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EFFECT OF SOIL AND FOLIAR APPLICATION OF ZINC ON GROWTH AND YIELD PARAMETERS OF CAULIFLOWER (*Brassica oleracea* Var.*Botrytis* L.)

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ABSTRACT
A field experiment entitled "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 randomised 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 sulphate as foliar spray along with RDF (150:100:125 N-P_2O_5-K_2O kg ha^{-1}) + 25t of FYM per hectare significantly increased growth parameters of cauliflower such as plant height (61.27 cm), number of leaves $plant^{-1}$(22.83) and plant spread (65.63 cm in N-S and 72.87 cm in E-W). Significantly higher yield attributes such as curd diameter (16.65 cm) weight of curd (0.678 kg) yield $plot^{-1}$ (35.813 kg $plot^{-1}$) and yield ha^{-1} (33.16 t ha^{-1}) was recorded in the treatment T_9 which received 4 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5 per cent Zn through zinc sulphate as foliar spray along with RDF and FYM.

KEYWORDS: Growth, yield, cauliflower, Zinc sulphate, foliar application.

INTRODUCTION

Zinc is a key nutrient for a plant to complete its life cycle. Zinc serves as an essential metal component of number of enzymes, *i.e*., dehydrogenase, carbonic anhydrase, super oxide dismutase etc. It is involved in synthesis of tryptophan, a precursor of IAA. Zinc has catalytic function and is essential for transformation of carbohydrate. It plays a vital role in metabolic processes of plant such as photosynthesis, respiration and other biochemical processes. It is required for normal cell division and other metabolic process. Zinc helps in formation of chlorophyll, the maintenance of the integrity of biological membranes and there by maintains the structural orientation of macromolecules and ion transport system. The interaction of zinc with phospholipids and sulphydryl groups of membrane proteins contributes for the maintenance of membranes (Cakmak, 2000). Zinc deficiency affects the growth of plant, shortened internodes, petioles, and small malformed leaves (little leaf) which results in the rosette symptom. Deficiency of zinc affect the protein and auxin synthesis and also causes interveinal chlorosis, reduced root growth, spikelet sterility and also adversely affect the quality of harvested products. 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 growth and yield parameters of cauliflower (*Brassica oleracea* var. *botrytis* L.).

MATERIAL 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 Table 1.

Detailed programme of work:

The details of field experiment conducted are given below.

Test Crop	: Cauliflower
Variety	: Unnathi
Spacing	: 45 cm X 30 cm
Location	: Farmer's field, Chintamani, Eastern dry zone
Design	: RCBD
Plot size	: 3.6 X 3 m (10.8 m^2)
No. of treatments	: 9
No. of replications	: 3
Source of zinc	: Zinc sulphate
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

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

TABLE 1: Initial physical and chemical properties of soil at experimental site

Sl. No.	Soil property	Content	Method followed
1.	Sand (%)	57.84	International pipette method (Piper, 1966)
	Silt (%)	7.69	
	Clay (%)	34.47	
	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 (Subbiah 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 1N ammonium acetate extraction & flame photometry method (Page *et al.*,1982)
8.	Exchangeble Ca[cmol (p^+) kg^{-1}]	6.75	Versenate titration method (Jackson,1973)
9.	Exchangeble 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)

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 sulphate were applied.

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

Observations on growth parameters: Following growth parameters were recorded at 45 days after transplanting and at harvest.

Plant height (cm): Plant height was measured from the base of the plant to the tip of the fully opened top leaf at 45 days after transplanting and at harvest. The Height of the randomly selected five plants was recorded. Average plant height was calculated and expressed in centimeters.

Number of leaves plant^{-1}: Total number of leaves in the plant was counted at 45 days after transplanting and at harvest. The mean value for each treatment was determined.

Plant Spread (cm): Maximum growth of plant in either direction (N-S and E-W) was measured and average was recorded as spread of plant and expressed in centimeters.

Yield and yield attributes: Following yield parameters were recorded at harvest of the crop. Five randomly selected plants were used to record the observation on yield components.

Diameter of curd (cm): Circumference of head at harvest was measured with a thread and later diameter of the knob was calculated by using the following formula (Rao, 1977) and the average diameter of the knob was worked out and expressed in centimeter

$$C = 2\pi r; \quad d = \frac{C}{\pi}$$

Where,

C = Circumference of the head (cm)

r = Radius of head (cm)

π = 3.14159

d = Diameter of the head (cm)

Curd weight (g): Cauliflower curds were harvested when they were fresh-looking, white, firm and attained complete maturity. Fresh weight of head (g) was recorded by using digital electronic balance and expressed in grams.

