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EFFECT OF DIFFERENT SOURCES AND LEVELS OF BORON ON GROWTH AND YIELD OF TOMATO (*Solanum lycopersicum*)

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ABSTRACT
A field experiment was conducted during 2016-17 on sandy loam soil at Nayanhalli village, Chintamani taluk, Chickaballapura district, Karnataka to study the effect of different sources (borax, boric acid and boron metalosate) and levels of boron on growth and yield of tomato (*Solanum lycopersicum*). The results of the experiment showed that treatment receiving recommended doses of NPK+FYM + 1.1 kg B ha^{-1} through borax as soil application + 0.05 per cent B through boron metalosate as foliar application recorded significantly higher plant height (105.01 and 126.76 cm), number of branches per plant (7.50 and 8.57) and chlorophyll content (39.23 and 33.45) at 60 and 90 days after transplanting of tomato. Similarly, significant increase in the yield parameters such as number of fruits per plant (40.33), ten fruit weight (865.67 g), fruit yield per plant (3.12 kg), fruit yield per plot (78.04 kg) and fruit yield (57.80 t ha^{-1}) were recorded highest in the treatment receiving 1.1 kg ha^{-1} B through soil and foliar application of 0.05 per cent boron metalosate along with recommended doses of NPK+FYM. Conclusively, combination of soil and foliar application of boron has got advantageous over only soil application of boron.

INTRODUCTION

Tomato (*Solanum lycopersicum*) is one of the most important and popular vegetable as it ranks third in the world's vegetable production, next to potato and sweet potato, and placing itself first as processing crop among the vegetables. Tomato is considered a heavy feeder of micronutrients and boron in particular is important (Srinivasamurthy *et al.*, 2003) role directly and indirectly in improving the yield and quality of tomato in addition to checking various diseases and physiological disorders (Magalhaes *et al.*, 1980). Boron improves the quality of tomato fruit, particularly size and shape, color, smoothness, firmness, keeping quality and chemical composition. Fruit shape, yield and shelf life of tomato were also improved by boron nutrition (Demoranville and Deubert 1987). It plays a vital role in the physiological processes of plants such as maturation, cell elongation and cell division, carbohydrate, protein and nucleic acid metabolisms, cytokinin synthesis, auxin and phenol metabolisms (Lewis, 1980). But boron deficiency is one of the major constraints to crop production (Sillanapaa, 1982), and has been reported in more than 80 countries and for 132 crops over the last 60 years (Shorrocks, 1997). In India, boron deficiency was initially reported 2 per cent in the year 1980 (Katyal and Vlek, 1995), which has now increased to 52 per cent (Singh, 2012).

Boron concentrations in soil vary from 2 to 200 mg B kg^{-1}, but generally less than 5-10 per cent is in available form to plants (Diana, 2006). Application of boron to soil is difficult to manage because typically very small amount is required, it is subjected to leaching, and the range of deficiency to toxicity level is very narrow (Reisenauer *et al.*, 1973). Majority of researchers found that foliar spray is more beneficial then soil application as they ensure uniform spread over the crop canopy, crop response is immediate and required in low rate (Mortvedt, 2000). However, to increase B use efficiency, the time of supplying boron to the crop should synchronise with the stage of their growth when the requirement for B are maximum or most critically important (Sarkar *et al.*, 2007). With this back ground present investigation was undertaken to study the efficiency of combined soil and foliar spray application on growth and yield of tomato.

MATERIAL AND METHODS

A field experiment was conducted during 2016-17 at Nayanhalli village, Chintamani taluk, Chickaballapur district. The experimental site is situated in Eastern Dry Zone (Zone 5) of Karnataka at 11° 53¹ N latitude and 76°57¹ E longitude at an elevation of 600 m above mean sea level. Soil was collected in bulk from different points of field. Then air dried, sieved and analysed for different soil properties and found that soil was of sandy clay loam texture (Piper, 1966) having pH of 6.8 (Jackson, 1973), organic carbon of 0.72 per cent (Walkley and Black, 1934), 286.3 kg ha^{-1} of available nitrogen (Subbiah and Asija, 1956), 27.5 kg ha^{-1} of available phosphorous (Jackson, 1973), 254.3 kg ha^{-1} of available potassium (Jackson, 1973) and 0.32 ppm of available boron (John *et al.*, 1975). The experiment was laid out in a randomized complete block design with ten treatments and three replications. The treatment details are given in Table 1.

