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Response of Hybrid Tomato *(Solanum lycopersiucm L)* for Calcium Nutrition: Growth, Root Traits and SPAD Index

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To evaluate the effect of various sources and levels of calcium fertilisation in improving the growth and SPAD index of hybrid tomato at different growth stages.
Study Design: Factorial randomized block design (FRBD) with three replications.
Place and Duration of Study: A field experiment was conducted in the farmer's field at Devarayapuram village, Thondamuthur block, Coimbatore from January to April, 2021.
Methodology: A field experiment was conducted with hybrid tomato *(Solanum lycopersiucm L)* Shivam by using various organic and inorganic calcium sources viz., calcium sulphate, calcium nitrate, calcium silicate, poultry manure and pressmud applied at different levels (0, 20, 40, 60, 80 kg Ca ha^{-1}) in a factorial randomized block design with three replications. The growth parameters such as plant height, root length, lateral root length, root volume and SPAD index were recorded as per standard protocols at different plant growth stages.
Results: A linear increase in the plant growth, root traits and SPAD index of hybrid tomato was noted by the addition of organic and inorganic sources of calcium and the highest values were observed with the application of 80 kg Ca ha^{-1}. Higher plant height (93.8 cm), root length (16.8 cm),

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lateral root length (13.3 g cc^{-1}) and SPAD index (62.0) was registered with poultry manure applied at 80 kg Ca ha^{-1} which was followed by pressmud applied at the same level. Skipping of calcium in the fertiliser schedule registered the lowest growth response of hybrid tomato at all the growth stages.

Conclusion: Inorganic Ca fertiliser sources though improved the growth, root traits and SPAD index of hybrid tomato at different growth stages, and it was comparatively lesser than the organic sources such as poultry manure and pressmud as calcium sources. The order of better growth performance was: Poultry manure > Pressmud > Ca silicate > Ca Nitrate > Ca sulphate. The lowest values of all the growth attributes were noted with NPK control. It was concluded that application of poultry manure at 80 kg Ca ha^{-1} would be effective in improving the growth, root traits and SPAD index of hybrid tomato.

Keywords: Calcium nutrition; hybrid tomato; SPAD; growth attributes; root traits.

1. INTRODUCTION

Calcium (Ca), the fifth most abundant element in the earth crust, plays an extremely important role in improving the plant growth. It act as secondary messenger which coordinate cellular activities and strengthens the plant cell by increasing the cell wall thickness. It also enhances the structural integrity of shoot and root of tomato plants [1], [2]. Calcium helps in nitrogen assimilation of plants which improves vegetative growth of plants. In plants, it helps in providing resistance against several diseases and alleviating stress [3]. Calcium translocated from root to shoot and other aerial organs through xylem by diffusion and root pressure gradient. Deficiency of calcium in plant occurs due to its immobility in soil and plant cells which lead to many physiological disorders like blossom end rot, bitter pit, tip burn and heart rot [4], [5], [6]. Calcium plays a most significant role in improving growth attributes such as plant height, root traits and photosynthesis in tomato plants.

Tomato, has more vitamins, minerals, antioxidants, dietary fibres hence is a more indispensible dietary component for its nutritious and phyto-chemical properties. It reduces the incidence of cancer, cataract formation, arteriosclerosis and cardiovascular diseases in human beings [7], [8]. Among all the essential nutrients, calcium has major role in achieving higher fruit yield and productivity of tomatoes. Calcium taken up by the tomato plants from soil is translocated slowly due its immobile nature [5], [9]. The deficiency of calcium in tomato fruits as blossom end rot is more noticeable and the literature concerning calcium fertilization using different calcium sources and levels on growth of tomato was scanty [10], [11]. Even in other crops such as apples, kiwi and apricot deficiency of calcium occurs due to its poor translocation to plants [2]. Hence, supplementation of calcium is essential for obtaining vigorous growth and development of tomato leaves, shoot, root and canopy. Therefore, a field study was conducted to know the response of tomato for Ca nutrition and to optimize various calcium sources and its levels for improving the growth, root traits and SPAD index of tomato.

