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Effect of bio-regulators and boron on growth and yield attributes of chilli (*Capsicum annuum* L.)

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Abstract
Chilli is one of the most commercially grown vegetable for its pungent fruits. Chillies are known to be very susceptible to periodic changes in climatic conditions and disseminating pests and diseases. Many scientists reported that the application of bioregulators as well as micronutrient application would be helpful increasing crop productivity. So, the current study was conducted in RCBD design with nine treatments of different concentrations of plant bioregulators and micronutrients using three replications. The results have shown that among the various treatments, foliar application of triacontanol at 0.25 percent (T2) recorded significantly maximum plant height (72.05 cm), canopy spread (N-S and E-W) (62.23 and 56.23 cm, respectively). However, the foliar application of boron at 0.10 percent (T8) recorded significantly maximum fruit length (12.30 cm), fruit girth (14.78 mm), 100 fresh fruit weight (615.00 g) and green chilli yield (34.17 t/ha). The obtained results can be correlated with biochemical changes in crop over the application of bioregulators and micronutrients in future.

Keywords: Chilli, bio- regulators, RCBD, micronutrients and productivity

Introduction
Chilli is a herbaceous or semi-woody annual or perennial. Its chromosome number is n = 12 (Thamburaj and Singh, 2003) [15]. Chilli is an often-cross pollinated crop. It is considered to be a good source of vitamin-C (ascorbic acid). Moreover, it also acquired great importance for its oleoresin content, which permits better distribution of colour and flavour of the food. Whereas the red colour extract is the attribute of carotenoid pigment capsanthin (0.2%-0.5%) (Choudhury, 1967) [5]. The production of chilli is governed not only by the inherent genetic yield potential but is greatly influenced by several environmental factors and management practices which adversely affect the yield of chilli. A multitude of biotic and abiotic variables have a negative impact on the production of chilli. Dropping of flower buds, flowers and early fruits from the plant as a result of a hormonal and physiological imbalance in the plant is also one of the crucial factors that greatly reduce chilli output. (Chaudhary *et al*., 2006) [3].

One of the most promising technologies to tackle these rising challenges consist of the use of plant bio-regulators which include natural substances, other than fertilizers and pesticides, able to promote plant growth and yield also, improve produce quality as well as resource use efficiency when applied to the crop in low quantities (Pelt and Popham, 2007) [11]. However, it has been realized that the deficiency of micronutrients has grown in both magnitude and extent affecting the productivity of chilli in certain areas (Bose and Tripathi, 1996) [2] due to intensive cropping, loss of top soil by erosion and leaching, decreased availability and use of farm yard manure (Fageria *et al*., 2002) [7]. This has become a major constraint to the production and productivity of vegetables in general and chilli in particular. Therefore, proper plant nutrition through micronutrients is one of the important factors in improving the growth, yield and quality of crops. Therefore, plants should be fed with nutrients continuously in order to get a higher yield. This study was carried out in compliance with existing literature on the promoting role of bio-regulators and boron in chilli.

Materials and Methods
Place and climate
This study was carried out at Amble village of Chikkamagaluru district. It is situated in South Western part of Karnataka between 12° 54´ 42´´ and 13° 53´ 53´´ North latitude and between 75° 04´ 46´´ and 76° 21´ 50´´ East longitude and at an altitude of 1090 meters above the mean sea level. The temperature varies from 11-20 °C during *winter* to 25-32 °C during summer season.

Experimental design

The experiment was laid out in Randomized Complete Block Design (RCBD) and replicated thrice. The distance of about 50 cm between replication and 30 cm between two plots. The plot size was 5.0 m × 4.0 m. Treatments were distributed randomly in the plots within the blocks. In a whole 9 treatments were administered to their respective plot in the field layout. The complete treatment application details were mentioned in table no. 1.

Record of observation

The parameters like (a) plant height measured from tip to collar of plant using measuring scale in terms of centimetre; (b) canopy spread measured in terms of centimetre for north-south and east-west direction; (c) Fruit length measured from basal tip to calyx attachment using measuring ruler in terms of millimeter; similarly, (d) Fruit girth using vernier calliper at the highly bulged portion in terms of millimeter; (e) fruit weight was measured using weighing balance for one hundred fruits in terms of grams; finally, (f) yield per hectare was calculated based on hectare plant population in terms of tonnes per hectares.

Statistical analysis

The analysis of variance (ANOVA) for randomized complete block design was estimated using WASP *V.2.0.* the general statistical and data computation was done using Microsoft excel tool.