Land was converted into required sized plots and levelling was ensured within each plot. The seedlings of 25 days old, vigorous and uniform size were transplanted on each bed in two rows followed a spacing of 120 x 45 cm^2 at a shallow depth of 2 to 2.5 cm and recommended dose of fertilizer (250:250:250 N, P_2O_5, K_2O kg ha^{-1}) and 10 t ha^{-1} of FYM were applied. The fertilizers used to supply NPK were urea, single super phosphate (SSP), muriate of potash (MOP), respectively. Half dose of nitrogen and full dose of P and K was mixed with soil before transplantation, while the remaining N was applied after two weeks of transplantation. Boron was applied through three different sources such as borax, boron metalosate and boric acid.

Borax was applied to soil during major nutrient application and boric acid and boron metalosate were applied during vegetative stage and fruit set stage as per the treatment. Growth parameters such as plant height, number of branches per plant and chlorophyll content were recorded at 30, 60 and 90 days after transplanting. Plant height was measured from the ground level to the tip of the main stem and chlorophyll content was recorded by SPAD-502. Yield parameters such as number of fruits per $plant^{-1}$, 10 fruit weight at 3rd, 5th and 8th picking and total fruit yield $plant^{-1}$ at harvest were recorded. The observations recorded in these studies were analysed statistically for test of significance following the Fisher's method of analysis of variance (ANOVA) as outlined by Cochran and Cox (1965). The level of significance on 'F' test was tested at five per cent. The results have been discussed based on critical difference at $p = 0.05$. Wherever the treatment differences were found non-significant, it is denoted as 'NS'.

RESULTS AND DISCUSSION

Growth parameters

Observations regarding effect of different sources and levels of boron on growth of tomato *i.e.*, plant height, number of branches per plant and chlorophyll content at different growth stages are presented in Table 2. The results of the experiment revealed that the application of different sources and levels of boron with recommended dose of fertilizers (NPK) as per different treatments had significant influence on crop attributes at 60 and 90 days after transplanting (DAT). However, at 30 DAT the increase was not found significant, that might be due to late response of crop to the treatments. At the later stage of crop growth, it was revealed that plant height (105.01 and 126.76 cm), no. of branches (7.50 and 8.57) and chlorophyll content (39.23 and 33.45) were significantly increased in the T_{10} treatment of NPK+FYM + 1.1 kg ha^{-1} B through borax + 0.05 per cent B through boron metalosate as foliar application at 60 and 90 DAT, respectively. However, it was found to be on par with the plant height (102.19 and 123.87 cm), no. of branches (7.30 and 8.47) and chlorophyll content (36.23 and 31.20) of T_9 treatment which received NPK+FYM + 0.82 kg ha^{-1} B through borax + 0.05 per cent B through boron metalosate as foliar application at 60 and 90 DAT, respectively (Fig. 1 and 2). In the present investigation increase in growth attributes might be due to association of boron with the development of cell wall and cell differentiation and hence, helps in root elongation and shoot growth of plant. Similar findings were also reported by Patel *et al*. (2007). There is perceptible increase in the plant height, number of branches and chlorophyll content of tomato plant which might be attributed that metalosate is amino acid chelated product, neutral in pH, 100 per cent soluble in water there by boron is easily penetrate to cuticle and enhance the growth attributes of tomato crop. Similar results of increase in growth parameters are recorded by Singh and Verma (1991). Foliar application of 100 ppm of boric acid three times *viz*., 40, 50, 60 days after transplanting produced significant improvement in growth parameters of tomato which might be due to the enhanced photosynthetic activity and metabolic activity with the application of boron (Lalit and Srivastava, 2004). Boron increased plant height and number of branches of tomato plant by promoting root growth and no of branches per plant (Bose and Tripathi, 1996). Yadav *et al*., 2001 indicated that the highest chlorophyll content was obtained with the optimum 1ppm of boron. The improvement in growth attributes as a result of B application may be due to the enhanced photosynthetic and metabolic activity which leads to an increase in various plant metabolic pathways responsible for cell division and elongation (Hatwar *et al*., 2003). The photosynthesis enhanced in the presence of B indicates that it

