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Response of Tomato to Different Levels of Calcium and Magnesium Concentration

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Abstract: An experiment was carried out at Agriculture Extension and Model Farm Service Center Timergara, Khyber Pakhtunkhwa, Pakistan during summer 2010 to investigate the response of tomato *(Lycopersicon esculentum* L.) cv 'Rio Grand' to different levels of calcium (Ca) and magnesium (Mg). The experiment was laid out in a randomized complete block design (RCBD) with two factors i.e. Ca and Mg levels; treatments were replicated three times. Three levels of Ca (0, 3 and 6%) and three levels of Mg (0, 2 and 4%) were applied as foliar spray and the data were recorded on plant height, number of branches plant^{-1}, number of flower cluster^{-1}, number of fruits clusrer^{-1}, number of fruits plant^{-1}, weight of fruit (gm), yield ha^{-1}(ton) and Blossom End Rot fruits%. Both Ca and Mg and their interaction significantly increased the growth and yield parameters. Among the different levels of Ca, 6% level showed significant increase in plant height (84.10 cm), number of branches plant^{-1} (6.35), number of flowers cluster^{-1} (24.42), number of fruits cluster^{-1}(5.68), number of fruits plant^{-1} (6.92), fruit weight (78.01 gm), yield ha^{-1} (21.14 tons) and low percentage of blossom end rot fruits (8.22). Magnesium also significantly affected growth and yield components. Among the different levels of Mg, 4% showed significant increase in plant height (85.68 cm), number of flowers cluster $^{-1}$(27.62), number of fruits cluster^{-1}(5.95), number of fruits plant^{-1} (6.22), yield ha^{-1} (20.26 tons) and less percentage of blossom end rot fruits (6.76). Based on the above results, it is recommended that 6% Ca concentration and 4% Mg concentration should be collectively applied to tomato for better growth and yield under the agro climatic conditions of Timergara Dir Pakistan.

Key words: Calcium · Concentration · Magnesium · Tomato

INTRODUCTION

Tomato (*Lycopersicon esculentum* L.), belonging to solanaceae family and second important vegetable after potato, is a well known vegetable grown all over the world. South America is the native origin of tomato and before Columbus its plants were brought to Europe by Red Indians and started cultivation. The plants of maximum size of tomato fruit have been taken from Peru to Italy, after that were taken to northern Europe and last to America in 1817 AD [1]. It was introduced to the Subcontinent (Indo-Pak) by the Europeans; later on local people also started its consumption due to its popularity. It is now used every where in the country in so many forms [2].

Tomato is a herbaceous plant with alternate leaves. The flowers are present in cluster on the stem between the nodes. Fruit of tomato is berry type having fleshy placenta and small kidney shaped seeds covered with short hairs. Fruit skin of different cultivars has deposition of cutin varying from cultivars to cultivars [3]. Tomato is a self pollinated crop, susceptible to high temperature, especially the large fruited fresh varieties. High night temperatures may lead to lower fruit set of small and seedless fruit development. Most favorable temperature

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for fruit set is 25-30°C [4]. All types of soil are suitable for tomato production including sandy and heavy clay with soil pH of 5.5 to 7.5 as the best ones. However sandy loam soil is considered best for early crop. Highest yields can be obtained by growing tomato in loam, clay loam and silty loam having enough organic matter [5].

Generally, a balanced supply of nutrients is essential for optimum yield and fruit quality. Calcium is an important nutrient that plays a key role in the structure of cell walls and cell membranes, fruit growth and development, as well as general fruit quality [6]. It enhances resistance to bacterial and viral diseases [7]. The Ca taken up from the soil is translocated to the leaves but very little goes from the leaves to the fruit [6]. Therefore, plants need a constant supply of Ca for vigorous leaf and root development and canopy growth [8]. Magnesium is a major constituent of cell wall [9]. It is vital for the process of photosynthesis and therefore for the life of the plant in general. It acts as a cofactor and activator of many enzymes and substrate transfer reactions [10]. Plants inadequately supplied with Mg show delay in reproductive phases. Although a lot of research work has been done on the requirements of tomato for major nutrients, but insufficient data is available on micronutrients requirements.

Keeping in view the importance of micronutrients, this study was initiated to find out the combined effect of Ca and Mg as foliar applications on the growth and yield of tomato.

