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Effect of Foliar Nutrition of Different Sources and Levels of Calcium Fertilizer on Nutrient Content and Uptake by Tomato

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A B S T R A C T

An experiment was conducted at Zonal Agricultural and Horticultural Research Station (ZAHRS), Navile, Shivamogga during *kharif* 2016 under naturally ventilated poly house condition in order to know the effect of foliar nutrition of different sources and levels of calcium on growth and yield of tomato (*Lycopersicum esculantum*). Three sources of calcium ($CaCl_2$, $CaNO_3$ and calcium ammonium nitrate) with three levels each (0.20, 0.50 and 0.80%) were applied as a foliar spray in a Complete Randomized Design (CRD) with three replications and ten treatments. Results of the experiment indicated that foliar application of tomato crop with different calcium sources increased the nutrient content and uptake by tomato fruit and leaves significantly over the control. However foliar spray of 0.5 per cent CAN resulted in increase in nutrient content *viz.*, pH (4.19), N (1.96 %), K (4.96 %), Ca (0.84 %), Mg (0.43 %) in fruit and in leaves at different stages (vegetative, flowering & fruiting stage). Nutrient uptake by the tomato fruit recorded significantly higher N, K, Ca, Mg (166.97, 438.70, 77.26, 39.55 kg ha^{-1}) content due to foliar application of 0.5 per cent CAN compared to other sources of Ca and control. Thus this experiment conclusively proves that nutrient supplementation with Ca (0.5% CAN) as foliar spray will enhance the quality of tomato fruit due to increased nutritional status.

Introduction

Tomato (*Solanum lycopersicum* L.), belongs to the family *solanaceae,* is one of the most important vegetable crop grown throughout the world under field and greenhouse conditions (Kaloo, 1986). In terms of human health, tomato is a major component in the daily diet in many countries, and constitutes an important source of minerals, vitamins, and antioxidants (Grierson and Kader, 1986).

Plant requires Ca to develop strong cell walls and membrane and calcium pectate in the middle lamella of the cell wall which regulates the entry of only those nutrients which are not toxic to plants. Conversely, insufficient Ca in plants leads to a breakdown of cell walls and membranes, susceptibility to a variety of diseases and post-harvest problems particularly in fresh produce such as tomato. In seeds, calcium is present as calcium pectate. In root tip, calcium is very essential for the meristematic activity, provides a base for neutralisation of organic acids and other toxins (like Aluminum) produced in plants. It plays a role in mitosis (cell division) and helps to maintain the chromosome structure. It is essential co-factor or an activator of a number of enzymes like hydrolases. It activates phospholipase, arginine kinase, amylase and adenosine tri phosphatase (ATPase) enzymes. It favours the assimilation of nitrogen into organic constituents especially proteins. Deficiency appears as browning and the dieback of growing tips of leaves. Leaves curl and margins turn brown, with newly emerging leaves sticking together at the margins leaving expanded leaves shredded at their margins. Probably the most well-known symptom of Ca deficiency in tomato is blossom end rot.

Foliar applied fertilizers usually compensate or alleviate this inadequacy (Erdal *et al.*, 2004; Lanauskas and Kvikliene, 2006). Foliar nutrition plays an important role in increasing nutrient content in fruiting vegetables using calcium fertilizers. Sprays of Ca normally prevent most physiological disorders, but the degree of success varies according to natural predisposition to the symptoms, growing season, cultivar, and environmental conditions. There are evidences to suggest that the increase of calcium in the fruits resulting from Ca sprays, however, is normally low or even inexistent.

In spite of its pivotal role in crop nutrition, but work on this is meager and less importance in crop production especially in vegetable crops as it is 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.

Materials and Methods

An experiment entitled "Effect of foliar nutrition of different sources and levels of calcium fertilizer on nutrient content and uptake by tomato" was conducted at ZAHRS, Navile, Shivamogga, in Karnataka state in India 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 during the period 2016-17. The experiment comprised 10 treatment combinations with three calcium sources and three levels tried under naturally ventilated poly house condition with tomato hybrid 'Arka Samrat' which was released from Indian Institute of Horticultural Research, Bangalore, India as test crop. 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.

The soil sample was analysed for initial 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}), deficit in sulfur (8.20 ppm), sufficient in exchangeable Ca and magnesium (8.70 & 6.76 meq/100g respectively).

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 concentrations. Seedlings were produced in pro-trays containing coco-peat as potting mixture. After 20 days of sowing, healthy plants were transplanted to main raised beds under polyhouse.

