated using the 2,6-dichlorophenol indophenol titration method (Thimmaiah, 1999).The extracted sample was mixed in 4 per cent oxalic acid and made upto a known volume (100ml) and centrifuged. 5 ml of the supernatant was added to 10 ml of 4% oxalic acid and titrated against the dye.

$$\text{Ascorbic acid (mg/100g)} = \frac{\text{Titer value} \times \text{Dye factor} \times \text{Volume made up (ml)} \times 100}{\text{Aliquot of extraction (ml)} \times \text{Weight of the sample taken (g)}}$$

Where, dye factor = 0.5/Titer value

### Statistical analysis

Data on yield and quality parameters were subjected to statistical analysis as described by Sundaraja *et al*, 1972. and subjected to statistical analysis using 'Biostat-IIHR' programme and 'SAS' programme.

## RESULTS AND DISCUSSION

### Fruit yield in tomato

Total mean yield in tomato differed significantly among various treatments during the two years of experimentation. Magnesium applied as $MgSO_4$ @ 50kg $ha^{-1}$significantly enhanced fruit yield. Application of higher levels of Mg depressed fruit yields, but, yield levels were higher than in plots without Mg application (Control) (Table 3). The mean of two year pooled data revealed lowest tomato yield in

**Table 2. Initial physical and chemical properties of soil**

| Parameter | Value | Methodology | Reference |
|---|---|---|---|
| Sand (%) | 80.30 | Hydrometer method | Piper (1966) |
| Silt (%) | 10.20 | Hydrometer method | Piper (1966) |
| Clay (%) | 9.50 | Hydrometer method | Piper (1966) |
| PH | 5.20 | Potentiometer method | Jackson (1973) |
| EC (dS $m^{-1}$) | 0.26 | Conductivity meter | Page *et al* (1982) |
| Organic carbon (%) | 0.40 | Walkely and Black wet oxidation method | Jackson (1973) |
| Available nitrogen (ppm) | 57.52 | Alkaline permanganate method | Subbaiah and Asija (1956) |
| Available phosphorus (ppm) | 6.56 | 0.5 M $NaHCO_3$ – extractable; Molybdate – ascorbic acid blue colour method | Page *et al* (1982) |
| Available potassium (ppm) | 110.50 | N $NH_4$ OAC – extractable; Flame photometer method | Page *et al* (1982) |
| $NH_4$OAC extractable calcium (ppm) | 1288.83 | Versanate titration method | Black (1965) |
| $NH_4$OAC extractable magnesium (ppm) | 281.58 | Versanate titration method | Black (1965) |

Control treatment (60.09 t $ha^{-1}$); highest yield was observed in RDF+$MgSO_4$ (50kg Mg/ha) (78.01t $ha^{-1}$) and RDF+$MgSO_4$ (25kg Mg/ha) (73.92t $ha^{-1}$), followed by RDF+$MgSO_4$ (75kg Mg/ha) (68.12 t $ha^{-1}$) and RDF+$MgSO_4$ (100kg Mg/ha) (67.80t $ha^{-1}$).

## Lycopene and Total Carotenoids

Magnesium significantly affected lycopene content in tomato fruits during both the years of experimentation (Table 4). Application of 50kg Mg /ha resulted in maximum lycopene content during the first year at II & IV harvest stage (9.33 & 9.10 mg/100g) and II year at II & IV harvest stage (8.33 & 8.10mg/100g) and the lowest lycopene at II & IV harvest stage (6.89 & 6.46 mg /100g) was observed in Control. During the II year, highest lycopene content was observed in the treatment of 50kg Mg/ha (8.33 Mg at II harvest stage and 8.10 Mg/100g at IV harvest stage) compared to Control (6.05 mg at II harvest stage and 5.92mg/100g at IV harvest stage). Similar results were reported by Bose *et al* (2006) in soils of West Bengal. They also stated that soil K deficiency to decreased lycopene content. According to Cox *et al* (2003), red fruiting cultivars had higher lycopene content than yellow or orange cultivars. There was also seasonal effect on lycopene and antioxidant levels in tomato fruits (Rosales *el al*, 2006, Toor *et al*, 2006) and effect of irrigation and nutritional status of plants (Dumas *et al*, 2003). The cultivar used in this study is a medium red variety and, generally, fruits contain 8-9mg lycopene/100g variation in lycopene content in the range of 5.9-9.1 mg/100g observed in different treatments in this study showed that applied Mg can enhance lycopene content in tomato hybrid 'Arka Ananya' in Alfisols.