2. MATERIALS AND METHODS

2.1 Experiment Description

A field experiment was conducted with two main factors including different calcium sources (Press mud, Poultry manure, Calcium silicate, Calcium Nitrate and Calcium sulphate) applied at five levels (0, 20, 40, 60 & 80 kg Ca ha^{-1}) on Factorial Randomized Block Design (FRBD) with three replications in the farmer's field (N 11º00.218, E 076º48.094) at Devarayapuram village, Coimbatore district. Recommended fertiliser nutrients such as Nitrogen, Phosphorus and Potassium were applied based on Soil Test Crop Response (STCR-IPNS) recommendation for a targeted yield of 70 t ha^{-1}. About 25 days old seedlings of tomato hybrid Shivam were transplanted with the spacing of 45 cm x 30 cm. Necessary plant protection measures were carried out as and when needed. The response of tomato plants for calcium nutrition at vegetative, flowering, fruiting and harvest stages was recorded and reported.

2.2 Experimental Soil Description

The experimental soil was sandy loam in texture with neutral pH (7.10) and belongs to Palaviduthi soil series. It has low available nitrogen (182 kg ha^{-1}), medium available phosphorus (21.3 kg ha^{-1}) and high available potassium (582 kg ha^{-1})

status. The secondary and micronutrients were sufficient in availability and the values were 288, 138, 11.2 mg kg^{-1} for calcium, magnesium and sulphur respectively. As regards the micronutrients, all are sufficient in availability and the values were 2.08, 13.5, 4.67, 1.84 and 0.59 mg kg^{-1} for zinc, iron, manganese, copper and boron respectively.

2.3 Measurement of Growth, Root Traits and SPAD Index

The plant height was measured randomly in ten plants from base of the plants to the tip of main shoot and the average of all plants was recorded at different growth stages viz., vegetative, flowering, fruiting and harvest and expressed in cm.

The root traits such as root length, lateral root length and root volume was measured at vegetative, flowering, fruiting and harvest stages of hybrid tomato plants. Root length was measured from base of the shoot to tip of root and expressed in centimetre (cm). Lateral root length was determined by measuring the length of nodal root and expressed in cm. The root volume was observed by immersing the washed root in a measuring cylinder filled with known quantity of water. The increase in volume of the water was measured and expressed in cubic centimetre (g cc^{-1}).

The SPAD index was measured on the fully expanded leaves (3^{rd} or 4^{th} leaf from apex) of hybrid tomato plants using the SPAD meter (SPAD 502, Minolta Camera Co. Ltd., Japan). Single SPAD index value for each treatment was measured from ten plants and the mean SPAD index was taken for comparisons.

2.4 Statistical Analysis

The data was analysed using AGRESS software version 7.01 to compare mean at least significant difference (P = 0.05). Wherever the treatment differences were found significant, critical differences (CD) were worked out at 5% level of significance and denoted by symbol * for 5% and ** for 1%. Non-significant comparisons were indicated as NS.

3. RESULTS AND DISCUSSION

3.1 Plant Height

The plant height, considered as the central part of plant ecology was strongly correlated with photosynthesis which was significantly enhanced by the application of different calcium sources and their levels at varied crop growth stages. Data showed significant increase in the plant height with increasing levels of calcium application which might be due to the involvement of calcium in enhancing the uptake of other nutrients such as nitrogen and boron [12]. Maximum plant height was recorded with poultry manure applied at 80 kg calcium ha^{-1} (93.7 cm) and minimum plant height was recorded in no calcium applied NPK control (75.3 cm) which was shown in Fig.1. Calcium helps in nitrogen assimilation which increases the vegetative growth of tomato plants [13], [5]. It also enhances the cell wall formation, cell wall integrity, cell division which in turn increases the vegetative growth. This increase in vegetative growth improved the photosynthetic efficiency of plants and resulted in higher growth and yield [14]. Application of poultry manure supplies many essential plant nutrients and provides better growing environment for improved plant growth [15-16].

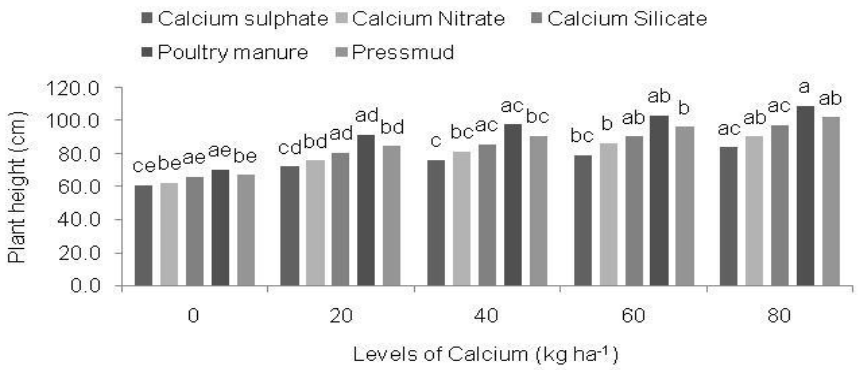

Fig. 1. Effect of various sources and levels of calcium on plant height at different growth stages of hybrid tomato (Error bars represents standard error n=3)

