THEORETICAL BIOLOGY FORUM

TBF: 433-437 (2023)
Research Article

Growth, yield, and economics of Knol khol (*Brassica caulorapa* var *gongylodes*) as influenced by soil and foliar application of zinc

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ABSTRACT

A field experiment was conducted in the farmer's field at Vijaypura, Bangalore Rural District, to study the effect of soil and foliar application of zinc on the growth, yield, and economics of Knol khol. The experiment was laid out in a randomized complete block design with 10 treatments replicated thrice. Results of the study indicated that the combined application of zinc to the soil and foliage significantly enhanced the growth and yield parameters of Knol khol. Significantly higher plant height (39.90 cm), number of leaves per plant (14.83), leaf length (19.68 cm), and yield (23 t ha^{-1}) were recorded in the treatment T_9, which received RDF and FYM along with 4 kg of zinc through $ZnSO_4$ as soil application and 0.14% zinc through zinc sulfate as a foliar spray. Also, higher benefit-cost ratio of 3.48 was recorded in the same treatment.

Keywords-*Zinc, Knol khol, Growth, Yield, Economics*

ARTICLE HISTORY

15 November 2022: Received
06 March 2023: Revised
22 May 2023: Accepted
09 August 2023: Available Online

DOI:
https://doi.org/10.61739/TBF.2023.12.2.433

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1. INTRODUCTION

Knol khol (*Brassica caulorapa* var. *gongylodes*) is a cool-season crop and is originated from the coastal countries of the Mediterranean region. It belongs to the family *Cruciferae* and is an important cole crop. Zinc is an indispenssable micronutrient required for proper plant growth and development. It has important roles in growth regulation, enzyme activation, gene expression and regulation, phytohormone activity, protein synthesis, photosynthesis, carbohydrate metabolism, fertility, seed production, and defense against diseases. As zinc is required for the synthesis of tryptophan which is a precursor of IAA, it also has an active role in the production of an essential growth hormone auxin [1]; [2].

With intensive cultivation, the introduction of high-yielding varieties of crops and the adoption of modern agricultural technologies has led to the removal of higher amount of nutrients resulting in multiple nutrient deficiencies, especially the micronutrients and zinc in particular. The deficiency of zinc is widespread and about 49% of Indian soils are zinc deficient [3]. Periodic assessment of soil test data also suggests that zinc deficiency in soils of India is likely to increase from 49 to 63% by the year 2025 as most of the marginal soils brought under cultivation are showing zinc deficiency [4]. Zinc is one of the most important micronutrients and plays a vital role in plant nutrition. Therefore, the present investigation was carried out to find the optimum dose of zinc for obtaining maximum growth, yield, and economics of Knol khol.

2. MATERIAL AND METHODS

2.1 Location of experimental site

A field experiment was conducted during 2017-2018 *Kharif* to study the effect of soil and foliar application of zinc on the growth and yield of Knol khol in a randomized complete block design with ten treatments replicated thrice in farmer's field at Vijaypura, Bangalore Rural District, Karnataka. The details of the field experiment conducted is given below.

Test Crop	Knol khol
Variety	White Vienna
Spacing	30 X 20 cm
Location	Vijaypura
Design	RCBD
Plot size	2.4 X 1.8 m (4.32 m^2)
No. of treatments	10
No. of replications	3
Source of micronutrient	Zinc sulfate
Foliar spray	Once - 30 DAT
Recommended dose of fertilizers (NPK kg ha^{-1})	150:100:125
FYM (t ha^{-1})	12.5

Zinc was applied in the form of zinc sulfate to both soil and foliage. The soil application was done before transplanting whereas foliar spray was done 30 days after transplanting the crop. The growth and yield parameters were recorded by adopting standard procedures.