Total carotenoids in tomato fruits differed significantly among different treatments (Table 5). Highest carotenoid content was observed in the treatment 50kg Mg/ha during I and II year. The content was 12.86 and 12.530 mg/100g

**Table 3. Effect of magnesium application on fruit yield (t/ha) of tomato hybrid Arka Ananya**

| Treatment | I year | II year | Mean |
|---|---|---|---|
| Control (RDF) | 59.10 | 61.08 | 60.09 |
| RDF+$MgSO_4$ 25kg/ha | 74.60 | 73.24 | 73.92 |
| RDF+$MgSO_4$ 50kg/ha | 77.53 | 78.40 | 78.01 |
| RDF+$MgSO_4$ 75kg/ha | 68.22 | 68.02 | 68.12 |
| RDF+$MgSO_4$ 100kg/ha | 68.10 | 67.49 | 67.80 |
| CD (*P=0.05*) | 8.75 | 8.07 | 6.31 |

**Table 4. Effect of magnesium application on lycopene content (mg/100 g) in tomato hybrid Arka Ananya**

| Treatment | I year | | II year | |
|---|---|---|---|---|
| | II Harvest | IV Harvest | II Harvest | IV Harvest |
| Control (RDF) | 6.89 | 6.46 | 6.05 | 5.92 |
| RDF+$MgSO_4$ 25kg/ha | 7.62 | 7.42 | 6.88 | 6.65 |
| RDF+$MgSO_4$ 50kg/ha | 9.33 | 9.10 | 8.33 | 8.10 |
| RDF+$MgSO_4$ 75kg/ha | 8.82 | 8.49 | 8.02 | 7.99 |
| RDF+$MgSO_4$ 100kg/ha | 8.80 | 8.27 | 7.97 | 7.83 |
| CV (%) | 9.52 | 8.83 | 10.6 | 8.26 |
| CD(*P=0.05*) | 1.49 | 1.32 | 1.49 | 1.14 |

**Table 5. Effect of magnesium application on total carotenoids (mg/100 g) content of tomato hybrid Arka Ananya**

| Treatment | I year | | II year | |
|---|---|---|---|---|
| | II Harvest | IV Harvest | II Harvest | IV Harvest |
| Control (RDF) | 8.91 | 8.18 | 8.84 | 8.51 |
| RDF+$MgSO_4$ 25kg/ha | 10.49 | 9.69 | 10.09 | 9.59 |
| RDF+$MgSO_4$ 50kg/ha | 12.86 | 12.53 | 12.03 | 11.87 |
| RDF+$MgSO_4$ 75kg/ha | 12.31 | 12.44 | 11.18 | 10.94 |
| RDF+$MgSO_4$ 100kg/ha | 12.02 | 12.12 | 10.93 | 10.30 |
| CV (%) | 9.30 | 13.37 | 9.50 | 10.95 |
| CD(*P=0.05*) | 1.98 | 2.77 | 1.90 | 2.11 |

**Table 6. Effect of magnesium application on total titratable acidity (mg/100g) in tomato hybrid Arka Ananya**

| Treatment | I year | | II year | |
|---|---|---|---|---|
| | II Harvest | IV Harvest | II Harvest | IV Harvest |
| Control (RDF) | 0.37 | 0.34 | 0.35 | 0.34 |
| RDF+$MgSO_4$ 25kg/ha | 0.38 | 0.36 | 0.39 | 0.38 |
| RDF+$MgSO_4$ 50kg/ha | 0.44 | 0.41 | 0.45 | 0.43 |
| RDF+$MgSO_4$ 75kg/ha | 0.39 | 0.37 | 0.42 | 0.40 |
| RDF+$MgSO_4$ 100kg/ha | 0.40 | 0.39 | 0.41 | 0.40 |
| CV (%) | 5.48 | 5.92 | 5.90 | 5.88 |
| CD (*P=0.05*) | 0.041 | 0.042 | 0.045 | 0.043 |