Dry weight of plant (g plant^{-1}): Five randomly selected plants were used to record dry matter production at harvest. These samples were dried at 60-70°C to a constant weight in hot air oven. Dry weight was recorded separately at harvest to assess the dry matter accumulation and total dry matter production and expressed in g plant^{-1}.

Yield per plot (kg plot^{-1}): Cauliflower curds from plot were harvested at complete maturity and yield was recorded in kg plot^{-1}.

Yield per hectare (t ha^{-1}): Total yield was estimated based on the curd yield per net plot and was expressed per hectare.

RESULTS AND DISCUSSION

Effect of soil and foliar application of zinc on growth parameters of cauliflower

Results on growth parameters *viz*., plant height, number of leaves and plant spread of plant at different growth stages as influenced by soil and foliar application of zinc are presented below.

Plant height (cm): The data with respect to plant height as influenced by soil and foliar application of zinc at 45 days after transplanting and at harvest is presented in Table 2.

TABLE 2: Effect of soil and foliar application of zinc on plant height, number of leaves per plant and plant spread of cauliflower

Treatments	Plant height (cm)		Number of leaves per plant		Plant spread (N-S)		Plant spread (E-W)	
	45 DAT	45 DAT	45 DAT	At Harvest	45 DAT	At Harvest	At Harvest	At Harvest
T_1	47.93	18.17	51.85	55.64	59.46	64.97	19.50	52.70
T_2	50.83	18.37	53.25	58.45	60.52	66.92	19.77	54.10
T_3	53.73	19.23	55.88	61.56	62.97	67.92	20.07	57.23
T_4	54.70	19.60	58.38	61.76	66.38	69.28	20.30	58.80
T_5	55.97	20.70	60.83	63.45	67.26	70.95	21.40	60.27
T_6	49.63	18.37	55.3	61.10	62.11	68.86	19.30	53.17
T_7	54.53	19.80	57.65	62.75	63.89	69.56	19.77	53.97
T_8	54.83	20.53	60.68	64.79	66.44	71.69	21.00	58.67
T_9	56.83	20.83	62.66	65.63	67.88	72.87	22.83	61.27
S.Em±	1.740	0.643	1.694	1.917	1.819	1.432	0.644	1.634
CD (5%)	5.217	1.927	4.945	5.746	5.455	4.293	1.93	4.891

At 45 days after transplanting: Significantly higher plant height (56.83 cm) was observed in T_9 (T_1 + 4 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5% zinc through $ZnSO_4$ as foliar spray) which is on par with T_5 (T_1 + 8 kg of Zn ha^{-1} through zinc sulphate as soil application) which recorded 55.97 cm. Significantly lower plant height of 47.93 cm was recorded in T_1which received RDF and FYM at 45days after transplanting. At harvest significantly higher plant height (61.27 cm) was recorded in T_9 which received T_1 + 4 kg of zinc ha^{-1} through zinc sulphate as soil application + 0.5% zinc through zinc sulphate as foliar spray which was on par with T_5 (T_1 + 8 kg of zinc ha^{-1} through zinc sulphate as soil application) which recorded 60.27 cm. Lower plant height (52.70) was recorded in T_1 which received RDF and FYM. Kanujia *et al*. (2006) revealed that foliar application of zinc @ 100 ppm gave the maximum plant height.

Number of leaves plant^{-1}: The data with respect to number of leaves per plant at 45 days after transplanting and at harvest are presented in Table 2.

45 days after transplanting: Number of leaves per plant influenced significantly by application of zinc. Treatment T_9 which received T_1 + 4 kg of zinc ha^{-1} through soil application along with foliar spray of zinc @ 0.5% has recorded significantly higher number of leaves per plant (20.83) which is on par with treatment T_5(20.70) which received T_1 + 8 kg of zinc ha^{-1} through zinc sulphate as soil application). Treatment which received RDF and FYM has recorded the lower number of leaves per plant (18.17). At harvest number of leaves per plant was recorded significantly higher (22.83) in T_9 which received T_1 + 4 kg of zinc ha^{-1} through zinc sulphate as soil application + 0.5 per cent zinc through zinc sulphate as foliar spray followed by T_5 which received T_1 + 8 kg of

zinc through zinc sulphate as soil application which recorded 21.40. Lower number of leaves per plant (19.50) was observed in T_1 which received RDF and FYM.