2.2 Treatment details

T_1	RDF + FYM (150:100:125 NPK kg ha^{-1} + 12.5 tons FYM ha^{-1})
T_2	T_1+ 2 kg of Zn through $ZnSO_4$ as soil application
T_3	T_1+ 4 kg of Zn through $ZnSO_4$ as soil application
T_4	T_1+ 6 kg of zinc through $ZnSO_4$ as soil application
T_5	T_1+ 8 kg of Zn through $ZnSO_4$ as soil application
T_6	T_1+ 1 kg of Zn through $ZnSO_4$ as soil application + 0.14% Zn through $ZnSO_4$ as foliar spray
T_7	T_1+ 2 kg of Zn through $ZnSO_4$ as soil application + 0.14% Zn through $ZnSO_4$ as foliar spray
T_8	T_1+ 3 kg of Zn through $ZnSO_4$ as soil application + 0.14% Zn through $ZnSO_4$ as foliar spray
T_9	T_1+ 4 kg of Zn through $ZnSO_4$ as soil application + 0.14% Zn through $ZnSO_4$ as foliar spray
T_{10}	Farmer's practice (3 bags urea + 3 bags DAP + 3 bags MOP)

2.3 Soil Sampling and Analysis

Before initiating the study, soil samples were collected and analyzed for various chemical properties and are presented in Table 1. The analytical value of the samples collected indicated that soil pH was neutral (7.80) with normal EC (0.42 dS m^{-1}), organic carbon (0.56%), available nitrogen (282.4 kg ha^{-1}), phosphorus (34.28 kg ha^{-1}) and potassium (266.4 kg ha^{-1}) were medium with deficiency of DTPA extractable zinc (0.48 mg kg^{-1}).

Table 1. Initial physicochemical properties of the soil of the experimental site

Sl. No.	Soil property	Content	Method followed
1	Sand (%)	58.90	International pipette method [5]
	Silt (%)	6.81	
	Clay (%)	33.70	
	Textural class	Sandy clay	
2	pH (1:2.5)	7.80	Potentiometry [6]
3	EC (1:2.5) (dS/m)	0.42	Conductometry [6]
4	OC (%)	0.56	Wet oxidation method [6]
5	CEC[cmol (p^+)/kg]	14.38	Neutral 1N, NH_4OAc method [6]
6	Available N (kg/ha)	282.4	Alkaline permanganate method [7]
7	Available P_2O_5 (kg/ha)	34.28	Oleson's method [6]
8	Available K_2O (kg/ha)	266.4	Neutral 1N ammonium acetate extraction & flame photometry method [8]
9	Exchangeble Ca [cmol (p^+)/kg]	4.92	Versenate titration method [6]
10	Exchangeble Mg [cmol (p^+)/kg]	2.68	Versenate titration method [6]
11	Available S (mg/kg)	12.24	Turbidometry method [9]
12	Available Zn (mg/kg)	0.48	DTPA extraction atomic absorption spectrophotometer method [10]
13	Available Fe (mg/kg)	3.28	
14	Available Mn (mg/kg)	2.10	
15	Available Cu (mg/kg)	0.78	
16	Available B (mg/kg)	0.52	Hot water-soluble extraction method [11]

3. RESULTS AND DISCUSSION

Results obtained under this were presented in different sections with detailed discussion.

3.1 Effect of graded levels of zinc on growth parameters of Knol Khol

The effects of graded levels of zinc on Knol khol growth parameters like plant height, number of leaves per plant, and leaf length both at 45 DAT and harvest are presented and discussed (Table 2).

3.1.1 Plant height

At 45 days after transplanting

Plant height did not differ significantly among the treatments. However, a higher plant height of 30.20 cm was in T_9 (T_1+ 4 kg of zinc through zinc sulfate as soil application + 0.14% zinc through zinc sulfate as a foliar spray), followed by T_8 (T_1 + 3 kg of zinc through zinc sulphate as soil application + 0.14% zinc through zinc sulfate as foliar spray) which recorded 29.37 cm. Significantly lower plant height of 25.40 and 26.35 cm was recorded in T_{10} (Farmer's practice) and T_1 (RDF + FYM), respectively.

At harvest

Significantly higher plant height (39.90 cm) was in T_9 (T_1+ 4 kg of zinc through zinc sulfate as soil application + 0.14% zinc through zinc sulfate as foliar spray), followed by T_8. A significantly lower plant height of 33.60 cm was recorded in T_{10} *i.e.* Farmer's practice.

3.1.2 Number of leaves per plant

At 45 days after transplanting

Number of leaves per plant did not differ significantly among treatments. However, a higher number of leaves (9.67) was

recorded in T_9 which received 4 kg of zinc through zinc sulfate as soil application + 0.14% zinc through zinc sulfate as foliar spray along with RDF (150:100:125 NPK kg ha^{-1}) and FYM followed by T_8 (9.33) which received 3 kg of zinc through zinc sulfate as soil application + 0.14% zinc through zinc sulfate as a foliar spray along with RDF (150:100:125 NPK kg ha^{-1}) and FYM. Significantly less number of leaves were recorded in T_{10} (Farmer's practice) followed by T_1 (RDF + FYM).