MATERIALS AND METHODS

The experiment entitled "Response of tomato (*Lycopersicon esculentum* L.) to different levels of Ca and Mg" was conducted during summer 2010, at Agriculture Extension and Model Farm Service Center Timergara, Khyber Pakhtunkhwa Pakistan. The experiment was laid out in a Randomized Complete Block Design (RCBD), with two factors i.e. Ca levels as factor A and Mg levels as factor B. The experiment was replicated three times. Plant to plant distance was kept 30 cm and row to row distance of 100 cm. Planting was done on raised beds of about 45 cm height using transplanting of the available tomato cultivar Rio Grand. The basal dozes of N @ 150 kg ha^{-1}, P @ 100 kg ha^{-1} and K 60 kg ha^{-1} were applied by using urea, Triple Super Phosphate (TSP) and potassium sulphate sources. Phosphorus, K and half N were mixed with soil before transplantation, while the remaining N was applied after two weeks of transplantation.

Table 1: Calcium and magnesium levels used in the experiment

Calcium levels		Magnesium levels	
Ca0	0 %	Mg0	0 %
Ca1	3 %	Mg1	2 %
Ca2	6%	Mg 2	4 %

During the research all other cultural activities like weeding, hoeing, irrigation were carried out at proper time. Before foliar application water was sprayed on the plant to know the exact amount of water for foliar application. After that solution of Ca and Mg were prepared for each treatments and replication. The solutions were applied to the plant with help of a spraying pump. The Ca and Mg were applied as a foliar application twice i.e. before flowering and at fruit setting. Sources of Ca and Mg used were $CaCl_2$ and $MgCl_2$, respectively.

RESULTS AND DISCUSSION

Plant height (cm) and number of branches plant^{-1}: Plant height was significantly increased by Ca, Mg and their interaction. The plant height increased from 79.61 cm in the control to a maximum of 84.10 cm with 6% concentration of Ca. Magnesium at 4% concentration resulted in an increase in plant height from 78.57 cm in control to 85.68 cm. Regarding interaction 6% Ca and 2% Mg application resulted in an increase in plant height of 87.30 cm as compared to other treatments (Table 2). Calcium application increased plant height by activating enzymes for cell mitosis, division and elongation and thus height [9]. Deficiency of Ca and boron decrease plant height by decreasing mitotic activity in the terminal meristem [11]. Thus, the application of calcium chloride and borax increases plant height [12]. Calcium, Mg and their interaction significantly increased plant height. Number of branches plant^{-1} increased from 5.53 in control to 6.35 in plants treated with 6% concentration of Ca. Plants treated with 2% Mg resulted in more number of branches (6.62) as compared to other treatments. The combined application of Ca and Mg @4% + 2%, respectively resulted in more number of branches (7.30) as compared to other treatments (Table 2). The increase in number of branches plant^{-1} might be due to the role of Ca and Mg in cell division, mitosis and carbohydrate metabolism [13].

Number of Flowers Cluster^{-1} and Number of Fruits Cluster^{-1}: Foliar application of Ca and Mg either alone or in combination significantly affected the number of fruit cluster^{-1}. Maximum number of flower cluster^{-1} (24.42) in

Table 2: Effect of calcium and magnesium on growth and yield of tomato

Treatments	Plant height(cm)[1]	Number of branches plant^{-1}	Number of flowers cluster^{-1}	Number of fruits cluster^{-1}
Calcium levels				
Ca0	79.61 c	5.53 b	19.08 c	4.58 c
Ca1	83.13 b	6.20 a	23.30 ab	5.55 ab
Ca2	84.10 a	6.35 a	24.42 a	5.68 a
Magnesium levels				
Mg0	78.57 c	5.02 c	19.75 a	4.53 c
Mg1	83.50 b	6.62 a	21.92 b	5.39 b
Mg2	85.68 a	6.45 a	27.62 c	5.95 a
Ca ×Mg				
Ca0Mg0	76.22	4.95	16.78	3.95
Ca0Mg1	81.12	5.23	17.80	4.84
Ca0Mg2	83.33	4.97	24.87	5.32
Ca1Mg0	81.13	5.80	21.97	4.67
Ca1Mg1	84.95	7.30	24.43	5.70
Ca1Mg2	87.30	7.22	29.13	6.23
Ca2Mg0	78.80	6.05	20.43	5.15
Ca2Mg1	84.52	6.67	22.45	5.97
Ca2Mg2	86.40	6.58	29.88	6.51