Results and Discussion

Plant height

Among the treatments studied, the treatment T2: (Triacontanol @ 0.25%) recorded significantly maximum plant height at 60 and 90 DAT (54.20 and 72.05 cm respectively). While T1: (Control) recorded minimum plant height at 60 and 90 DAT (40.39 and 59.01 cm) (Table 2). One of the most obvious signs of growth is an increase in plant height and it is an important character in plant vigour. The plant height was dramatically affected by the application of triacontanol. It might be due to the increased activity of meristematic cells, cell division, cell enlargement, increased internodal length and metabolic efficiency all contributed to the increase in height and resulted in better vegetative growth. A similar increase in height of the plant was also in chilli by Verma (2020) [17] and Sarwar *et al*. (2022) [12].

Canopy spread

Significantly maximum canopy spread (N-S and E-W) was noticed in the treatment T2: (Triacontanol @ 0.25%) at 60 and 90 DAT (40.28, 62.23 and 33.56, 56.23 cm, respectively). While T1: (Control) recorded minimum canopy spread at 60 and 90 DAT (29.78, 48.51 and 23.53, 41.51 cm, respectively) (Table 2). An increase in canopy spread might be due to the endogenous application of triacontanol which facilitates numerous plant metabolic activities leading to better growth and development. The positive role of triacontanol in enhancing photosynthesis activity is evident from the increase in the root growth system, higher water uptake of the plant could be the reason for an increase in the canopy plant. Photosynthesis has been implicated as an important plant response to triacontanol (Eriksen *et al*. 1981) [6] and the increased canopy spread was attributed to improved photosynthesis, stimulated respiration and enhanced accumulation of photosynthates. This could presumably be attributed to an increase in the number and size of chloroplasts as revealed by Chen *et al*. (2003) [4]. The results are in line with the work of Sharma (1995) [13] in tomato.

Fruit length and fruit girth

Significantly maximum fruit length (12.30 cm) and fruit girth (14.78 mm) were recorded in the plant treated with T8: (Boron @ 0.10%). While T_1: (Control) recorded minimum fruit length (10.21 cm) and fruit girth (10.54 mm) (Table 2). This increase in length and girth might be due to greater photosynthesis owing to the greater accumulation of carbohydrates and translocation of food materials to reproductive parts. Wojcik & Wojcik (2003) [18] suggested that it might be due to cell division, quicker multiplication of cells in the reproductive organs and more accumulation of photosynthates which were synthesized in the leaf and translocated towards the fruit. The results are in agreement with the earlier findings of Ashraf *et al*. (2020) [1], Malik *et al*. (2020) [10] and Kamalakannan *et al.* (2021) [9] in chilli.

100 fresh fruit weight

Significantly maximum 100 fresh fruit weight (615.00 g) was recorded in the treatment T_8: (Boron @ 0.10%). While T_1: (Control) recorded a minimum 100 fresh fruit weight (577.00 g) (Table 2). Significantly maximum 100 fresh fruit weight was associated with an increase in the size of the fruit. As the fruit length and fruit girth increased 100 fresh fruit weight also increased. It might be due to the role of boron in the accumulation of photosynthates that has a correlation with fruit weight, because boron expanded the cells, causing cell division and work in the volume of intercellular space in mesocarpic cells in addition to quick translocation of metabolites to fruits reported by Shukha (2011) [14]. These results are in line with Ashraf *et al*. (2020) [1] and Malik *et al*. (2020) [10] in chilli.

Green chilli yield

Significantly maximum green chilli yield (34.17 t/ha) was recorded in the treatment T8: (Boron @ 0.10%). While T_1: (Control) recorded minimum green chilli yield (28.23 t/ha) (Table 2). It might be attributed to the role of boron in pollen tube elongation, better fertilization, utilization of nutrients resulting in rapid cell division, synthesis of native auxins and increased translocation of metabolites which reduced flower drop resulting in increased flower and fruit set. According to Verma *et al*., 1973 [16], boron not only affects the formation and accumulation of different fractions of carbohydrates but also its utilization for normal physiological and metabolic processes in the plant. Hatwar *et al*. (2003) [8] suggested that foliar application of boron speeds up the process of photosynthesis which resultantly increased the photosynthates (CH_2O) by the result of which increased the number and weight of fruits and ultimately increased the yield per plant and hectare. The results are in agreement with the earlier findings Ashraf *et al*. (2020) [1] and Kamalakannan *et al.* (2021) [9] in chilli.

