Foliar Application Effect of Boron, Calcium and Nitrogen on Vegetative and Reproductive Attributes of Tomato (*Solanum lycopersicum.* L)

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Abstract: The goal of this study was to observe the impact of different nutrients and their combinations on growth and yield of tomato (*Solanum lycopersicum.* L) cultivar named nagina was used at Horticultural Research Area, University of Agriculture, Faisalabad. Parameters like plant height, number of leaves per plant, number of flowers per plant, number of clusters per plant, number of flowers per cluster, number of fruits per plant, average fruit weight (g), yield per plant (kg), number of infected fruits per plant, total soluble solids%, Vitamin C at Fruit Ripening, fruit color were studied. Different combinations and concentrations of boron, calcium and nitrogen were used as treatments in earlier experiments to study their performance and the best one selected for tomato crop. The combinations used were T_0 (Control), T_1 (Boron = 0.1% solution), T_2 (Boron = 0.2% solution), T_3 (Calcium = 0.2% solution), T_4 (Calcium = 0.3% solution), T_5 (Nitrogen = 2% solution), T_6 (Nitrogen = 2% solution), T_7 (Boron = 0.1% + Calcium = 0.2% solution), T_8 (Boron = 0.1% + Calcium = 0.3% solution), T_9 (Boron = 0.2% + Calcium = 0.2% solution), T_{10} (Boron = 0.2% + Calcium = 0.3% solution), T_{11} (Boron = 0.1% + Calcium = 0.2% + nitrogen = 2% solution) and T_{12} (Boron = 0.2% + Calcium = 0.3% + nitrogen = 3% solution).
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Introduction:

Tomato (*Lycopersicon esculentum* L.) belongs to Solanaceae family and is an important vegetable crop of Pakistan. It is originated in the America where its indigenous name was tomati. From Maxico tomato was taken to Europe and then to Asia (Bashir *et al*. 1994). Tomato plant is classified as warm-season crop and it required about 25˚C to 29˚C for its growth (Gautam *et al*. 1982). The optimum range of daytime temperatures for the growth and development of tomato plants has been reported to be between 25 - 30°C, with an upper limit of 35°C for growth, yield and fruit quality of tomatoes. Temperature above freezing may cause damage to both plant and fruit (Zhang, 2010). Hundred grams of edible parts of edible parts of tomato contains 0.9 g protein, 0.1 g fat, 3.5 g carbohydrates, 15-20 Kcal energy, 500-1000 IU vitamin "A", 0.1 mg thiamine, 0.02 mg riboflavin, 0.6 mg niacin, 20-30 mg vitamin "C", 6-9 mg calcium, 0.8 g fiber and 0.3 mg iron. Tomato also has high medicinal values; vitamins are important bone growth, cell division and differentiation, maintaining surface lining of eyes, respiratory and intestinal tracts. Vitamin C is important in forming collagen, a protein that gives structure to bones, cartilage, muscles and blood vessels. It also helps in absorption of iron (Goplan *et al*. 1980). Boron is an essential and important micronutrient for the vegetative and reproductive growth of the tomato. Boron deficiency symptoms generally appear first on the younger leaves at the top of the plants; plants fail to produce functional flowers and may produce no seeds. Plants subjected to boron deficiency have been observed to result in sterility or low germination of pollen. Failure to set fruit is common, and the fruit may be ridged, show corky patches, and ripens unevenly (Gupta and Philip, 2006). Many physiological disorders have been studied in tomato and blossom-and rot is a main quality deteriorating physiological disorder that occurs worldwide wherever tomatoes are grown. This disorder resulted in direct fruit losses upto 50%. Most cultivars of tomato can be affected by this physiological disorder, although differences in susceptibility have been reported (Salunkhe and Desci, 1982). Blossom-end rot in tomato is characterized by brown pectinacious inclusions occurring in the epidermis and pericarp, at the stylar end of the fruit. Cell membranes become disorganized and tissue necrosis develops underneath, with the skin remaining intact. Calcium starvation is considered as a major

contributing factor for blossom end-rot in tomato (Adam *et al*., 1999). The nutrients applied through foliar method are instantly available to a plant that is why this method is better than others (Kuepper, 2003). An important practice in tomato production is the use of starter fertilizer, a mild fertilizer solution in the water used around each plant at transplanting. Starter fertilizers have soluble phosphate and nitrogen in ratio of 3-1. The high phosphate with some nitrogen encourages earlier root growth and rapid plant establishment (Firake *et al*. 1990).