The leaf samples of fifth leaf were collected at different growth stages *i.e* vegetative, flowering and fruiting after foliar application of different calcium sources and fruits were collected at harvest stage and analysed for different nutrients content (Ward and Johnston, 1960). Both leaf and fruit samples were washed with tap water and then with distilled water. The samples were first air dried and then oven dried at 65°C. The dried samples were powdered and used for analysis of different nutrient content *viz.,* N, P, K, Ca, Mg (Jackson, 1973), S (Black, 1965) and micronutrients like Zn, Cu, Fe, Cu by following standard methods of analysis. And the nutrient uptake by tomato fruit and leaf were calculated by multiplying the nutrient content with the total dry matter production and expressed in kg ha^{-1} (Robinson *et al.,* 1986).

The recorded data on different parameters were statistically analyzed based on the procedure given by Gomez and Gomez (1984) to find out the treatment differences. Critical differences were worked out at 5 per cent probability level where the treatments differed significantly.

Results and Discussion

The effects of foliar application of calcium sources and levels on nutrients *viz.,* N, P, K, Ca, Mg, S, Fe, Mn, Zn and Cu content of tomato leaves were found to be statistically significant. The nutrient content in tomato leaves were measured at different growth stages like vegetative, flowering and fruiting stages furnished in Table 1, 2 and 3. The foliar spray of 0.5 per cent CAN (T_9) increased the nutrient content followed by the foliar spray of 0.8 per cent CAN (T_{10}).

There was an increase in nutrient content at different growth stages. This is mainly due the fact that as the growth of plant increases the nutrient content and uptake is also increased. Calcium is essential for the formation of cell wall and calcium pectate in the middle lamella of the cell wall which regulates the entry of only those nutrients which are not toxic to plants and provides a base for neutralisation of organic acids and other toxins (like Al) produced in plants there by it helps in increasing the nutrient uptake. It plays a role in mitosis (cell division) and helps to maintain the chromosome structure. These findings are in agreement with Yildirim *et al.,* (2009), Lolaei (2012), Nadeem *et al.,* (2013) and Shafeek *et al.,* (2013) in tomato.

The foliar spray of 0.5 per cent CAN (T_9) increased the nutrient uptake followed by the foliar spray of 0.8 per cent CAN (T_{10}). There was an increase in nutrient uptake by tomato leaves at different growth stages. This is mainly due to the fact that as the growth of plant increases the nutrient uptake is also increased.

Tomato fruits were acidic in nature after treating the plants with 0.5 per cent CAN as foliar spray there was a slight increase in pH (4.19) was noticed over control (3.98). Increase in pH is mainly due to the Ca content present in CAN (Table 4). It acts as a base, due to increased pH the EC of fruit juice was also increased slightly.

The nutrient content of tomato fruits measured at harvest stage was significantly influenced by Ca spray (Table 4 and 5). Foliar spray of Ca influenced the nutrient content and uptake. The foliar spray of 0.5 per cent CAN (T_9) increased nutrient content of tomato fruits significantly followed by the foliar spray of 0.8 per cent CAN (T_{10}).

There was an increase in nutrient content and also uptake of Ca in all the treatments except control. Calcium is very essential for the meristematic activity. Provides a base for neutralisation of organic acids and other toxins (like Al) produced in plants. It plays a role in mitosis and favours the assimilation of nitrogen into organic constituents especially proteins. These findings are in agreement with Elzbieta and Zenia (2009) in sweet pepper, Subbiah and Rani (1994), Arabloo (2003), Kumar *et al.,* (2006), David *et al.,* (2009), Tsechelidis *et al.,* (2010), Ahmad and Mahdi (2012), Ireneusz (2012) and Mohammad Ali (2016) in tomato.

Table.1 Effect of foliar spray of different sources and levels of calcium on primary nutrient content of tomato leaves at different growth stages

Treatments	Vegetative stage (%)			Flowering stage (%)			Fruiting stage (%)		
	N	P	K	N	P	K	N	P	K
T_1: Control (WS)	2.73	0.25	3.10	2.91	0.30	3.51	3.12	0.37	3.69
T_2: $CaCl_2$ @ 0.2 % FS	2.87	0.31	3.61	3.16	0.36	4.10	3.23	0.40	4.27
T_3: $CaCl_2$ @ 0.5 % FS	2.89	0.36	3.81	3.24	0.39	4.20	3.30	0.42	4.37
T_4: $CaCl_2$ @ 0.8 % FS	3.12	0.51	4.64	3.31	0.56	4.71	3.58	0.60	4.84
T_5: $CaNO_3$ @ 0.2 % FS	3.13	0.42	4.09	3.24	0.46	4.39	3.37	0.49	4.62
T_6: $CaNO_3$ @ 0.5 % FS	3.20	0.44	4.23	3.27	0.49	4.42	3.44	0.52	4.66
T_7: $CaNO_3$ @ 0.8 % FS	3.39	0.50	4.51	3.46	0.54	4.69	3.60	0.59	4.77
T_8: CAN @ 0.2 % FS	3.28	0.46	4.42	3.41	0.48	4.53	3.57	0.54	4.70
T_9: CAN @ 0.5 % FS	3.44	0.59	4.80	3.49	0.62	5.03	3.84	0.65	5.07
T_{10}: CAN @ 0.8 % FS	3.42	0.57	4.77	3.45	0.59	4.86	3.68	0.63	4.96
S.Em ±	0.04	0.02	0.08	0.02	0.01	0.05	0.05	0.02	0.02
CD @ 5 %	0.12	0.05	0.24	0.06	0.04	0.16	0.14	0.07	0.05