Table 3: Effect of calcium and magnesium on growth and yield of tomato

Calcium and magnesium levels	Number of fruits plant^{-1}	Fruit weight (g)	Yield ha^{-1} (tons)	Blossom end rot fruits %
Calcium levels				
Ca0	4.29 d	70.23 c	17.72 c	15.97 a
Ca1	6.29 b	75.01 b	20.01 b	10.02 b
Ca2	6.92 a	78.01 a	21.14 a	8.22 c
Magnesium levels				
Mg0	5.14 c	73.78 c	18.03 c	17.86 a
Mg1	6.18 ab	78.24 b	20.09 ab	10.02 b
Mg2	6.22 a	88.52 a	20.26 a	6.76 c
Ca ×Mg				
Ca0Mg0	3.56	59.55	15.86	24.10
Ca0Mg1	4.50	71.83	18.82	13.00
Ca0Mg2	4.72	85.17	18.75	8.64
Ca1Mg0	6.45	64.55	18.39	14.00
Ca1Mg1	6.55	79.31	20.69	8.50
Ca1Mg2	6.60	88.93	21.23	5.84
Ca2Mg0	5.49	65.12	19.79	11.33
Ca2Mg1	7.28	84.83	21.38	7.22
Ca2Mg2	7.38	91.78	22.12	5.10

plants received Ca applied at the rate of 6% concentration. Magnesium application at the rate of 4% concentration resulted in increase in number of flowers cluster^{-1} (27.62) which was less in other treatments. Plants treated with 6% Ca and 4% Mg resulted in maximum number of flowers cluster^{-1} (29.88) as compared to other treatments. A number of scientists reported similar results [14, 15]. It is apparent from the results that number of fruits cluster^{-1} increased in plants treated with 6% Ca and 4% Mg alone. Maximum numbers of fruit cluster^{-1} were recorded in plants treated with combination of Ca and Mg of 6% and 4%, respectively. Number of fruit cluster^{-1} depends on the number of flower cluster^{-1}. Since the number of flowers cluster $^{-1}$ is more in plants treated with maximum amount of Ca and Mg. So number of fruits cluster^{-1} was maximum in these treatments. Calcium and magnesium are the vital nutrients for plant growth and have important role in photosynthesis, enzymes activation and carbohydrate metabolism [10].

Number of Fruits Plant^{-1} and Fruit Weight (Gm): Significant result was observed relating the number of fruits plant^{-1} in tomato in response to Ca and Mg varying concentrations. Maximum number of fruits plant^{-1} (6.92) was recorded in plants treated with 6% calcium concentration while it was less (4.29) in control.

Magnesium application @ 4% resulted in maximum number of fruits plant^{-1} (6.22); while minimum number of fruits plant^{-1} (5.14) was recorded in control. The number of fruits plant^{-1} was increased further from 3.56 to 7.38 with the combined application of 6% Ca and 4% Mg. Since the number of fruits plant^{-1} depends on the number of flowers and number of fruits cluster^{-1} along with nutrients uptake which were highest in plants treated with maximum amount of Ca and Mg. Also, Ca and Mg play important role in chlorophyll components, cell wall and membrane integrity, enhancing pollen germination and growth and activators of enzyme [16, 17]. Their deficiency may cause abscission of flowers. Therefore, the increase in number of fruits may be due to sufficient carbohydrate availability. Fruit weight increased significantly from 70.23 g to 78.01 g with 6% of Ca. It increased further from 73.78 g to 88.52 with 4% of Mg. However, the combined application of 6% Ca and 4% Mg resulted in higher fruit weight (91.78 g). Both Ca and Mg are involved in various cellular functions such as activation of enzymes, photosynthesis and carbohydrate metabolism, therefore there deficiency may cause poor fruit growth and yield [13].

Yield Ha^{-1} (Ton) and Blossom End Rot Fruits Percentage: The yield of plants treated with calcium and magnesium was significantly higher as compared to control plants. Yield was increased from 17.72 tons in control to 21.14 tons in plants received 6% calcium concentration. Maximum yield of 20.26 t was recorded in plants treated with 4% Mg while minimum yield (18.03 t) was recorded in control. Calcium and magnesium used combined (6% + 4%) resulted in increased yield of 22.12 t as compared to other treatments. Both Ca and Mg are the essential elements for the growth and yield of plants and act as the activators of enzyme [10]. Also Mg is important in the process of photosynthesis and therefore increases the production [10]. Final yield depends on so many factors such as nutrients uptake, number of fruits plant^{-1}and fruit weight. As Ca and Mg resulted in increase in these parameters, ultimately yield was increased. The application of Ca, Mg and their interaction significantly affected the rate of blossom end rot disorder. Blossom end rot disorder was less (8.22 and 6.76%) in fruits of plants treated with 6% Ca and 4% Mg, respectively as compared to control where it was maximum (15.97 and 17.86 %). The combined application of 6% + 4% Ca and Mg reduced blossom end rot disorder %. The decrease in blossom end rot disorder was with increase in Ca and Mg concentration. It is a physiological disorder caused by calcium deficiency [8]. Magnesium deficiency is also responsible for the increasing blossom end rot disorder in tomato [14]. It reduces fruit quality and market value [16]. These findings are also in agreement with the work of other researchers [15].

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