Materials and Methods:

The experiment was conducted at University of Agriculture, Faisalabad, Pakistan during year 2011-2012. This field experiment was laid out in a Randomized Complete Block Design (RCBD) with twelve treatments + one absolute control which replicated thrice to investigate the effect of different concentrations and combinations of boron (boric acid), calcium ($CaCl_2$) and nitrogen (urea) as foliar application (3 sprays) at 10 days intervals on tomato. Crop was looked after properly. The following treatments were studied. (T_0) control (T_1), Boron 0.1% solution (T_2), Boron 0.2% solution (T_3), Calcium 0.2% solution (T_4), Calcium 0.3% solution (T_5), Nitrogen (Urea) = 2% solution (T_6), Nitrogen (Urea) = 3% solution (T_7), Boron (boric acid) = 0.1% + calcium chloride = 0.2% solution (T_8), Boron (boric acid) = 0.1% + calcium chloride = 0.3% solution (T_9), Boron (boric acid) = 0.2% + calcium chloride = 0.2% solution (T_{10}), Boron (boric acid) = 0.2% + calcium chloride = 0.3% solution (T_{11}), Boron (boric acid) = 0.1% + calcium chloride = 0.2% + nitrogen (urea) = 2% solution (T_{12}), Boron (boric acid) = 0.2% + calcium chloride = 0.3% + nitrogen (urea) = 3% solution. Data related to different parameters like plant height, number of leaves per plant, number of flowers per plant, number of clusters per plant, number of flowers per cluster, number of fruits per plant, average fruit weight (g), yield per plant (kg), number of infected fruits per plant, total soluble solids%, fruit color, lycopene content will be collected and analyzed using STATISTICA computer program. The least significant difference at 5% level of probability was used to test the differences among mean values (Steel and Torrie, 1984).

Results and Discussion:

Vegetative growth characters

Data presented in (Table 1) indicated that the vegetative growth characters of tomato, *i.e.,* plant height and number of leaves were significantly affected by the tested treatments. Clear also, that treatment T_{12} applying boron (0.2%) with foliar spraying by calcium (0.3%) plus nitrogen fertilizer (3%) gave the best plant growth parameters, then other treatments and T_0 (Control) was the lowest. These results might be due to availability and rapid uptake of nitrogen since it is a primary component of all nucleic acids, protein and chlorophyll.

On the other hand, boron plays an important role in activation of cell division and cell elongation. As well as calcium is important for proper cell division, cell elongation, cell wall development, Nitrate uptake and metabolism. Therefore, boron, calcium and nitrogen enhances the amount of metabolites necessary for building plant organs, consequently the vegetative growth of plants (Marschner, 1995). The obtained results are in general agreement with those reported by Ashiq (1993), Millia et al. (1996), Hussain et al., (2001), J. B. Jones. (2007) and Mustafa, et al., (2011).

Flowering traits

The effect of foliar sprays of boron, calcium and nitrogen on number of flowers/ plant, number of flower clusters / plant, number of flowers / cluster were significant in this experiment presented in (Table 2) in all treatments of the experiment T_{12} boron (0.2%) with foliar spraying by calcium (0.3%) plus nitrogen fertilizer (3%) reflected more number of flowers per plant, number of flower cluster per plant and number of flowers per cluster than other treatments. The obtained results seemed to be in general agreements with those reported by foliar application of boric acid significantly influence the flowering (Rajput et al, 2003). Application of nitrogen gave the best results in number of flower (Mishra, 1994), Walls, (1989), Balley, (1999), Tian, (1999) and Arif et al., 2006).

Table 1: Foliar application effect of boron, calcium and nitrogen on plant height and number of leaves per plant.