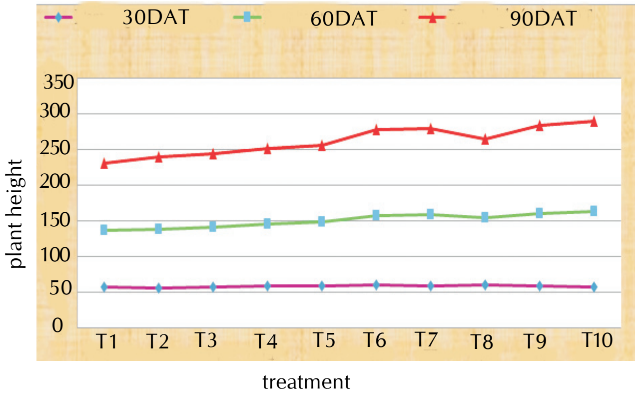

Figure 1: Plant height (cm) of tomato at different growth stages as influenced by different sources and levels of boron

Table 1: Treatment details

T_1	NPK + FYM
T_2	T_1 + 1.1 kg ha^{-1} Boron through Borax as Soil application
T_3	T_1 +1.6 kg ha^{-1} Boron through Borax as Soil application
T_4	T_1 + 2.2 kg ha^{-1} Boron through Borax as Soil application
T_5	T_1 + 0.55 kg ha^{-1} Boron through Borax as Soil application + 0.05 % Boron through Boric acid as foliar spray
T_6	T_1 + 0.82 kg ha^{-1} Boron through Borax as Soil application + 0.05 % Boron through Boric acid as foliar spray
T_7	T_1 + 1.1 kg ha^{-1} Boron through Borax as Soil application + 0.05 % Boron through Boric acid as foliar spray
T_8	T_1 + 0.55 kg ha^{-1} Boron through Borax as Soil application + 0.05 % Boron through Boron metalosate as foliar spray
T_9	T_1 + 0.82 kg ha^{-1} Boron through Borax as Soil application + 0.05 % Boron through Boron metalosate as foliar spray
T_{10}	T_1 + 1.1 kg ha^{-1} Boron through Borax as Soil application + 0.05 % Boron through Boron metalosate as foliar spray

Table 2: Plant height of tomato at different growth stages as influenced by different sources and levels of boron.

Treatments	Number of branches			Plant height (cm)			Chlorophyll content		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
T_1	4.11	5.53	6.32	57.70	80.33	93.62	10.81	18.76	16.75
T_2	4.04	5.77	6.87	56.68	82.66	101.28	11.01	21.84	19.52
T_3	4.14	5.99	7.22	57.82	84.50	103	10.42	24.14	21.56
T_4	4.35	6.08	7.84	58.94	87.23	106.11	11.90	25.48	22.77
T_5	4.43	6.30	8.07	60.17	89.66	106.77	11.39	27.56	24.63
T_6	4.50	6.79	8.33	61.20	97.30	119.88	11.63	31.23	28.23
T_7	4.45	7	8.37	59.76	100.11	119.95	10.42	33.52	31.2
T_8	4.62	6.47	8.07	60.70	95.03	109.47	11.90	29.35	26.21
T_9	4.72	7.30	8.47	58.94	102.19	123.87	11.70	36.23	31.2
T10	4.61	7.50	8.57	58.74	105.01	126.76	11.10	39.23	33.45
SE.m. ±	0.22	0.29	0.28	1.75	2.72	3.55	0.49	1.97	1.77
CD (5%)	NS	0.86	0.83	NS	8.08	10.56	NS	5.86	5.25

Table 3: Yield and yield attributes of tomato as influenced by different sources and levels of boron

Treatments	No. of fruits per plant	10 fruit weight(g)	Yield parameters Fruit Yield (kg/plant)	Yield /plot (kg)	Yield/ha (t/ha)
T_1	22.67	533.46	2.05	51.25	38.05
T_2	25.08	547.96	2.24	56.08	41.71
T_3	26.44	637.32	2.34	58.42	43.52
T_4	29.33	712.52	2.40	59.95	44.48
T_5	31.20	722.97	2.46	61.58	45.78
T_6	34.49	777.67	2.63	65.87	48.96
T_7	37.33	816.71	2.78	69.41	51.59
T_8	34.20	732.33	2.60	65.11	48.39
T_9	38.67	838.63	3.01	75.24	55.92
T10	40.33	865.67	3.12	78.04	57.8
SE.m. ±	1.33	22.36	0.16	3.55	2.96
CD (5 %)	3.95	66.43	0.48	10.56	8.8

