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Effect of Soil and Foliar Application of Zinc on Quality Parameters of Cauliflower (*Brassica oleracea* var *botrytis* L.)

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ABSTRACT

A field experiment on Effect of soil and foliar application of zinc on growth and yield parameters of cauliflower (*Brassica oleracea* var *botrytis* L.) was conducted in the farmer's field during *kharif* 2018. The experiment was laid out in a Randomized Complete Block Design with 9 treatments and 3 replications. The results revealed that application of 4 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5% Zn through zinc sulfate as foliar spray along with RDF (150 : 100 : 125 N-P_2O_5-K_2O kg ha^{-1}) + 25 t of FYM per hectare significantly increases the quality parameters viz., total soluble solids and ascorbic acid (vitamin C) were increased significantly with soil and foliar application of zinc.

Keywords Quality parameters, Ascorbic acid, Cauliflower, Zinc sulfate, Foliar application.

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INTRODUCTION

Among micronutrients, zinc is considered as one of the first nutrient essential for the plants and has got greater significance in crop production due to its wider occurrence of deficiency in different agro-climatic regions of the country and spectacular response of crops to its application. The extent of Zn deficiency varies widely with the nature of soil. Coarse textured, calcareous or alkaline pH, low organic carbon and highly eroded soils are more prone to occurrence of zinc deficiency. In India more than 40% of soils are deficient in zinc and in Karnataka 73% of soils are deficient in zinc (Srinivasarao and Sudha 2013). Cauliflower (*Brassica oleracea* var *botrytis* L.) is one of the important cole crops grown in India which belongs to family Brassicaceae. Cauliflower is originated in ancient Asia minor in northeastern part of the Mediterranean. It is one of the important daily consumed vegetable in the world. Cauliflower is grown extensively in tropical and temperate regions of the world viz., China, Germany, India, Indonesia, Japan, Korea, Poland, Russia, Taiwan, Turkey, USA and several other countries (Rai and Yadav 2005). Cauliflower is known for its nutritive value, digestibility and for preparation of delicious dishes. Cauliflower seedlings are used for salad and green. The curd is used in curries, soups and pickles. It contains higher amount of vitamin C, folate and also rich source of vitamins like riboflavin, thiamine, nicotinic acid and has antioxidants. It contains indole-3-cardinal that affects the metabolism of estrogen. The extract from the inflorescence used to cure scurvy. It decreases the risk of heart attack, brain disorder, reduces the blood cholesterol and also reduces the risk of cancer. It lowers the blood cholesterol and also good for skin health. Deficiency of Zn noticed in most soils of Karnataka. Though some work has been done on the influence of these micronutrients in field and fruits crops (Babu and Singh 2001 in Litchi) not much information is reported regarding their effect on vegetables especially cole crops. The literature pertaining to zinc nutrition on cole crops is very scanty. Keeping in view of the above facts a research work entitled Effect of soil and foliar application of zinc on quality parameters of cauliflower (*Brassica oleracea* var *botrytis* L.).

MATERIALS AND METHODS

Location of the experimental site

The experiment was carried out in the farmer's field at Konapalli, Chintamani Taluk, Chickkaballapur District. The experimental farm is situated in Eastern Dry Zone (Zone 5) of Karnataka at 13.4020^o N latitude and 78.0551^o E longitude with elevation of 865 m above mean sea level. Initial physical and chemical parameters of soil given in Table1.

Detailed program of work

Fertilizer application

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 zinc in the form of zinc sulfate were applied.

Table 1. Initial physical and chemical properties of soil at experimental site.

