RESEARCH ARTICLE

EFFECT OF SOIL AND FOLIAR APPLICATION OF BORON ON YIELD AND QUALITY PARAMETERS OF CAULIFLOWER (*BRASSICA OLERACEA* VAR *BOTRYTIS* L.)

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Abstract: A field experiment entitled "Studies on soil and foliar application of boron on soil properties, growth, yield and quality of cauliflower (Brassica oleracea var. botrytis L.)" was carried out in farmer's field during Kharif 2018. The experiment was laid out in a RCBD with nine treatments which were replicated thrice. Yield and quality parameters significantly influenced by combined soil and foliar application of different sources and levels of boron. The results of the experiment indicated that significantly higher curd diameter (16.91 cm), curd weight (0.988 g), yield plot^{-1} (23.81 kg), yield ha^{-1} (36.74 t) and higher quality parameters *viz.*, Total soluble solids (6.06^{o}Brix) and ascorbic acid (61.24 mg 100g-1) content was recorded in treatment which received combined application boron (T_9). Lowest values were recorded under control treatment which received only recommended dose fertilizer (T_1). Hence the combined soil and foliar application significantly influence the yield and quality of cauliflower.

Keywords: Boron, Cauliflower, Foliar application, Soil application, Yield

INTRODUCTION

The micronutrients are those which are required in small quantities also called as trace elements. Even though they are required in small quantities, play an important role as that of macronutrients. Among the micronutrients boron is a nonmetal nutrient element required by the plants.Boron plays an important role in cell wall synthesis, root elongation, sugar translocation, nucleic acid metabolism, lignification, pollen grain germination and tissue differentiation. In soil it is available in both organic and inorganic forms which is made available to plants through decomposition of organic matter and/or dissolution of boron containing minerals. Plant absorbs boron in the form of borate (BO_3^-), $H_3BO_3$and its availability in soil is influenced by soil pH and availability decreases with increase in pH. The deficiency of boron affects the growing tips of plant which leads to proliferation of branches. The branches and new leaves are distorted and becomes thick, brittle and also show mottled chlorosis. Root growth also affected by boron deficiency. Under boron deficiency, normal cell wall expansion is disrupted.

Cauliflower (*Brassica oleracea*L. var. *botrytis*) is an annual plant. The edible portion of cauliflower is head, which is normally called as curd. Cauliflower is grown extensively in tropical and temperate regions of the world. Cauliflower is a heavy feeder therefore it needs higher nutrition with macronutrients and also with micronutrients especially boron. Boron deficiency occurs in widely in cruciferous and other crops such as knol-khol (Brown heart, knob cracking), beetroot (Heart rot), turnip (Brown heart), groundnut (Hollow heart) and broccoli and cauliflower (Hollow stem). Requirement of boron in vegetables generally more than other crops (Alam, 2007). Boron deficiency symptoms in cauliflower appears as watersoaked areas in the centre of the curd and in later stages stem becomes hallow with cavity surrounded by water soaked tissues. Finally, curd colour changes to rusty brown, bitter in taste and becomes rotten (Singh *et al*., 2017b).

In modern agricultural practices and intensive cultivation with high yielding varieties over the years with less or no micronutrient management has resulted in greater depletion of boron in soil.Widespread born deficiency was reported from eastern dry zone of Karnataka. Though major work has been done on the influence of macronutrients on cauliflower, adequate information is not reported regarding effect of boron on vegetables especially cole crops. Hence research was conducted to study the effect of boron on yield and quality of cauliflower.

MATERIALS AND METHODS

Location of the experimental site

An experiment was conducted during *Kharif* 2018 in the farmer's field at Konappalli village, Chintamani taluk, Chikkaballapurdistrict Karnataka. The experimental site is situated in Eastern Dry Zone (Zone 5) of Karnataka at 13.402° Nlatitude and

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78.055° E longitude at an elevation of 866 m above mean sea level.

Initial soil properties and treatment details

Analysis of initial soil properties indicated the low availability of boron (Table 1). Initial soil properties represent medium availability of all the major nutrients.The impact of soil and foliar application of boron on cauliflower was studied by conducting a field experimentin randomize block design including 9 treatments with 3 replications. The treatment details given in Table 2. Cauliflower variety Unnati seedlings were raised in nursey with proper management practices in plastic pro trays (98 cells). 25 days old seedlings were transplanted to the main field and planted at spacing of 45×30 cm with individual plot size of 3.6×3.0 m.