FS- Foliar spray; WS- Water spray; CAN- Calcium ammonium nitrate

Table.2 Effect of foliar spray of different sources and levels of calcium on secondary nutrient content of tomato leaves at different growth stages

Treatments	Vegetative stage (%)			Flowering stage (%)			Fruiting stage (%)		
	Ca	Mg	S	Ca	Mg	S	Ca	Mg	S
T_1: Control (WS)	0.86	0.45	0.15	0.89	0.55	0.21	0.92	0.57	0.23
T_2: $CaCl_2$ @ 0.2 % FS	0.89	0.47	0.18	0.94	0.57	0.25	0.98	0.59	0.29
T_3: $CaCl_2$ @ 0.5 % FS	0.94	0.53	0.20	1.07	0.59	0.27	1.09	0.64	0.31
T_4: $CaCl_2$ @ 0.8 % FS	1.39	0.73	0.22	1.45	0.77	0.29	1.48	0.79	0.36
T_5: $CaNO_3$ @ 0.2 % FS	1.04	0.64	0.21	1.07	0.75	0.23	1.09	0.78	0.27
T_6: $CaNO_3$ @ 0.5 % FS	1.11	0.72	0.21	1.14	0.67	0.26	1.17	0.69	0.29
T_7: $CaNO_3$ @ 0.8 % FS	1.31	0.75	0.21	1.35	0.76	0.27	1.38	0.79	0.34
T_8: CAN @ 0.2 % FS	1.27	0.70	0.22	1.31	0.74	0.26	1.34	0.77	0.32
T_9: CAN @ 0.5 % FS	1.50	0.81	0.24	1.55	0.84	0.34	1.57	0.87	0.38
T_{10}: CAN @ 0.8 % FS	1.42	0.76	0.23	1.46	0.78	0.32	1.50	0.81	0.37
S.Em ±	0.01	0.01	0.02	0.01	0.01	0.01	0.00	0.01	0.02
CD @ 5 %	0.03	0.03	0.06	0.03	0.03	0.02	0.01	0.03	0.05

FS- Foliar spray; WS- Water spray; CAN- Calcium ammonium nitrate

Table.3 Effect of foliar spray of different sources and levels of calcium on total micro nutrient content of tomato leaves at different growth stages

Treatments	Total micronutrient (mg kg^{-1})											
	Vegetative stage				Flowering stage				Fruiting stage			
	Fe	Cu	Mn	Zn	Fe	Cu	Mn	Zn	Fe	Cu	Mn	Zn
T_1: Control (WS)	187.10	27.54	21.62	16.82	193.56	28.46	29.80	20.35	226.46	29.81	32.94	26.84
T_2: $CaCl_2$ @ 0.2 % FS	274.76	28.99	35.17	18.89	298.31	31.14	33.64	21.86	293.28	36.32	44.33	27.93
T_3: $CaCl_2$ @ 0.5 % FS	275.52	29.86	40.47	21.62	314.57	31.39	37.66	26.46	298.74	36.99	46.17	28.11
T_4: $CaCl_2$ @ 0.8 % FS	322.09	41.39	42.61	28.44	342.67	41.88	45.57	30.28	345.54	48.32	47.54	30.47
T_5: $CaNO_3$ @ 0.2 % FS	233.18	31.32	30.34	24.05	252.29	31.95	39.81	26.66	277.04	37.41	40.44	27.04
T_6: $CaNO_3$ @ 0.5 % FS	240.92	31.60	33.66	25.07	253.65	32.26	41.33	26.76	304.54	39.37	40.97	27.37
T_7: $CaNO_3$ @ 0.8 % FS	273.65	38.65	35.23	28.14	303.92	40.81	43.07	29.16	317.18	41.39	45.04	29.91
T_8: CAN @ 0.2 % FS	264.52	35.81	34.86	27.03	273.66	36.17	41.67	27.22	314.81	40.79	44.49	29.34
T_9: CAN @ 0.5 % FS	377.28	46.03	49.42	37.54	382.91	50.39	50.71	37.69	390.21	55.31	51.00	45.56
T_{10}: CAN @ 0.8 % FS	342.51	42.32	43.77	29.92	357.99	43.08	48.47	30.86	367.54	50.62	50.37	33.12
S.Em ±	1.97	0.54	0.56	0.41	3.47	0.70	1.52	0.78	1.64	0.75	0.56	0.37
CD @ 5 %	5.80	1.58	1.66	1.20	10.25	2.07	4.48	2.29	4.85	2.21	1.64	1.10