Plant spread (cm): The data on plant spread of cauliflower as influenced by soil and foliar application of zinc is presented in the Table 2. Plant spread differed significantly with soil and foliar application of zinc.

North-South direction: At 45 DAT, spread of plant in north-south direction differed significantly with soil and foliar application of zinc. The higher plant spread in north-south direction (62.66 cm) was recorded in the treatment which received4 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5 % Zn through $ZnSO_4$ as foliar spray and RDF along with FYM (T_9). It is found on par with the treatment which received T_1+ 8 kg of Zn ha^{-1}through $ZnSO_4$ as soil application (T_5) which has recorded 60.83cm 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 60.68 cm. Lowest was recorded in T_1 (51.85 cm) which received only RDF and FYM. At harvest, treatment which received4 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5 % Zn through $ZnSO_4$ as foliar spray and RDF along with FYM (T_9) has recorded the maximum plant spread (65.63 cm) and found on par with the treatment 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 64.79 cm and T_1+ 8 kg of Zn ha^{-1}through $ZnSO_4$ as soil application (T_5) which has recorded 63.45 cm. Lowest was recorded in T_1 (55.64 cm) which received only RDF (150:100:125 N-P_2O_5 - K_2O kg ha^{-1}) and FYM.

East-West direction: Treatment which received4 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5 % Zn through $ZnSO_4$ as foliar spray and RDF along with FYM (T_9) has recorded the maximum plant spread (67.88 cm) in east-west direction followed by T_1+ 8 kg of Zn ha^{-1}through $ZnSO_4$ as soil application (T_5) which has recorded 67.26 cm at 45 DAT. Lowest was recorded in T_1 (59.46 cm) which received only RDF (150:100:125 N-P_2O_5 - K_2O kg ha^{-1}) and FYM. At harvest, maximum plant spread in east-west direction (72.87 cm) was recorded in treatment which received4 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 71.69 cm and T1+ 8 kg of Zn ha-1through ZnSO4 as soil application (T5) which has recorded 70.95 cm. T1 has recorded the minimum plant spread in both direction.

Effect of soil and foliar application of zinc on yield parameters of cauliflower

The yield parameters like curd diameter, weight of curd, yield per plot and yield per hectare as influenced by soil and foliar application of zinc are presented in Table 3.

TABLE 3: Effect of soil and foliar application of zinc on curd diameter, curd weight, yield (kg $plot^{-1}$) and Yield (t ha^{-1}) of cauliflower

Treatments	Curd diameter (cm)	Curd weight (kg)	Yield (kg $plot^{-1}$)	Yield (t ha^{-1})
T_1	13.67	0.565	29.02	26.87
T_2	13.89	0.588	29.88	27.67
T_3	14.18	0.616	31.81	29.45
T_4	14.56	0.635	34.17	31.64
T_5	15.89	0.637	35.50	32.87
T_6	14.05	0.577	30.19	27.95
T_7	14.23	0.585	31.69	29.34
T_8	15.45	0.653	34.48	31.93
T_9	16.65	0.678	35.81	33.16
S.Em ±	0.488	0.018	0.488	0.990
CD (5%)	1.463	0.053	1.463	2.968

Curd diameter (cm): Application of zinc as soil application and foliar spray significantly influenced the diameter of cauliflower curd. Data with respect to the curd diameter as influenced by soil and foliar application of zinc is presented in Table 3. Diameter of curd was recorded significantly higher in T_9 (16.65 cm) which received T_1 + 4 kg of zinc ha^{-1} through zinc sulphate as soil application + 0.5 per cent zinc through zinc sulphate as foliar spray which was found on par with T_5 (15.89 cm) which received T_1 + 8 kg of zinc ha^{-1} through zinc sulphate as soil application and T_8 which received T_1 + 3 kg of Zn ha^{-1}through zinc sulphate as soil application + 0.5 per cent zinc through zinc sulphate as foliar spray. T_1 has recorded lowest curd diameter (13.67 cm) which received RDF+ FYM.

Curd weight (kg): The data with respect to curd weight as influenced by soil and foliar application of zinc are given in Table 6 and Fig 6. Treatment consists of T_1+ 4 kg of zinc ha^{-1} as soil application along with 0.5 per cent zinc as foliar spray (T_9) has recorded significantly higher curd weight (0.678 kg) followed by T_8 (0.653 kg) and T_5 which has recorded curd weight of 0.637 kg. Lowest curd weight (0.565 kg) was observed in T_1 which received RDF and FYM.