Field management

Recommended dose of fertilizers for cauliflower crop is 150-100-125 kg N-P_2O_5-K_2O ha^{-1} and FYM 25 t ha^{-1} and they were applied according to the treatment details. Nitrogen in the form of urea, P_2O_5 in the form of SSP, K_2O in the form of muriate of potash and boron in the form of borax for soil application and boric acid for foliar spray. Soil application of boron done at the time of basal application of fertilizer.Foliar application of the treatment was done 30 days after transplanting (DAT)

Observations recorded

Yield parameters

Curd diameter (cm): The circumference of curd head at harvest was measured in cm with a thread and later diameter of curd was calculated by using the following formula and the average diameter of curd was worked out.

$$C = 2\pi r \text{ and } d = \frac{C}{\pi}$$

Where, C = Circumference of the curd (cm)

r = Radius of curd (cm)

π = 3.14159

d = diameter of the curd (cm)

Weight of the curd (g): Weight of five curds at edible maturity stage was recorded using electronic weighing balance. The average curd weight was expressed in grams.

Marketable curd yield (t ha^{-1}): Marketable curds were weighed on electronic balance and their yield per plot was recorded in kilogram which was converted into tonnes per hectare as given below:

$$\text{Marketable (curds) yield } (tha^{-1}) = \frac{\text{Marketable curd yield (kg } plot^{-1}\text{) x 10,000}}{\text{Net plot area } (m^2) \text{ x 1000}}$$

Quality parameters

Ascorbic acid (mg 100g^{-1}): The ascorbic acid content in cauliflower was estimated by using the method given by Ranganna (1977).

Extraction:A tissue sample of 1 g was macerated with 4 ml of 3% metaphosphoric acid in a mortar and pestle. The homogenate was centrifuged for 20 minutes at1000 rpm and then the supernatant was carefully decanted into a flask and final volume was made up to 25 ml with 3% metaphosphoric acid.

Estimation: An aliquot sample of the extract was titrated with 2, 6-dichlorophenol indophenol reagent until a pink end-point (which persists for 15 seconds). A standard curve was prepared by titrating a known amount of ascorbate (1-50 mg) with 2, 6-dichlorophenol indophenols reagent. Total amount of ascorbate present in the sample was calculated from the standard curve. The results were expressed in mg ascorbic acid per 100 g fresh weight. Ascorbic acid was calculated by using following formula:

$$\text{Ascorbic acid (mg 100 } g^{-1}) = \frac{\text{(Titer value} \times \text{Dye factor} \times \text{Volume made up)}}{\text{(Volume of filtrate taken} \times \text{Weight of sample taken)}} \times 100$$

Total soluble solids (TSS): Total soluble solids were estimated by using Erma Hand Refractometer and value was recorded as ^{o}Brix at room temperature.

Statistical analysis: The observations recorded in these studies were analysed statistically for test of significance following the Fisher's method of analysis of variance (ANOVA). The level of significance on 'F' test was tested at five percent. 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

Effect of sources and levels of boron on yield and yield attributes of cauliflower

The results on yield attributes *viz*., curd diameter, net weight of curd, yield per plot and yield ha^{-1} as influenced by different sources and levels of boron are presented in Table 3.The yield components such as curd diameter (cm), net curd weight (g), yield $plot^{-1}$ and yield ha^{-1} of cauliflower were varied significantly withsources and levels of boron. Significantly higher curd diameter (16.91cm),net curd weight (0.988 g), yield $plot^{-1}$ (23.81 kg)and yield ha^{-1}(36.74 t ha^{-1}) of cauliflower was recorded in the treatment which received 2.5 kg ha^{-1} B through borax as soil application + 0.25 per cent B through boric acid as foliar application along with RDF and FYM (T_9) and found on par with T_5 (T_1 + 5.0 kg ha^{-1} B through borax as soil application). Significantly lower yield parameters were recorded under treatment T_1 which supplied with only RDF.The increase in yield parameters might be due to the application of boron as both soil and foliar spray which increased the absorption of boron in cauliflower. Boron played significant role in increasing the curd yield which might be due to its role in enhancing the translocation of carbohydrates from the site of their synthesis to the storage tissue in the curd (Kamal Kant*et al.*, 2013). Patel *et al.* (2017) revealed that curd weight with or without leaves, curd diameter, yield plot^{-1} and yield ha^{-1} were found significantly higher, which received combined application of RDF + boron (1.5 %) + ammonium molybdate (2.5 %).

Effect of sources and levels of boron on quality attributes of cauliflower

The ascorbic acid and total soluble solids of cauliflower curd was significantly increased by sources and levels of boron and the results presented in Table 4. The higher values of ascorbic acid (61.24 mg 100g^{-1}) and total soluble solids (6.06 ^{o}Brix) were recorded in treatment which received T_1 + 2.5 kg ha^{-1} B through borax as soil application + 0.25 per cent B through boric acid as foliar application. Treatment T_1 which supplied with only RDF recorded the lowest for the same. This might be due to boron application which improved the sugar translocation from site of synthesis to storage parts and translocation of nutrients. Singh et al. (2017a) revealed that combined application of boron at 2.0 kg, manganese at 2.5 kg and zinc at 3.0 kg ha^{-1} recorded significantly higher total soluble solids and vitamin C content.