Sl. No.	Soil property	Content	Method followed
	Sand (%)	57.84	
	Silt (%)	7.69	
1.	Clay (%)	34.47	International pipette method (Piper 1966)
	Textural class	Sandy Clay	
2.	pH (1 : 2.5)	8.36	Potentiometry (Jackson 1973)
3.	EC (1 : 2.5) (dS m^{-1})	0.22	Conductometry (Jackson 1973)
4.	OC (%)	0.63	Wet oxidation method (Jackson 1973)
5.	Available N (kg ha^{-1})	382.60	Alkaline permanganate method (Subbaiah and Asija 1956)
6.	Available P_2O_5 (kg ha^{-1})	32.30	Oleson's method (Jackson 1973)
7.	Available K_2O (kg ha^{-1})	208.00	Neutral IN ammonium acetate extraction & flame photometry method (Page et al. 1982)
8.	Exchangeable Ca (cmol (p$^+$) kg^{-1})	6.75	Versenate titration method (Jackson 1973)
9.	Exchangeable Mg (cmol (p$^+$) kg $^{-1}$)	3.0	Versenate titration method (Jackson 1973)
10.	Available S (mg kg $^{-1}$)	16.6	Turbidometry method (Black 1965)
11.	DTPA extractable Zn (mg kg^{-1})	0.46	DTPA extraction, atomic absorption spectrophotometer method (Lindsay and Norvel 1978)
12.	DTPA extractable Fe (mg kg^{-1})	1.98	
13.	DTPA extractable Mn (mg kg^{-1})	1.95	
14.	DTPA extractable Cu (mg kg^{-1})	0.42	
15.	Available B (mg kg^{-1})	0.34	Hot water soluble extraction method (Berger and Troug 1939)

Foliar spray : As per the treatment details, the foliar spray of zinc @ 0.5% through zinc sulfate was taken at 30 days after transplanting.

Quality parameters

Chlorophyll content (SPAD meter reading) : By using SPAD-502 meterchlorophyll content of randomly selected plants were recorded at 45 days after transplanting and at harvest.

Ascorbic acid content (vitamin C) : Ascorbic acid content was estimated by the procedure outlined by AOAC (1970) which is based on the reduction of 2, 6-dichlorophenol indophenol (2, 6-DCPIP) by ascorbic acid.

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 :

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

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

Table 2. The details of field experiment conducted are given in Table 2.

Test crop	: Cauliflower
Variety	: Unnathi
Spacing	: 45 cm × 30 cm
Location	: Farmer's field, Chintamani, Eastern dry zone
Design	: RCBD
Plot size	: 3.6 × 3 m (10.8 m^2)
No. of treatments	: 9
No. of replications	: 3
Source of zinc	: Zinc sulfate
Foliar spray	: 30 DAT
Recommended dose of fertilizers ($N : P_2O_5 : K_2O$ kg ha^{-1})	: 150 : 100 : 125
FYM (t ha^{-1})	: 25

Table 2. Continued.

	Treatment details
Sl. No.	Treatment details
T_1	RDF + FYM
T_2	T_1 + 2 kg of Zn ha^{-1} through $ZnSO_4$ as soil application
T_3	T_1 + 4 kg of Zn ha^{-1} through $ZnSO_4$ as soil application
T_4	T_1+ 6 kg of Zn ha^{-1} through $ZnSO_4$ as soil application
T_5	T_1 + 8 kg of Zn ha^{-1} through $ZnSO_4$ as soil application
T_6	T_1 + 1 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5% Zn through $ZnSO_4$ as foliar spray
T_7	T_1 + 2 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5% Zn through $ZnSO_4$ as foliar spray
T_8	T_1 + 3 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5 % Zn through $ZnSO_4$ as foliar spray
T_9	T_1 + 4 kg of Zn ha^{-1} through $ZnSO_4$ as soil application+ 0.5% Zn through $ZnSO_4$ as foliar spray

RESULTS AND DISCUSSION

Effect of soil and foliar application of zinc on chlorophyll content (SPAD meter reading) of cauliflower

Data on chlorophyll content at growth different stages of cauliflower as influenced by soil and foliar application of zinc are presented in Table 3. Chlorophyll content differed significantly with the soil and foliar application of zinc. At 45 DAT, treatment which received 4 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5% Zn through $ZnSO_4$ as foliar spray and RDF (150 : 100 : 125 $N-P_2O_5-K_2O$ kg ha^{-1}) along with FYM (T_9) has recorded maximum chlorophyll content (57.88) followed by treatment (T_5) which received T_1 + 8 kg of Zn ha^{-1} through $ZnSO_4$ as soil application (56.91) and T_1 + 3 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5% Zn through $ZnSO_4$ as foliar spray (T_8) which has recorded 56.27. Lowest was recorded inT_1 treatment (51.78). At harvest, significantly high-

Table 3. Effect of soil and foliar application of zinc on chlorophyll content (SPAD reading) of cauliflower.