Yield per plot (kg $plot^{-1}$): The yield of cauliflower as influenced by soil and foliar application of zinc is given in Table 7 and Fig 7. Yield per plot recorded significantly higher (35.81 kg $plot^{-1}$) in treatment combination of 4 kg of zinc ha^{-1} as soil application + 0.5 percent zinc as foliar spray along with RDF (150:100:125 N-P_2O_5-K_2O kg ha^{-1}) and FYM (T_9) and it was found on par with T_5 which received 8 kg zinc ha^{-1} as soil application along with RDF (150:100:125 N-P_2O_5-K_2O kg ha^{-1}) and FYM. The lower

curd weight was recorded in treatment T_1 received RDF and FYM (29.02 kg plot^{-1}).

4.3.4 Yield per hectare (t ha^{-1}): The yield of cauliflower as influenced by soil and foliar application of zinc is given in Table 7 and Fig 7. Significantly higher yield was recorded in treatment received 4 kg of zinc ha^{-1} as soil application + 0.5 percent zinc as foliar spray along with RDF (150:100:125 N-P_2O_5-K_2O kg ha^{-1}) and FYM (T_9) which has recorded 33.16 t ha^{-1} followed by T_5 which received 8 kg zinc ha^{-1} as soil application along with RDF and FYM which has recorded 32.87 t ha^{-1}. Lowest yield (26.87 t ha^{-1}) was recorded in the treatment which received RDF (150:100:125 N-P_2O_5-K_2O kg ha^{-1}) and FYM.

Yield parameters such as curd diameter, weight of curd, yield per plot and yield per hectare in cauliflower were significantly influenced by soil and foliar application of zinc. Zinc application had significant effect on yield attributes and yield of cauliflower. With increase in the levels of zinc up to 4 kg Zn ha^{-1} along with foliar spray of zinc @ 0.5 % has recorded the higher yield attributes like curd weight, curd diameter, yield per plant and total yield of curd per hectare over the treatment which received only RDF and FYM. Yield components such as diameter, weight of curd, yield per plot and yield per hectare were recorded significantly higher in treatment T_9 (T_1 + 4 kg of zinc ha^{-1} through zinc sulphate as soil application + 0.5 per cent zinc through zinc sulphate as foliar spray). This might be possible due to increased supply of zinc through soil application and also through foliar application improved the availability of zinc in the plants leading to proper growth and development by playing an important role in regulating the auxin concentration in plants. Significant increase in the yield under the influence of zinc was largely a function of significant increase in growth and consequent increase in different yield attributes and yield. Besides this, zinc also helps in increasing the absorption of essential element by increasing the cation exchange capacity of roots. Hence application of zinc in soil with lower zinc content improves the growth and development of cauliflower. The results were found in confirmation with Lashkari *et al*. (2008). Alok and Nayak in 2008 reported that yield and head weight of cabbage was recorded higher with 100 ppm zinc application as foliar spray. Davood *et al*. (2010) reported that application of zinc along with boron resulted in improving the growth, yield of knol khol. Soil application of 7.5 kg zinc per ha significantly enhanced the yield attributes like fruit length, number of fruits per plant, fruit yield per plant, per plot and per hectare (Sharma *et al*., 2018). Vineet *et al.* (2016) concluded application of 20 kg ha^{-1} zinc recorded maximum growth, yield and quality of Indian mustard over control plot. Yadav *et al*., 2014 stated that yield parameters in cauliflower increased significantly with foliar application of zinc @ 40 ppm. Similar results were reported by Singh and Verma (1991) in cauliflower, Anjali *et al*., 2015 in okra, Deepika and Anitha Pitagi (2015) in radish and Sahito *et al.*, 2014 in mustard.

CONCUSSION

Application of 4 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5 per cent Zn through zinc sulphate 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 increased growth parameters of cauliflower such as plant height (61.27 cm), number of leaves plant^{-1}(22.83) and plant spread (65.63 cm in N-S and 72.87 cm in E-W). Significantly higher yield attributes such as curd diameter (16.65 cm) weight of curd (0.678 kg) yield plot^{-1} (35.813 kg plot^{-1}) and yield ha^{-1} (33.16 t ha^{-1}) was recorded in the treatment T_9 which received 4 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5 per cent Zn through zinc sulphate as foliar spray along with RDF and FYM.

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