Table 1: Detail of bio-regulators and boron foliar spray formulation for treatment application

Sl. No.	Treatment	Concentration	Brand Name	Formulation
1.	Control	-	-	Normal Irrigation Water
2.	Triacontanol	0.25 %	Vishal® 0.1% E.W.	To prepare 0.25 and 0.50 per cent triacontanol solution, 2.5 and 5.0 ml of Vishal® was dissolved in some quantity of water respectively and the final volume was made to 1000 ml.
3.		0.50 %		
4.	Sea Weed Extract	0.25 %	Biovita®	To prepare 0.25 and 0.50 per cent seaweed extract solution, 2.5 ml and 5.0 ml of Biovita® was dissolved in some quantity of water respectively and the final volume was made to 1000 ml.
5.		0.50 %		
6.	Humic Acid	0.25 %	Humigro®	To prepare 0.25 and 0.50 per cent humic acid solution, 2.5 ml and 5.0 ml of Humigro® was dissolved in some quantity of water respectively and the final volume was made to 1000 ml.
7.		0.50 %		
8.	Boron	0.10 %	Solubor® Boron 20 %	To prepare 0.10 and 0.20 per cent boron solution, 1.0 and 2.0 g of Solubar® were dissolved in some quantity of water respectively and the final volume was made to 1000 ml.
9.		0.20 %		

Table 2: Effect of bio-regulators and boron on growth and yield attributes of chilli.

Treatments	Parameters						
	Plant height (cm)	Canopy spread (cm)		Fruit length (mm)	Fruit girth (mm)	100 fruit wt. (g)	Yield(t/ ha)
		N-S	E-W				
T_1	59.01	48.51	41.51	10.24	10.54	577.00	28.23
T_2	72.05	62.23	56.23	11.40	14.10	608.00	33.01
T_3	65.30	55.43	48.62	10.39	11.63	581.10	29.90
T_4	64.29	53.91	45.47	10.32	11.21	579.00	29.08
T_5	70.98	60.05	53.21	11.46	13.83	606.00	32.09
T_6	61.27	50.23	42.62	9.85	11.02	578.01	28.74
T_7	67.38	58.31	49.20	10.78	13.12	600.00	31.20
T_8	68.21	59.56	50.83	12.30	14.78	615.00	34.17
T_9	62.29	52.23	43.31	10.50	12.24	589.09	30.48
S. Em±	0.81	0.69	0.66	0.16	0.14	2.10	0.33
CD @ 5%	3.35	2.87	2.71	0.66	0.59	6.80	1.12

*Significant at 5 percent level, T_1: Control, T_2: Triacontanol @ 0.25%, T_3: Triacontanol @ 0.50%, T_4: Sea Weed Extract @ 0.25%, T_5: Sea Weed Extract 0.50%, T_6: Humic Acid @ 0.25%, T_7: Humic Acid @ 0.50%, T_8: Boron 0.10%, T_9: Boron @ 0.20%

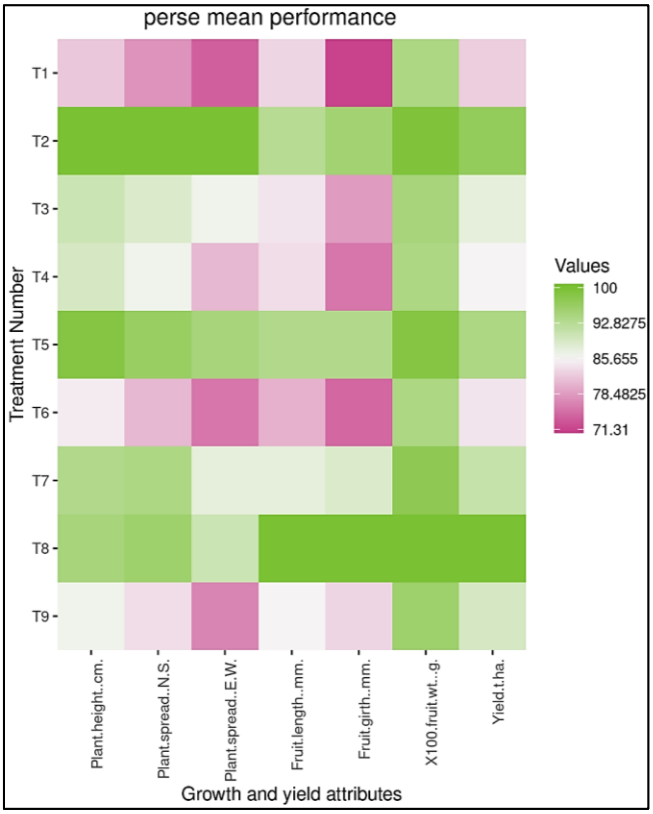

Fig 1: Heatmap of perse mean performance of plant growth and yield attributes over different plant bio-regulator and boron concentration in mode of foliar application

Conclusion

India ranks first in chilli cultivation area in the world and ranks seventh to eight in position in productivity due to climate change impact, pest and disease occurrence as well as poor agronomic practices. In order to tackle such problems, we need to improve our package of practice and proper management of micronutrient. With this view we conducted an experiment to investigate the proper dosage of bio-regulator as well as boron in enhancing crop productivity. Finally, the experiment was ended up with the result of triacontanol at 0.25 percent and boron at 0.10 percent resulted better performance in terms of growth and yield of chilli crop respectively in mode of foliar application.

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