At harvest

A significantly higher number of leaves (14.83) were recorded in T_9 (T_1 + 4 kg of zinc through zinc sulfate as soil application + 0.14% zinc through zinc sulfate as a foliar spray), followed by T_8 (T_1 + 3 kg of zinc through zinc sulfate as soil application + 0.14% zinc through zinc sulfate as a foliar spray) which recorded 14.30. The lower number of leaves of 10.33 and 10.67 were recorded in T_{10}(Farmer's practice) and T_1 (RDF + FYM), respectively.

3.1.3 Leaf length

At 45 days after transplanting

Leaf length did not differ significantly among treatments. However, a higher leaf length of 17.33 cm was recorded in T_9 (T_1 + 4 kg of zinc through zinc sulfate as soil application + 0.14% zinc through zinc sulfate as a foliar spray), followed by T_8 (T_1 + 3 kg of zinc through zinc sulfate as soil application + 0.14% zinc through zinc sulfate as foliar spray) which recorded 16.63 cm. The lower leaf length of 13.30 and 13.60 cm was recorded in T_{10} (Farmer's practice) and T_1 (RDF + FYM) respectively.

At harvest

Significantly higher leaf length of 19.68 cm was recorded in T_9 (T_1 + 4 kg of zinc through zinc sulfate as soil application + 0.14% zinc through zinc sulfate as foliar spray), followed by T_8 (T_1 + 3 kg of zinc through zinc sulfate as soil application + 0.14% zinc through zinc sulfate as foliar spray) which recorded 19.38 cm. The lower leaf length of 16.12 cm was recorded in T_{10} (Farmer's practice) followed by T_1 (RDF + FYM) which was recorded at 16.40 cm.

The increase in plant growth attributes may be due to better nutrient absorption and uptake, particularly zinc as the soil was deficient in zinc. The increase in growth attributes as a result of zinc application might be due to the metabolic roles of zinc in the plant and its activity as a component of many enzymes. It may also be due to the important role of zinc in the synthesis of tryptophan which is the precursor of IAA synthesis which helps in cell division, activity of meristematic tissues and expansion of cell and hence improving the growth of the plant [12]; [13]; [14].

Table 2. Effect of graded levels of zinc on growth parameters of Knol khol

Treatments	Plant height (cm)		Number of leaves per plant		Leaf length (cm)	
	45 DAT	At harvest	45 DAT	At harvest	45 DAT	At harvest
T_1	26.35	34.75	6.67	10.67	13.60	16.40
T_2	26.74	35.35	7.00	11.00	13.75	16.83
T_3	27.64	37.25	7.67	12.00	14.45	17.65
T_4	28.35	37.82	8.00	12.33	14.67	18.28
T_5	29.25	38.65	8.67	13.70	15.50	18.78
T_6	27.23	36.65	7.33	11.40	14.20	17.35
T_7	28.60	38.12	8.33	13.00	15.30	18.67
T_8	29.37	39.27	9.33	14.30	16.63	19.38
T_9	30.20	39.90	9.67	14.83	17.33	19.68
T_{10}	25.40	33.60	6.33	10.33	13.30	16.12
CD (p=0.05)	**NS**	**0.55**	**NS**	**0.40**	**NS**	**0.21**

3.2 Effect of graded levels of zinc on yield Parameters

The yield parameters like knob diameter, knob volume, weight of knob, and yield per hectare as influenced by the application of graded levels of zinc are presented in Table 3.

3.2.1 Knob diameter

The knob diameter was significantly higher in T_9 (6.25 cm) which consists of 4 kg of zinc through zinc sulfate as soil application and 0.14% zinc through zinc sulfate as a foliar spray along with RDF (150:100:125 NPK kg ha^{-1}) and FYM followed by T_8. The lower knob diameter of 4.97 and 5.04 cm was recorded in T_{10}(Farmer's practice) and T_1 (RDF + FYM), respectively.