	Treatments	Chlorophyll content 45 DAT	At harvest
T_1	RDF + FYM (150 : 100 : 125 N - P_2O_5-K_2O kg ha^{-1} + 25 tons FYM ha^{-1})	51.78	54.27
T_2	T_1 + 2 kg of Zn ha^{-1} through $ZNSO_4$ as soil application	52.64	54.92
T_3	T_1 + 4 kg of Zn ha^{-1} through $ZnSO_4$ as soil application	53.34	54.66
T_4	T_1 + 6 kg of Zn ha^{-1} through $ZnSO_4$ as soil application	55.12	56.40
T_5	T_1+ 8 kg of Zn ha^{-1} through $ZnSO_4$ as soil application	56.91	58.37
T_6	T_1+ 1 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5% Zn through $ZnSO_4$ as foliar spray	52.51	55.26
T_7	T_1 + 2 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5% Zn through $ZnSO_4$ as foliar spray	53.85	56.59
T_8	T_1 + 3 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5% Zn through $ZnSO_4$ as foliar spray	56.27	59.28
T_9	T_1 + 4 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5% Zn through $ZnSO_4$ as foliar spray	57.88	60.09
SEm ±		1.268	1.271
CD (5%)		3.803	3.812

er chlorophyll content (60.09) was recorded in the treatment received 4 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5% Zn through $ZnSO_4$ as foliar spray and RDF (150 : 100 : 125 N-P_2O_5 –K_2O kg ha^{-1}) along with FYM (T_9) followed by T_1 + 3 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5% Zn through $ZnSO_4$ as foliar spray (T_8) which has recorded 59.28 and T_1 + 8 kg of Zn ha^{-1} through $ZnSO_4$ as soil application (T_5) which has recorded 58.37. Lowest value was recorded in the treatment received RDF + FYM (150 : 100 : 125 N-P_2O_5-K_2O kg ha^{-1} + 25 tons FYM ha^{-1}) which has recorded 54.27.

The catalytic or stimulatory effect of zinc on most of the physiological and metabolic process of plant may be responsible for the growth of plant. Zinc is also an essential component of enzymes and plays an important role in nitrogen metabolism which resulting in uptake of nitrogen by the plants. The synergistic effect of zinc on nitrogen resulted in increased uptake of nitrogen by the plants and hence there is an increased growth. Zinc is necessary for normal cell division and other plant metabolic processes (Singh and Verma 1991), it is helpful in improving the growth of cauliflower by increasing the growth promoting hormone i.e., auxin content of plant and playing a role in cellular oxidation. Increased chlorophyll content might be due to fact that besides the role of zinc in chlorophyll formation, it also influenced cell division, meristematic activity of tissues and expansion of cell and formation of cell wall. Similar results were reported by Lashkari et al. (2008). Sivakumar et al. (2005) also reported that the foliar application of zinc @ 0.5% resulted in highest chlorophyll content in okra.

Effect of soil and foliar application of zinc on TSS and ascorbic acid content of cauliflower

The quality parameters like total soluble solids (°Brix) and ascorbic acid (mg 100 g^{-1}) as influenced by soil and foliar application of zinc is presented in Table 4.

Table 4. Effect of soil and foliar application of zinc on quality parameters of cauliflower.

	Treatments	Total soluble solids (°Brix)	Ascorbic acid (mg 100 g^{-1})
T_1	RDF + FYM (150 : 100 : 125 N-P_2O_5-K_2O kg ha^{-1} + 25 tons FYM ha^{-1})	5.10	49.76
T_2	T_1 + 2 kg of Zn ha^{-1} through $ZnSO_4$ as soil application	5.47	50.76
T_3	T_1 + 4 kg of Zn ha^{-1} through $ZnSO_4$ as soil application	5.40	52.19
T_4	T_1 + 6 kg of Zn ha^{-1} through $ZnSO_4$ as soil application	5.70	55.43
T_5	T_1 + 8 kg of Zn ha^{-1} through $ZnSO_4$ as soil application	6.00	59.64

Table 4. Continued.

