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Tomato fruit quality as influenced by calcium foliar spray

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Abstract
Experiment was carried out under greenhouse condition at Zonal Agricultural and Horticultural Research Station (ZAHRS), Navile, Shivamogga during *kharif* 2016 to know the response of tomato fruit to different calcium sources and levels. Three sources of calcium were applied as a foliar spray [Calcium chloride ($CaCl_2$), Calcium nitrate ($CaNO_3$) and calcium ammonium nitrate (CAN)] with three levels (0.20, 0.50 and 0.80 %, respectively). The results indicated that foliar application of calcium through different sources increased the quality of tomato significantly over the control (water spray). Treatment applied with foliar spray of 0.5 per cent CAN as recorded significantly higher fruit quality attributes like TSS (5.00 °Brix) and titrable acidity (0.23 %), lycopene content of 79.66 mg kg^{-1}, fruit firmness (0.33 kg cm^{-2}), PLW (0.45 to 4.57 %), over the other treatments. The Ca content and uptake (0.84 %, and 77.26 kg ha^{-1}) was recorded highest by tomato fruits due to foliar spray of CAN @ 0.5 % compared with control. The next best alternative source of calcium for foliar spray found to be $CaCl_2$ @ 0.8 % which shows higher quality and nutrient content of tomato fruit.

Keywords: Calcium, total soluble solids, titrable acidity, ca content and uptake

Introduction

In Human diet vegetables occupy a prominent position owing to their richness in vitamins and minerals. Vegetables play role in human diet as a protective food needs no advocacy. Many numbers of vegetable crops are grown i.e. more than seventy types of vegetable in India but maximum emphasis has been given on tomato, brinjal, chilli, cauliflower, cabbage, pea and important cucurbits. Tomato is one among them (*Lycopersicon esculentum* Mill.) belonging to the Solanaceae family, most popularly and widely grown vegetable crops. It was originated from Tropical America (Thompson and Kelly, 1957) [14] popularly called as "Poormans Orange" and important to human diet because of higher nutritive value and lower market price. It is consumed as fresh ripe fruit, cooked vegetable and also as processed food products like sauce, soup, ketchup, etc. It is also consumed as raw fruit in vegetable salad. Hence, there is a great demand of tomato in market as fresh fruit. Having excellent source of vitamin C and plays important role in our daily diet. In addition, it is rich in medicinal value too, as its pulp and juice helps in digestion by promoting gastric secretion and also acts as purifier. It is said to be useful in treating mouth cancer and sore mouth.

Tomato is the largest vegetable crop after potato and sweet potato in world, but it tops the list of canned vegetables. The total global area under tomato crop is 46.16 lakh ha and the global production is to the tune of 1279.93 lakh tones (Annon, 2015) [2]. The physicochemical and keeping quality of tomato is influenced by many factors among them application of major and micro nutrients either through soil application or foliar spray plays an important role in maintaining the quality of fruits.

Among the secondary nutrients, calcium acts as a component of cells holding the structure of cell walls and stabilizing cell membranes. It also has a direct influence on the salt balance within plant cells and activates potassium to regulate the opening and closing of stomata to allow water movement from the plant. Calcium enhances pollen germination; regulates some enzyme systems; and influences the growth and health of cells and conductive tissues. It has a key specific influence on tomato fruit quality especially Blossom End Rot (BER).

Foliar applied fertilizers usually compensate for or alleviate this inadequacy. Foliar nutrition plays an important role in increasing nutrient content in fruiting vegetables using calcium fertilizers. Sprays of calcium normally prevent most physiological disorders, but the degree of success varies according to natural pre disposition to the symptoms growing seasons, cultivar and environmental conditions. There are evidences to suggest that the increase of calcium in the fruits resulting from calcium sprays, however, is normally low or even inexistent. Moreover, calcium fertilizers have a consistent effect on fruit flesh firmness, soluble solids content and natural weight loss

In spite of its pivotal role in crop nutrition, but less importance and work has been done in vegetable crops especially in tomato production as a secondary nutrient. Hence, an experiment was planned to know the efficiency of different sources and levels of Ca through foliar spray on tomato crop.