3.2 Root Traits

Root traits such as root length, lateral root length and root volume are important in plant growth attributes for better anchorage to plants, absorption and conduction of water and nutrients to shoots and storage of reserve food. Here also, all the root traits were significantly influenced by different calcium sources and its levels at different plant growth stages. Higher root length (16.8 cm), lateral root length (13.3 cm), root volume (7.37 g cc^{-1}) were recorded with poultry manure applied at 80 kg Ca ha^{-1} and lesser root length (11.4 cm), lateral root length (8.31 cm) and root volume (5.16 g cc^{-1}) was observed in the field where no calcium was applied (Figs. 2 & 3, Table 1).

Calcium addition being a structural element, strengthens cell wall, helps in cell division and cell elongation which positively influences the root traits of tomato plants [17], [18].

3.3 SPAD Index

The chlorophyll content in the plants is essential for photosynthesis which helps to channelize the energy of sunlight into chemical energy. The chlorophyll index (SPAD) at different plant growth period was measured and it was significantly influenced by various calcium sources and levels. The highest SPAD index was recorded with poultry manure applied at 80 kg Ca ha^{-1} (62.0) and the lowest (52.4) index was recorded with control plot where no calcium was applied (Table 2). This might be due to the role of calcium in enhancing the photosynthetic pigment synthesis and also conquers the degradation of chlorophyll pigment [19], [20]. The increase in chlorophyll index with calcium application might be also due to its role in regulating stomatal movement and reducing the respiration rate besides activating the enzymes NAD kinase which enhances NADP production led to increased photosynthesis [21].

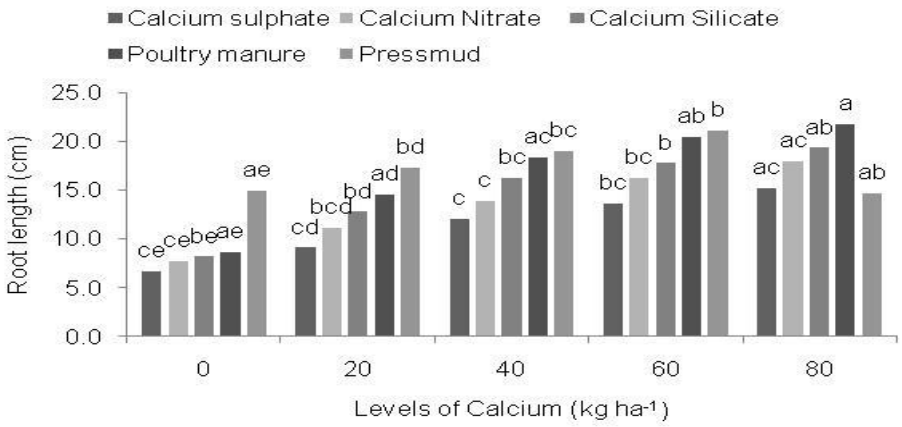

Fig. 2. Effect of various sources and levels of calcium on root length at different growth stages of hybrid tomato. (Error bars represents standard error, n = 3)

Table1. Effect of various sources and levels of calcium on lateral root length at different growth stages of hybrid tomato

Sources	Lateral root length (cm)					
	Levels of Calcium (kg ha^{-1})					
	0	20	40	60	80	Mean ± SD
Calcium sulphate	6.55^{abc}	7.05^{ab}	8.35^{ab}	8.95^{ab}	10.7^{ab}	8.31±1.63
Calcium Nitrate	6.85^{c}	8.15^{bc}	9.85^{ac}	11.1^{bc}	12.1^{ac}	9.59±2.11
Calcium Silicate	7.25^{bc}	9.85^{bc}	12.1^{abc}	13.0^{bc}	14.2^{abc}	11.3±2.73
Poultry manure	8.45^{ac}	12.8^{ab}	14.1^{ac}	14.9^{ab}	16.1^{a}	13.3±2.94
Press mud	7.75^{ac}	11.0^{ab}	12.3^{ac}	13.5^{ab}	14.7^{ab}	11.8±2.67
Mean ± SD	7.70±0.75	14.1±0.69	19.9±0.60	24.8±4.58	28.1±4.32	10.8±1.93
	S	L	St	S*L	S*St	S*L*St
SEd	0.09	0.08	0.07	0.18	0.16	0.35
CD (P=0.05)	0.13	0.16	0.14	0.35	0.31	NS