**Table 7. Effect of magnesium application on ascorbic acid (mg/100g) content in tomato hybrid Arka Ananya**

| Treatment | I year | | II year | |
|---|---|---|---|---|
| | II Harvest | IV Harvest | II Harvest | IV Harvest |
| Control (RDF) | 21.84 | 20.67 | 21.25 | 20.17 |
| RDF+$MgSO_4$ 25kg/ha | 27.03 | 25.70 | 25.93 | 25.55 |
| RDF+$MgSO_4$ 50kg/ha | 32.22 | 30.41 | 31.41 | 29.95 |
| RDF+$MgSO_4$ 75kg/ha | 29.34 | 28.01 | 29.08 | 27.67 |
| RDF+$MgSO_4$ 100kg/ha | 28.08 | 26.75 | 27.26 | 26.08 |
| CV (%) | 7.39 | 9.37 | 7.23 | 7.63 |
| CD*(P=0.05)* | 5.57 | 4.64 | 5.18 | 5.43 |

carotenoids in the treatment 50kg Mg/ha during I year at II & IV harvest stage, respectively. Similarly, during the second year, carotenoid content was 12.03 at II harvest & 11.87 mg/100 g at IV harvest. Lowest levels of carotenoids (8.91, 8.18, 8.84 & 8.51 mg/100 g during I & II year at II & IV harvest stage, respectively) were recorded in Control treatment Jean Aghofack –Nguemezi and Valere (2010) carried out similar studies on the effect of fertilizer containing Ca and Mg on growth, development and quality of tomato fruits in Cameroon. They reported no significant alteration in carotenoid content in tomato fruits. This was partly due to the fact that these soils were as such rich in available Mg. Several others have also reported carotenoids as remaining either unaltered, or even decreasing in content. However, in this study, Mg applied to the soils low in available Mg had enhanced carotenoid levels in tomato. Hence, in these soils, farmers can benefit by adding Mg containing fertilizers to soils low in available Mg.

### Acidity and Ascorbic Acid

Applied Mg significantly influenced acidity and ascorbic acid content in tomato during the two years of experimentation (Tables 6 & 7). During the first year, highest acidity was recorded in the treatment 50kg Mg/ha (0.44mg/100g) followed by the treatment 100kg Mg/ha (0.40mg/100g); lowest was recorded in the Control (0.37mg/100g) during the I year at the II harvest stage. Similar results were obtained in the IV harvest stage. Where the lowest was observed in Control (0.34mg/100g). During the second year highest acidity of the fruit was recorded in treatment 50 Kg Mg/ha (0.45 and 0.43 mg/100g at II & IV harvest stage respectively) and the lowest acidity (0.35 and 0.34 mg/100g at II & IV harvest stage respectively) was observed in the control (RDF only) (Table 6). Shibli *et al* (1995) evaluated physico-chemical properties of the fruits of four open-pollinated tomato cultivars (Pello, E. Mich, Pakit and Riogrande) grown under rainfed conditions in Jordan, and recorded 0.3 % titratable acidity in soils low in available Mg.

Similar to acidity, highly significant difference in ascorbic acid content in tomato was observed among different treatments (Table 7). Magnesium application resulted in ascorbic acid ranging from 20.17 to 32.22mg/100g in fresh fruit during both years. Maximum ascorbic acid content was observed in the treatment of 50kg Mg/ha (II harvest-32.22 & IV harvest 30.41 mg/100g) and lowest ascorbic acid content in Control during the I year experiment. Similarly, during the second year, highest ascorbic acid content (II harvest-31.41 & IV harvest-29.95 mg/100g) was recorded in the treatment 50kg Mg/ha. This was in agreement with findings of Gulshan *et al* (1991) who evaluated nine tomato varieties during summer in Tarai region and reported highest (16.2mg/100g) and lowest (8.8 mg/100 g) ascorbic acid content in the tomato plant. Shibli *et al* (1995) also reported similar results.

Results of field experiments clearly indicate that yield in hybrid tomato can be enhanced through application of 50kg Mg/ha in Alfisols. In addition to fruit yield significant improvement in quality of the fruits was seen as indicated by enhanced levels of total titratable acidity, lycopene, carotenoids and ascorbic acid. Hence, farmer applying $MgSO_4$ to the crop can realize higher yields and good quality tomato, with little investment.

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