Material and Methods

The experimental site is situated at $14^0 0'$ to $14^0 1'$ North latitude and 75^0 40' to 75^0 42' east longitude with an altitude of 650 meters above the mean sea level (MSL). The experiment comprised 10 treatment combinations with three calcium sources and three levels tried under naturally ventilated polyhouse with test crop tomato, hybrid 'Arka Samrat'. The experiment was laid out in Completely Randomized Design (CRD) with three replications. The recommended doses of fertilizers were applied @ 250: 250: 250 N, P_2O_5, and K_2O kg ha^{-1} to all the treatments through Urea, Diammonium phosphate (DAP) and Murate of potash (MOP).

The different sources of calcium fertilizer were used as a foliar nutrition *viz.*, calcium chloride ($CaCl_2$), calcium nitrate ($CaNO_3$) and calcium ammonium nitrate (CAN) at 0.20, 0.50 and 0.80 per cent concentration each. Seedlings were grown in pro-trays containing coco-peat as potting mixture. 20 days old healthy seedlings were transplanted to greenhouse.

The growth, yield and quality parameters of fruits were recorded. The tomato fruits were taken and analyzed for different quality parameters and nutrient content by following standard methods of analysis. Titrable acidity estimation was done as per procedure given by AOAC and TSS (Dongare *et al.* and Dong *et al*.).

The treatment details are as follows, T_1: control (water spray), T_2: $CaCl_2$ @ 0.2 % foliar spray (FS), T_3: $CaCl_2$ @ 0.5 % FS, T_4: $CaCl_2$ @ 0.8 % FS, T_5: $CaNO_3$ @ 0.2 % FS, T_6: $CaNO_3$ @ 0.5 % FS, T_7: $CaNO_3$ @ 0.8 % FS, T_8: CAN @ 0.2 % FS, T_9: CAN @ 0.5 % FS, T_{10}: CAN @ 0.8 % FS.

The initial soil was analysed for nutrient status and have sandy loam texture, slightly neutral pH (7.63), high in organic carbon (7.10g kg^{-1}) medium in available nitrogen (301.52 kg ha^{-1}), phosphorus (53.83kg ha^{-1}) and high in potassium (493.25kg ha^{-1}), deficient in sulfur (8.20ppm), but sufficient in exchangeable Ca and Mg (8.70 & 6.76 meq 100^{-1} g respectively).

Results and Discussion

Effect of foliar application of different sources and levels of calcium on titrable acidity and TSS of tomato

The plants received 0.5 per cent CAN as foliar spray recorded higher TSS and acidity content of 5.00° Brix and 0.23% of the fruit followed by CAN @ 0.8 per cent as foliar spray (4.83° Brix and 0.20%) and which found on par with the treatment which received $CaCl_2$ @ 0.8 per cent as foliar spray. Acidity is a factor that decides the quality of fruit (Fig 1 & 2). The acidity seems to be the most important quality trait for tomato as a fresh market produce used in culinary preparation. Being the result of complex chemical reaction, the organic acids are synthesized and these incorporate the sour taste to the juice. Organic acid synthesis is influenced by the hormonal balance inside the plant system. Maintenance of proper acidity, simultaneously increasing the soluble solids would go a long way not only for the production of better table tomato for culinary purpose but also for processed products like tomato jam, sauce, ketchup etc. The effect is in conformity with several previous works of Salam *et al*., Arthur *et al.* and Kazemi in tomato.