FS- Foliar spray; WS- Water spray; CAN- Calcium ammonium nitrate

Table.4 Effect of foliar spray of different sources and levels of calcium on pH, EC and nutrient content of tomato fruit at harvest

Treatments	pH	EC (dS m^{-1})	Primary nutrients content (%)			Secondary nutrient content (%)		
			N	P	K	Ca	Mg	S
T_1: Control (WS)	3.98	0.084	1.13	0.24	3.92	0.57	0.12	0.19
T_2: $CaCl_2$ @ 0.2 % FS	4.06	0.106	1.35	0.25	4.03	0.59	0.23	0.20
T_3: $CaCl_2$ @ 0.5 % FS	4.08	0.109	1.45	0.28	4.16	0.63	0.27	0.21
T_4: $CaCl_2$ @ 0.8 % FS	4.14	0.118	1.51	0.30	4.72	0.79	0.33	0.22
T_5: $CaNO_3$ @ 0.2 % FS	3.99	0.111	1.64	0.27	4.49	0.65	0.30	0.20
T_6: $CaNO_3$ @ 0.5 % FS	4.10	0.114	1.65	0.28	4.59	0.75	0.32	0.21
T_7: $CaNO_3$ @ 0.8 % FS	4.11	0.117	1.87	0.30	4.66	0.78	0.38	0.21
T_8: CAN @ 0.2 % FS	3.99	0.115	1.81	0.29	4.65	0.76	0.36	0.21
T_9: CAN @ 0.5 % FS	4.19	0.121	1.96	0.39	4.96	0.84	0.43	0.23
T_{10}: CAN @ 0.8 % FS	4.18	0.119	1.89	0.31	4.85	0.80	0.41	0.22
S.Em ±	0.02	0.18	0.01	0.01	0.04	0.00	0.00	0.01
CD @ 5 %	0.07	0.52	0.03	0.03	0.13	0.01	0.01	NS

Table.5 Effect of foliar spray of different sources and levels of calcium on nutrient uptake by tomato fruit

Treatments	Nutrient uptake (kg ha^{-1})					
	N	P	K	Ca	Mg	S
T_1: Control (WS)	82.55	18.62	273.74	46.03	11.69	12.27
T_2: $CaCl_2$ @ 0.2 % FS	99.46	21.50	388.39	48.89	19.06	14.86
T_3: $CaCl_2$ @ 0.5 % FS	116.90	22.38	396.34	52.79	22.62	16.00
T_4: $CaCl_2$ @ 0.8 % FS	117.86	23.04	405.82	68.55	31.64	18.20
T_5: $CaNO_3$ @ 0.2 % FS	120.60	20.76	338.91	54.13	25.92	14.64
T_6: $CaNO_3$ @ 0.5 % FS	128.58	21.02	343.47	63.74	27.21	17.99
T_7: $CaNO_3$ @ 0.8 % FS	162.73	22.29	380.61	67.38	30.60	17.89
T_8: CAN @ 0.2 % FS	138.92	21.74	368.80	64.62	28.63	17.68
T_9: CAN @ 0.5 % FS	166.97	27.26	438.70	77.26	39.55	18.43
T_{10}: CAN @ 0.8 % FS	166.48	26.78	429.41	69.86	35.80	18.40
S.Em ±	1.77	0.38	4.10	0.08	0.04	0.48
CD @ 5 %	5.22	1.11	12.31	0.23	0.13	1.43

FS- Foliar spray; WS- Water spray; CAN- Calcium ammonium nitrate

Presently, foliar fertilization is frequently applied in agricultural practice. This mode of fertilization should be recommended in plant production because it is environmental friendly and gives the possibility to achieve high productivity and good quality yields. The results presented in this experiments revealed that application of different Ca sources as foliar spray will enhance the nutrient content and uptake by tomato crop. All the sources of Ca found to be effective and significantly increased nutrient content and uptake. However, results of experiment demonstrated that tomato crops fertilized with 0.5 per cent CAN as foliar spray was most effective and higher use efficiency followed by foliar spray of $CaCl_2$ at 0.8 per cent compare to other sources and concentrations.

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