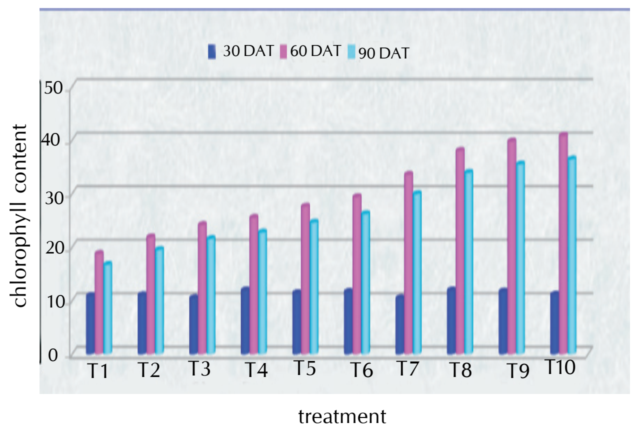

Figure. 2: Chlorophyll content of tomato plant at different growth stages as influenced by different sources and levels of boron

helps to activate the synthesis of tryptophan and precursor of indole acetic acid (IAA) which is responsible for stimulation of plant growth and accumulation of biomass (Kumar and Singh, 2018)

Yield parameters

The yield attributing parameters such as number of fruits plant^{-1}, ten fruits weight (g), fruit yield per plant (kg), fruit yield per plot (kg) and fruit yield (kg) in tomato are significantly influenced by different sources and levels of boron (Table 3).

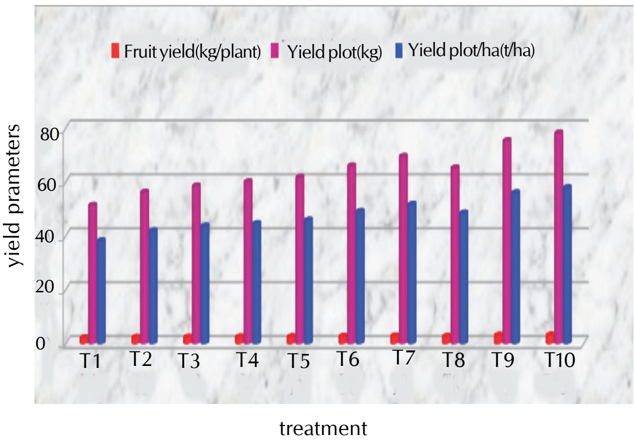

Figure 3: Yield parameters of tomato as influenced by different sources and levels of boron

Application of boron recorded 9.61 - 51.90 per cent increase in yield per hectare compare to farmers input (NPK+ FYM). Among different treatments, the physical parameter of fruits such as number of fruits (40.33), ten fruits weight (865.67 g), fruit yield per plant (3.12 kg), fruit yield per plot (78.04 kg) and fruit yield per hectare (57.80 kg) were recorded significantly higher in treatment T_{10} (T_1 + 1.1 kg ha^{-1} B through borax as soil application + 0.05 *per cent* B through boron metalosate as foliar application) (Fig. 3). This might be due to metalosate is an amino acid chelated product, neutral in pH, 100 per cent soluble in water there by boron content in metalosate might have easily penetrate to cuticle and enhance the yield attributes of tomato crop. Significant increase in yield attributes may be associated partly to the low status of boron in the soil under study and partly to the greater requirement of the nutrient by the crop (Ganie *et al*., 2014). Increase in fruit yield may be attributed that chelated metalosate is a liquid fertiliser, rapidly absorbed, helps in translocation of photosynthates to sink (fruit) and metabolized by plants as the application of boron metalosate increased 12.03 to 22.14 per cent yield per hectare over boric acid foliar application. The results are in line with the findings of Yadav *et al*. (2001), Lalit and Srivastava (2004) reported higher yield of fruit by soil and foliar application of boron rather than soil application alone. The improvement in plant growth might be due to enhancement in photosynthetic and other metabolic activities, which lead to an increase in plant metabolism. Similar results were also reported by Meena *et al*. (2015). Boron helps in the absorption of water, carbohydrate metabolism and its deficiency may cause sterility, small fruit size and poor yield (Haque , 2011), as boron is an important nutrient involved in the physiological processes of reproductive organs like stigma receptivity, pollen viability *etc*. which are very vital for the successful flowering, pollination and fertilization (Layek *et al*., 2014).

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