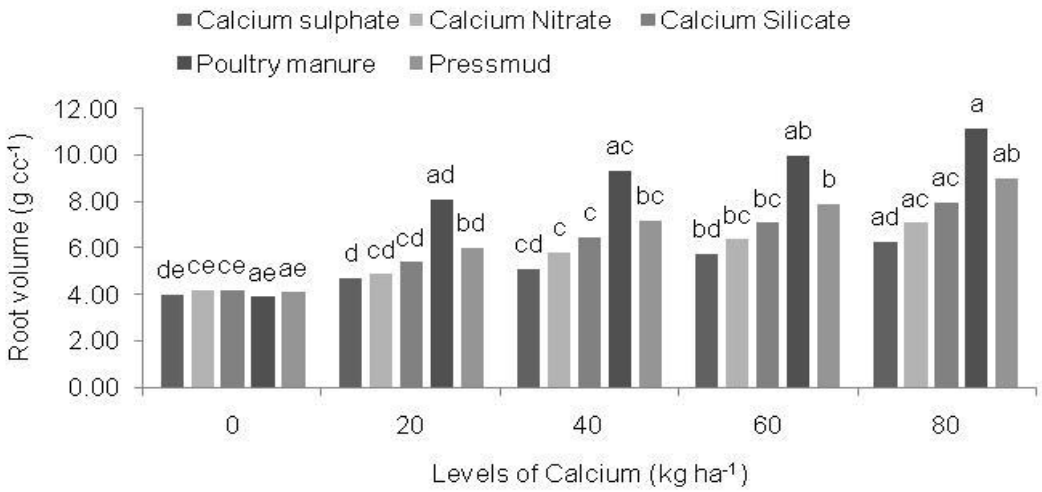

Fig. 3. Effect of various sources and levels of calcium on root volume at different growth stages of hybrid tomato (Error bars represents standard error, n = 3)

Table 2. Effect of various sources and levels of calcium on SPAD index at different growth stages of hybrid tomato

Sources	SPAD index					
	Levels of Calcium (kg ha^{-1})					
	0	20	40	60	80	Mean ± SD
Calcium sulphate	50.3^{cd}	51.7^{abc}	52.3^{cd}	53.3^{bc}	54.5^{ac}	52.4±1.59
Calcium Nitrate	49.1^{bd}	53.0^{ab}	54.7^{bcd}	55.9^{bc}	57.5^{ab}	54.0±3.22
Calcium Silicate	49.7^{cd}	55.8^{dc}	57.0^{cd}	57.9^{bc}	59.4^{ac}	56.0±3.73
Poultry manure	51.3^{abd}	60.0^{ab}	62.3^{abc}	65.4^{abc}	70.9^{ab}	62.0±7.26
Press mud	49.8^{bd}	57.6^{ab}	59.6^{bcd}	61.6^{bc}	63.7^{ab}	58.4±5.35
Mean ± SD	41.7±0.82	49.7±3.37	54.3±3.93	59.0±4.77	64.3±6.37	84.1±7.72
	S	L	St	S*L	S*St	S*L*St
SEd	0.66	0.67	0.59	1.48	1.32	2.09
CD (P=0.05)	1.30	1.40	1.16	2.92	NS	2.96

4. CONCLUSION

Results showed better growth response of hybrid tomato for various sources and levels of calcium fertilisation. Addition of organic manures as calcium sources (Poultry manure and Press mud) provided better soil environment and improved the growth, root traits and SPAD index of the crop at different growth stages than the inorganic fertiliser Ca sources. Application of 80 kg calcium as poultry manure significantly increased the growth attributes, SPAD index and root traits of hybrid tomato followed by pressmud applied at same level. Out of the three inorganic calcium sources, application of 80 kg Ca ha^{-1} as Calcium silicate recorded the better growth attributes followed by calcium nitrate > calcium sulphate. Inclusion of calcium in the fertiliser schedule increased the growth response of hybrid tomato due to its involvement in cell wall strengthening, cell wall elongation, enzyme activation and stress mitigation.

DISCLAIMER

The products used for this research are commonly and predominantly used products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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