Effect of foliar application of different sources and levels of calcium on lycopene content

The significant differences were recorded in lycopene content of fruit due to different sources of Ca with different levels presented in Fig.3**.** Both the treatments CAN @ 0.5% foliar spray (T_9) and CAN @ 0.8% foliar spray (T_{10}) had showed higher lycopene content of 79.66 and 75.66 mg/kg of tissue, respectively as compared to control (Water spray) which recorded 57.19 mg/kg of tissue. The reason might be due to enhancement of enzyme activity of a lycopene due to Ca and also other micro-elements nutrition were involved in carbohydrate metabolism and there exists positive and close relationship with formation of lycopene content in fruits. The Ca plays a physiological role in synthesis of enzymes, total carbohydrates, proteins and lipids in tomato. This effect was in consonance with previous findings of Santosh Kumari and Iran *et al.* in tomato.

Effect of foliar application of different calcium sources on tomato fruit firmness

The data on comparative effect of calcium sources on fruit firmness of tomato is represented in Fig.4. It is observed from the data that plants treated with CAN @ 0.5% as a foliar spray maintained higher firmness as compared to other treatments. CAN treated plants demonstrated the best effect to maintain fruit firmness and registered maximum fruit firmness (0.33 kg/cm^2) followed by T_{10} (CAN @ 0.8% foliar spray) (0.33 kg/cm^2) and it was on par with T_4 ($CaCl_2$ @ 0.8% foliar spray) (0.33 kg/cm^2). Lowest fruit firmness was recorded in control treated with water spray (T_1). This might be due to fruits treated with higher concentration of calcium recorded more firmness as compared to untreated fruits which may be due to reduced extent of fruit softening. These findings are in agreement with Bouzo and Cortez, Arthur *et al.,* and Batra *et al.,* in tomato.

Calcium content and uptake by tomato as influenced by foliar applied Ca through different sources and levels

Significant differences were recorded in Ca content and uptake by tomato fruit due to effect of different sources of Ca with different levels (Fig. 5 & 6). The Ca content and uptake was recorded highest in the treatment receiving CAN @ 0.5 per cent as foliar spray (0.84%, 77.26 kg/ha) followed by CAN @ 0.8 per cent (0.80%, 69.86kg/ha) and $CaCl_2$ @ 0.8 per cent as foliar spray (0.79%, 68.55 kg/ha). There was an increase in Ca content and also uptake of Ca in all the treatments except control. Calcium is very essential for the meristematic activity. It provides a base for neutralization of organic acids and other toxins (like Al) produced in plants. It plays a role in mitosis. This favours the assimilation of nitrogen into organic constituents especially proteins. These findings are in agreement with Elzbieta and Zenia in sweet pepper, Yildirim *et al.* and Shafeek *et al.,* in tomato.

Effect of foliar applied calcium on physiological loss in weight by tomato

The significant differences were noted in physiological loss in weight in fruits due to different sources of Ca with different levels presented in Table-1. The physiological loss in weight of tomato fruit was varied significantly among the treatments. It was varied from 0.62 to 3.69 %in CAN @ 0.5% foliar spray (T_9) followed by CAN @ 0.8% foliar spray (T_{10}) and $CaCl_2$ @ 0.8% foliar spray (T_4) in the range of 0.45 to 4.57% & 0.81 to 6.57 % respectively. The least loss in weight was observed in treatment T_9 followed by T_{10} and T_4 this might be due to the fruits treated with higher concentration of calcium (0.75%) recorded less loss in weight (7.2 %) as against (9.5 %) in untreated fruits. A significant increase in the extent of weight loss of fruits was recorded with the advancement of storage period. Fruit harvested earlier exhibited more loss in weight than those harvested late, which may be due to more transpiration and metabolic processes. These findings are in conformity with Bhat, *et al.* in Bartlett pear. Treated fruits exhibited less loss in weight than untreated fruits. Fruits treated with higher concentrations of calcium chloride recorded less loss of weight which may be due to reduced transpiration during pre-climacteric and climacteric phases. (Tingwa and Young). The treatment T_1 control spray with water was expressed highest loss in fruit weight (6.43 to 21.61%).