3.2.2 Knob volume

Knob volume was recorded significantly higher in T_9 (T_1 + 4 kg of zinc through zinc sulfate as soil application + 0.14% zinc through zinc sulfate as foliar spray) 127.29 cm^3 followed by T_8. The lower knob volume of 61.76 cm^3 was recorded in T_{10} (Farmer's practice) followed by T_1 (RDF + FYM) which recorded 66.68 cm^3.

3.2.3 Weight of knob

The significantly higher weight of knob of 137.91 g was in T_9 which received 4 kg of zinc through zinc sulfate as soil application + 0.14% zinc through zinc sulfate as a foliar spray along with RDF (150:100:125 NPK kg ha^{-1}) + FYM followed by T_8. The lower weight of the knob of 84.77 and 92.68 g was recorded in T_{10}(Farmer's practice) and T_1 (RDF + FYM) respectively.

3.2.4 Yield

Yield per hectare was significantly higher in T_9 (T_1 + 4 kg of zinc through zinc sulphate as soil application + 0.14% zinc through zinc sulfate as foliar spray 23.00 t ha^{-1}, followed by T_8. The lower yield per hectare of 18.00 t ha^{-1} was recorded in T_{10} (Farmer's practice).

The increase in yield parameters might be due to the combined soil and foliar application of zinc which resulted in the increased supply of the available zinc to the plants leading to proper growth and development. Zinc sulphate being highly soluble in water, improved its availability and uptake by the plant. Further, the favourable effect of zinc on photosynthesis and metabolic process augmented the production of photosynthates and their translocation to the knob which is the absolute sink and improved the yield. [12] reported that the application of 100 % of the recommended dose of nitrogen and zinc at 6 kg ha^{-1} significantly increased the knob diameter, knob volume, fresh weight, and total yield of Knol khol. [15] and [16] concluded that zinc plays an important role in the production of biomass. [17] revealed that yield and yield attributes were highest with foliar spray of zinc as zinc sulphate at 100 mg/kg in cabbage [18]; [14].

Table 3. Effect of graded levels of zinc on yield parameters of Knol khol crop

Treatments	Knob diameter (cm)	Knob volume (cm^3)	Weight of knob (g)	Yield ($t\ ha^{-1}$)
T_1	5.04	66.68	92.68	20.50
T_2	5.20	78.73	97.25	21.02
T_3	5.52	87.53	112.97	21.57
T_4	5.68	95.34	118.24	21.71
T_5	5.86	105.31	126.73	22.22
T_6	5.29	81.10	108.24	21.34
T_7	5.74	98.58	123.44	22.08
T_8	6.12	119.65	132.50	22.50
T_9	6.25	127.29	137.91	23.00
T_{10}	4.97	61.76	84.77	18.00
CD (p=0.05)	**0.19**	**4.85**	**5.14**	**0.24**

3.3 Effect of graded levels of zinc on economics of Knol khol

Higher benefit-cost ratio of 3.48 was recorded with the application of 4 kg of Zn through $ZnSO_4$ as soil application + 0.14% Zn through zinc sulphate as a foliar spray along with RDF and FYM followed by application of 3 kg of Zn through $ZnSO_4$ as soil application + 0.14% Zn through zinc sulfate as foliar spray along with RDF and FYM (3.39) (Table 4). However, the lower benefit-cost ratio of 2.52 was recorded in T_{10} (Farmer's practice) followed by T_1(RDF + FYM) which was recorded 3.03 [19]; [20]; [21]; [22].

Table 4. Effect of Graded levels of zinc on economic parameters of Knol khol cultivation

Treatments	Yield (t/ha)	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
T_1	20.50	68652	276750	208098	3.03
T_2	21.02	68728	283770	215042	3.13
T_3	21.57	68804	291195	222391	3.23
T_4	21.71	68880	293085	224205	3.26
T_5	22.22	68956	299970	231014	3.35
T_6	21.34	69140	288090	218950	3.17
T_7	22.08	69178	298080	228902	3.31
T_8	22.50	69216	303750	234534	3.39
T_9	23.00	69254	310500	241246	3.48
T_{10}	18.00	58760	207000	148240	2.52

4. CONCLUSION

Application of zinc *i.e.*, soil application (4 kg ha^{-1}) and foliar application (0.14%) along with RDF (150:100:125 NPK kg ha^{-1}) and FYM (12.5 t ha^{-1}) has a significant effect on growth, yield and economics of Knol khol.

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