Treatments	Plant height (cm)	No. of leaves/ plant
T_0	64.933 c	20.167 f
T_1	83.733 abc	27.733 bc
T_2	87.467 ab	29.200 abc
T_3	81.433 abc	27.100 bc
T_4	81.867 abc	28.333 bc
T_5	69.333 bc	21.433 ef
T_6	74.733 abc	24.867 cde
T_7	77.000 abc	26.067 cd
T_8	72.200 abc	22.300 def
T_9	73.800 abc	22.533 def
T_{10}	88.467 ab	31.067 ab
T_{11}	78.333 abc	27.067 bc
T_{12}	90.400 a	33.067 a

Means followed by the same letter in a column do not differ significantly at $p \leq 0.05\%$

Table 2: Foliar application effect of boron, calcium and nitrogen on number of flowers per plant, number of flower cluster per plant and number of flowers per cluster.

Treatments	No. of flowers/ plant	No. of flower clusters/plant	No. of flowers/ Cluster
T_0	30.733 g	4.0667 d	4.0667 c
T_1	39.633 ad	5.0667 bcd	5.7333 abc
T_2	41.833 ab	6.1667 abc	6.6000 ab
T_3	38.067 ae	4.9667 bcd	5.6333 abc
T_4	41.300 ac	5.4000 abcd	5.7667 abc
T_5	31.833 fg	4.1667 d	4.5333 c
T_6	35.067 dg	4.6333 d	5.1667 abc
T_7	35.833 cg	4.8667 cd	5.3000 abc
T_8	32.400 eg	4.2667 d	5.0667 bc
T_9	33.967 dg	4.6333 d	5.0667 bc
T_{10}	42.833 ab	6.4000 ab	6.8333 ab
T_{11}	37.267 bf	4.9667 bcd	5.4000 ac
T_{12}	43.067 a	6.6333 a	6.9667 a

Means followed by the same letter in a column do not differ significantly at $p \leq 0.05\%$

Yield and its components

The data in Table (3) show that number of fruits per plant, fruit weight and yield per plant were significantly affected by different treatments, whereas, the maximum value of number of fruits, fruit weight and yield per plant was recorded in T_{12} (Boron (boric acid) = 0.2% + calcium chloride = 0.3% + nitrogen (urea) = 3%). It may also be stated that the sufficient application and the efficient absorption of N and foliar calcium and boron addition were promote the production of more photosynthesis required for good fruit tomato yield and its components. These results are in agreement with those reported by El-Shall *et al*. (2003), Moussa *et al*. (1993), Rauf *et al*. (1998), Wojcik and Lewondowski (2003).

Table 3: Foliar application effect of boron, calcium and nitrogen on number of fruits per plant, fruit weight and yield per plant.

Treatments	No. of fruits / plant	Fruit weight	Yield/ Plant
T_0	21.067 f	30.967 e	0.9000 c
T_1	27.967 ae	40.500 ac	1.5667 ac
T_2	29.067 ac	42.100 ab	1.7667 ab
T_3	26.400 bf	38.067 bd	1.5333 ac
T_4	28.600 ad	42.067 ab	1.7333 ab
T_5	22.167 ef	31.133 e	1.3000 bc
T_6	23.967 cf	33.900 ce	1.4667 ac
T_7	25.400 bf	35.067 ce	1.5000 ac
T_8	22.400 ef	31.267 e	1.3333 bc
T_9	22.733 df	33.067 de	1.4333 ac
T_{10}	30.167 ab	43.467 ab	2.0000 ab
T_{11}	26.067 bf	37.300 be	1.5333 ac
T_{12}	32.733 a	45.200 a	2.1333 a

Means followed by the same letter in a column do not differ significantly at $p \leq 0.05\%$

Conclusion:

In this experiment foliar application of boron, calcium and nitrogen were applied on tomato. Among all treatments in experiment T_{12} (Boron (boric acid) = 0.2% + calcium chloride = 0.3% + nitrogen (urea) = 3% solution) proved better results in all parameters (vegetative growth characters, flowering traits, and yield components) followed by T_{10} which shows nearly same effect then other treatments (Boron (boric acid) = 0.2% + calcium chloride = 0.3% solution) while T_0 (control) was found at the bottom among all treatments. On the basis of this experiment treatment T_{12} is recommended as best nutrients combination and concentration that can be used for the farmer practices to get better production.

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