Table 1. Initial soil properties of the experimental site and methods followed for analysis

Sl. No.	Soil property	Value	Method followed
1.	pH (1:2.5) Soil: Water	8.36	Potentiometry (Jackson, 1973)
2.	EC (1:2.5) Soil: Water (dSm^{-1})	0.22	Conductometry (Jackson, 1973)
3.	Organic carbon (%)	0.63	Wet oxidation method (Jackson, 1973)
4.	Available N (kgha^{-1})	382.6	Alkaline permanganate method (Subbiah and Asija, 1956)
5.	Available P_2O_5 (kgha^{-1})	32.29	Olsen's method (Jackson 1973)
6.	Available K_2O (kgha^{-1})	207.9	Neutral 1<u>N</u> NH_4OAc extractant& flame photometry method (Page*et al.*, 1982)
7.	Exchangeable Ca (meq 100g^{-1})	6.75	Versenate titration method (Jackson,1973)
8.	Exchangeable Mg (meq 100g^{-1})	3.0	Versenate titration method (Jackson,1973)
9.	Available S (mg kg^{-1})	16.6	Turbidometric method (Black 1975)
10.	DTPA extractable Zn (mg kg^{-1})	0.462	DTPA extraction, Atomic adsorption spectrophotometric method (Lindsay and Norwell, 1978)
11.	Available Fe (mg kg^{-1})	1.978	
12.	Available Mn (mg kg^{-1})	1.948	
13.	Available Cu (mg kg^{-1})	0.42	
14.	Available B (mg kg^{-1})	0.345	Hot water-soluble extraction method and colorimetry using Azomethane-H reagent (John *et al.*, 1975)

Table 2. Details of treatment followed in the experiment.

T_1	NPK (150-100-125 kg ha^{-1}) + FYM (25 t ha^{-1})
T_2	T_1 + 2.0 kg ha^{-1} B through borax as soil application
T_3	T_1 + 3.0 kg ha^{-1} B through borax as soil application
T_4	T_1 + 4.0 kg ha^{-1} B through borax as soil application
T_5	T_1 + 5.0 kg ha^{-1} B through borax as soil application
T_6	T_1 + 1.0 kg ha^{-1} B through borax as soil application + 0.25% B through boric acid as foliar application
T_7	T_1 + 1.5 kg ha^{-1} B through borax as soil application + 0.25% B through boric acid as foliar application
T_8	T_1 + 2.0 kg ha^{-1} B through borax as soil application + 0.25% B through boric acid as foliar application
T_9	T_1 + 2.5 kg ha^{-1} B through borax as soil application + 0.25% B through boric acid as foliar application

Table 3. Effect of sources and levels of boron on yield parameters of cauliflower.

Treatments	Curd diameter(cm)	Curd weight (g)	Yield plot^{-1} (kg)	Yield ha^{-1} (t)
T_1	13.74	0.784	20.21	31.18
T_2	14.67	0.826	20.74	32.00
T_3	15.21	0.863	21.46	33.11
T_4	15.94	0.891	22.46	34.67
T_5	16.44	0.953	23.09	35.63
T_6	14.83	0.849	21.07	32.52

T_7	15.75	0.877	22.03	34.00
T_8	16.28	0.914	22.70	35.04
T_9	16.91	0.988	23.81	36.74
S. Em±	0.504	0.029	0.509	1.112
CD (5%)	1.510	0.087	1.522	3.333

Table 4. Effect of sources and levels of boron on quality parameters of cauliflower.

Treatments	**Quality parameters**	
	Total soluble solids (^{o}Brix)	**Ascorbic acid (mg 100g^{-1})**
T_1	5.04	48.14
T_2	5.32	52.47
T_3	5.59	54.36
T_4	5.74	55.84
T_5	5.93	58.92
T_6	5.57	53.75
T_7	5.68	56.31
T_8	5.84	58.67
T_9	6.06	61.24
S.Em±	0.162	1.590
CD (5%)	0.486	4.768

CONCLUSION

The yield components such as curd diameter (cm), net curd weight (g), yield plot^{-1} and yield ha^{-1} of cauliflower and quality parameters *viz.*, total soluble solids and ascorbic acid (vitamin C) were varied significantly sources and levels of boron. Application of 2.5 kg ha^{-1} boron through borax as soil application and 0.25 per cent boron through boric acid as foliar application along with RDF (150-100-125 kg N-P_2O_5-K_2O ha^{-1}) + FYM (25 t ha^{-1}) had higher influence on yield, and quality parameters in cauliflower crop.

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