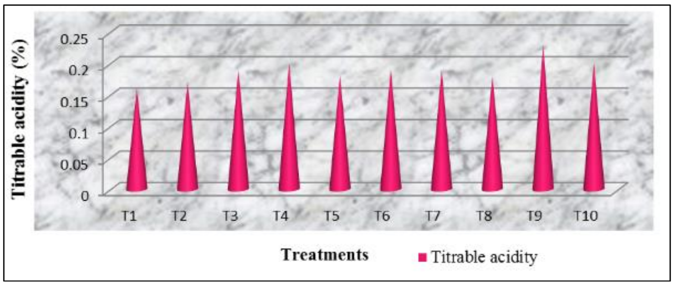

Fig 1: Effect of foliar application of different sources and levels of calcium on titrable acidity of tomato

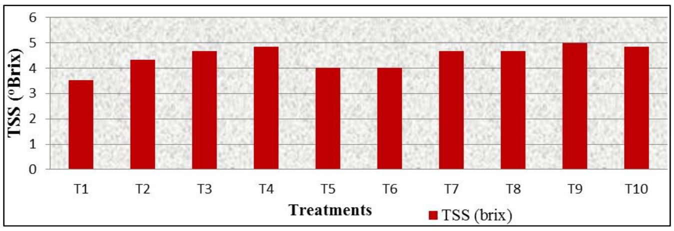

Fig 2: Effect of foliar application of different sources and levels of calcium on TSS (°Brix) of tomato

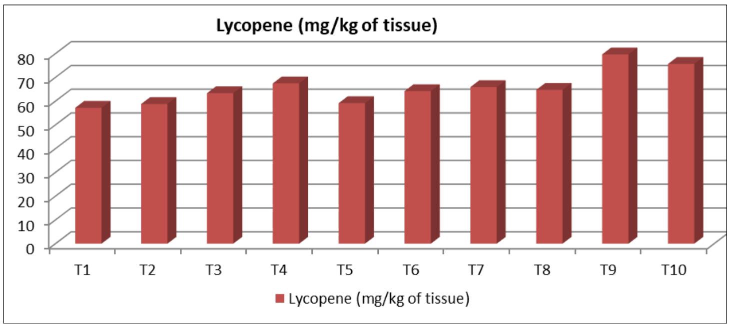

Fig 3: Effect of foliar application of different calcium sources on lycopene content of tomato

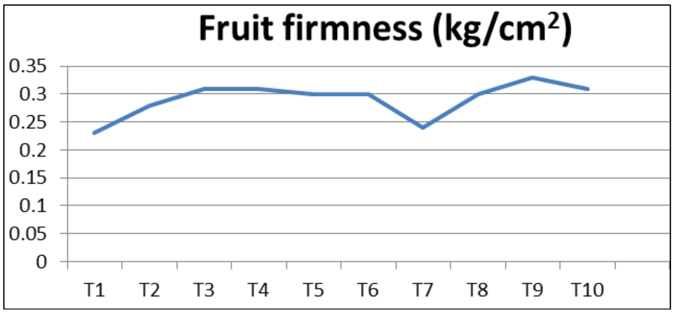

Fig 4: Effect of foliar application of different calcium sources on tomato fruit firmness

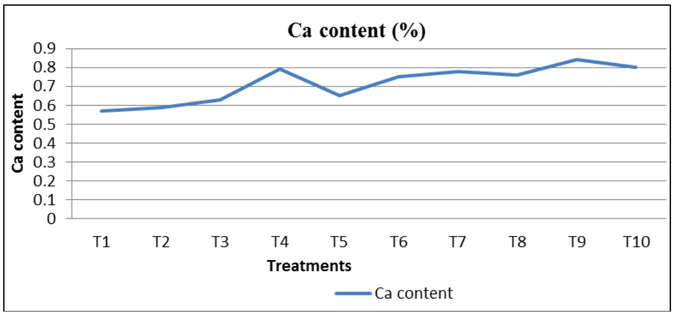

Fig 5: Calcium content by tomato as influenced by foliar applied Ca through different sources and levels