	Treatments	Total soluble solids (°Brix)	Ascorbic acid (mg 100 g^{-1})
T_6	T_1 + 1 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5% Zn through $ZnSO_4$ as foliar spray	5.33	51.32
T_7	T_1 + 2 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5% Zn through $ZnSO_4$ as foliar spray	5.37	54.34
T_8	T_1 + 3 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5% Zn through $ZnSO_4$ as foliar spray	6.10	57.54
T_9	T_1 + 4 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5% Zn through $ZnSO_4$ as foliar spray	6.13	60.13
	SEm ±	0.162	1.350
	CD (5%)	0.487	4.049

Total soluble solids (°Brix) : The soil and foliar application of zinc significantly influenced the total soluble solids in cauliflower curd. Significantly higher total soluble solids (6.13 °Brix) was recorded with the treatment combination of 4 kg of zinc ha^{-1} as soil application + 0.5% zinc as foliar spray along with RDF (150 : 100 : 125 N-P_2O_5-K_2O kg ha^{-1}) and FYM (T_9). It was found at par with T_5 which received 8 kg of zinc ha^{-1} as soil application along with RDF + FYM and T_8 which received 3 kg of zinc ha^{-1} as soil application + 0.5% zinc as foliar spray along with RDF (150 : 100 : 125 N-P_2O_5-K_2O kg ha^{-1}) and FYM. Lowest total soluble solids (5.10 °Brix) was recorded in T_1 which received RDF (150 : 100 : 125 N-P_2O_5-K_2O kg ha^{-1}) and FYM. Earlier it was reported that significantly higher TSS in the cauliflower was observed with application of 40 ppm zinc as foliar spray.

Ascorbic acid (mg kg^{-1}) : Significantly higher ascorbic acid (60.13 mg 100 g^{-1}) was recorded in T_9 (T_1 + 4 kg of zinc ha^{-1} as soil application + 0.5% zinc as foliar spray) followed by T_5 which received 8 kg of zinc as soil application along with RDF + FYM which has recorded 59.64 mg 100 g^{-1}. Lowest ascorbic acid (49.76 mg 100 g^{-1}) was recorded in the treatment T_1 which received only RDF (150 : 100 : 125 N-P_2O_5-K_2O kg ha^{-1}) and FYM.

Total soluble solids and ascorbic acid content of cauliflower were significantly influenced by soil and foliar application of zinc. Application of zinc @ 4 kg ha^{-1}+ 0.5% zinc as foliar spray along with recommended dose of fertilizers (150 : 100 : 125 N-P_2O_5-K_2O kg ha^{-1}) and FYM resulted in increased quality attributes like TSS and ascorbic acid in cauliflower. Similar results were obtained by Verma et al. (2017), stated that application of zinc at 5-7.5 kg ha^{-1} recorded significantly higher protein and ascorbic acid content in cauliflower curd. Application of 30 kg zinc ha^{-1} resulted in maximum and significantly increased the quality attributes viz., total soluble solids, ascorbic acid, total sugars, reducing sugars and non-reducing sugars in sprouting broccoli (Shivran et al. 2017).

Zinc played a major role in increasing CEC of roots which helps in increasing absorption of nutrient from the soil. Further, it helps in synthesis of chlorophyll and maintaining the auxin concentration and its stimulatory effect on plant physiological and metabolic process, might have helped the plants in increasing the quality attributes. The results were found in line with Gajendra et al. (2014), stated that TSS and ascorbic acid content has increased by application of zinc along with boron and manganese in broccoli. Similar results were obtained by Kotecha et al. (2016), reported that the application of zinc sulfate at 0.5% ha significantly increased the ascorbic acid in cabbage. Results were in line with the findings of Kaur et al. (2018) in potato, Verma et al. (2017) in cauliflower, Zhao (2006) in cabbage, Ramachandra et al. (2014) in tomato and Singh et al. (2018) in potato.

CONCLUSION

Quality parameters viz., total soluble solids and ascorbic acid (vitamin C) were increased significantly with soil and foliar application of zinc. Application of 4 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5% Zn through zinc sulfate as foliar spray along with RDF (150 : 100 : 125 N-P_2O_5-K_2O kg ha^{-1}) and

FYM (25 t ha^{-1}) significantly increased the total soluble solids (6.13 ^{o}Brix) and ascorbic acid (vitamin C) which recorded 60.13 mg 100 g^{-1}.

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