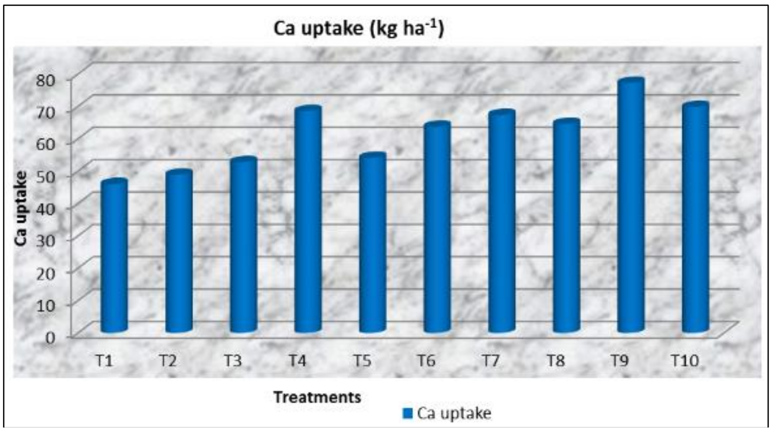

Fig 6: Calcium uptake by tomato as influenced by foliar applied Ca through different sources and levels

Table 1: Effect of foliar applied calcium on physiological loss in weight by tomato

Treatments	Physiological loss in weight (%)			
	After 3 days	After 5 days	After 7 days	After 9 days
T_1: Control (WS)	6.43 (14.69)	11.86 (20.15)	15.12 (22.89)	21.61 (27.72)
T_2: $CaCl_2$ @ 0.2% FS	3.38 (10.59)	6.30 (14.54)	9.59 (18.04)	16.13 (23.69)
T_3: $CaCl_2$ @ 0.5% FS	3.22 (10.34)	5.77 (13.90)	9.10 (17.56)	11.65 (19.97)
T_4: $CaCl_2$ @ 0.8% FS	0.81 (5.16)	2.03 (8.20)	3.34 (10.53)	6.57 (14.86)
T_5: $CaNO_3$ @ 0.2% FS	2.61 (9.30)	4.89 (12.78)	6.84 (15.16)	11.96 (20.24)
T_6: $CaNO_3$ @ 0.5% FS	1.47 (6.88)	4.07 (11.65)	5.63 (13.73)	9.85 (18.30)
T_7: $CaNO_3$ @ 0.8% FS	1.44 (6.89)	3.12 (10.18)	5.39 (13.43)	8.33 (16.78)
T_8: CAN @ 0.2% FS	1.07 (5.95)	2.33 (8.78)	5.71 (13.83)	8.02 (16.46)
T_9: CAN @ 0.5% FS	0.62 (4.50)	1.68 (7.44)	2.32 (8.76)	3.69 (11.06)
T_{10}: CAN @ 0.8% FS	0.75 (4.97)	1.86 (7.85)	2.85 (9.72)	4.57 (12.35)
S.Em ±	0.15	0.19	0.20	0.22
CD @ 5%	0.44	0.56	0.58	0.64

FS- Foliar spray; WS- Water spray; CAN- Calcium ammonium nitrate; Values in parentheses are arc sine transformation

Conclusion

From the experimental results it can be concluded that, foliar application of CA enhanced the growth, yield and quality of tomato crop. All the sources of CA found to be significantly effective in increasing fruit yield and quality of tomato fruit. However, the highest effect and use efficiency was observed due to foliar spray of 0.5% CAN fertilizer as foliar spray followed by foliar spray of $CaCl_2$ at 0.8% compare to other sources and concentrations.

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