Mysore J. Agric. Sci., 57 (4) : 203-209 (2023)

Effect of Soil and Foliar Application of Zinc on Nutritional Composition and Uptake by Knol Khol (*Brassica caulorapa* var. *gongylodes* L.)

R. Pavithra and C. T. Subbarayappa
Department of Soil Science and Agricultural Chemistry, College of Agriculture, UAS, GKVK, Bengaluru - 560 065
e-Mail : pavithra199326@gmail.com

Authors Contribution

R. Pavithra :
Carried out the experiment and drafted the manuscript;
C. T. Subbarayappa :
Conceived the study, designing, coordination and edited the manuscript

Corresponding Author :
R. Pavithra
Department of Soil Science and Agricultural Chemistry, College of Agriculture, UAS, GKVK, Bengaluru

Received : January 2023
Accepted : September 2023

Abstract

A field experiment was conducted in the farmer's field at Vijaypura, Bengaluru Rural District during *kharif* 2017, to study the effect of soil and foliar application of zinc on nutritional composition and uptake by knol khol. The experiment was laid out in a randomized complete block design with 10 treatments replicated thrice. The experimental results indicated that significantly higher nitrogen (2.36%), phosphorus (0.37%), potassium (1.60%), sulphur (0.65%) and zinc content (36.48 mg kg^{-1}) was recorded in knol khol shoot by application of RDF and FYM along with 4 kg of zinc through $ZnSO_4$ as soil application and 0.14 per cent zinc through zinc sulphate as foliar spray (T_9). Significantly higher nitrogen (2.48%), phosphorus (0.39%), potassium (2.24%), sulphur (0.82%) and zinc content (38.67 mg kg^{-1}) was recorded in knol khol knob with the combined soil and foliar application of zinc @ 4 kg and 0.14 per cent through zinc sulphate respectively, along with RDF and FYM (T_9). Uptake of nitrogen (100.05 kg ha^{-1}), phosphorous (15.70 kg ha^{-1}), potassium (72.74 kg ha^{-1}), sulphur (28.76 kg ha^{-1}) and zinc (154.96 g ha^{-1}) by knol khol crop was recorded significantly higher in T_9 (4 kg of zinc through zinc sulphate as soil application + 0.14 per cent zinc through zinc sulphate as foliar spray along with RDF and FYM).

Keywords : Zinc, Knol khol, Nutrient content, Shoot, Knob, Uptake

Micronutrients are indispensable for growth and development of crops in general and vegetables in particular. The nutritional value and quality of crops is becoming a major concern in the recent years. Therefore, application of micronutrients to sustain soil health and crop productivity besides maintaining the quality of vegetables is of profound importance. However, foliar application of micronutrients shows better efficacy than soil application as the uptake and assimilation of micronutrients by latter method takes more time (Kumar *et al*., 2016).

Zinc is an essential micronutrient and plays a very important role in plant metabolism by influencing the activities of hydrogenase and carbonic anhydrase, stabilization of ribosomal fractions and synthesis of cytochrome (Tisdale *et al*., 1984). Plant enzymes activated by zinc are involved in carbohydrate metabolism, maintenance of the integrity of cellular membranes, protein synthesis, regulation of auxin synthesis and pollen formation (Marschner, 1995). Its deficiency results in the development of abnormalities in plants which become visible as deficiency symptoms such as stunted growth, chlorosis and smaller leaves, spikelet sterility and can also adversely affect the quality of the produce. In this present study, an attempt has been made to study the effect of soil and foliar application of zinc on the nutritional composition and uptake by knol khol.

Knol khol (*Brassica caulorapa* var. *gongylodes* L.) is a winter season crop and is originated from the coastal countries of Mediterranean region. It belongs to the family *Cruciferae* and is a close relative of cabbage and cauliflower (cole crops). It is popular in Kashmir, West Bengal, Maharashtra, Assam, Uttar Pradesh,

Punjab and some parts of south India. The stem swells and stores edible food material especially starch and sugars. When consumed as raw it gives a sweetish taste with a slight aroma. Knol khol is characterized by the formation of the knob which arises from thickening of the stem tissue above the cotyledon. The knob is used for human consumption either as raw or cooked. It is also utilized for making salad and pickles.

Material and Methods

A field experiment was conducted to study the effect of soil and foliar application of zinc on nutritional composition and uptake by knol khol in a randomized complete block design with ten treatments replicated thrice in farmer's field at Vijaypura, Bangalore Rural District, Karnataka during *kharif* 2017. The treatments were T_1= RDF (150:100:125 N:P_2O_5:K_2O kg ha^{-1}) + FYM (12.5 t 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 application, T_7= T_1+ 2 kg of Zn through $ZnSO_4$ as soil application + 0.14% Zn through $ZnSO_4$ as foliar application, T_8= T_1+ 3 kg of Zn through $ZnSO_4$ as soil application + 0.14% Zn through $ZnSO_4$ as foliar application, T_9= T_1+ 4 kg of Zn through $ZnSO_4$ as soil application + 0.14% Zn through $ZnSO_4$ as foliar application and T_{10}= Farmer's practice (3 bags urea + 3 bags DAP + 3 bags MoP *i.e.,* 89.1:30:90 N:P_2O_5:K_2O kg ha^{-1}). Zinc was applied in the form of zinc sulphate both as soil and foliar application. The soil application was done before transplanting whereas foliar spray was done 30 days after transplanting the crop. The nutrient content of shoot and knob was determined by adopting standard procedures. Nutrient uptake for major, secondary and micronutrients were calculated by the formula mentioned below and is expressed in kg per hectare for macronutrients and gram per hectare for micronutrients.

$$\text{Macronutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient concentration (\%) x Dry matter yield (kg ha}^{-1}\text{)}}{100}$$

$$\text{Micronutrient uptake (g ha}^{-1}\text{)} = \frac{\text{Nutrient concentration (mg kg}^{-1}\text{) x Dry matter yield (kg ha}^{-1}\text{)}}{1000}$$

Results and Discussion

Physico-chemical Properties

The initial soil properties of soil in Table 1 indicated that the soil pH was neutral (7.80) with normal EC (0.42 dS m^{-1}) and medium in organic carbon (5.6 g kg^{-1}). The available nitrogen (282.4 kg ha^{-1}), phosphorous (34.28 kg ha^{-1}) and potassium (266.4 kg ha^{-1}) were medium and DTPA extractable zinc (0.48 mg kg^{-1}) was deficient.

Table I

Initial physical and chemical properties of the soil of the experimental site

Parameters	Values	
pH (1:2.5)	7.80	Potentiometry (Jackson, 1973)
EC (1:2.5) (dS m^{-1})	0.42	Conductometry (Jackson, 1973)
OC (g kg^{-1})	5.6	Wet oxidation method (Jackson, 1973)
Available N (kg ha^{-1})	282.4	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P_2O_5 (kg ha^{-1})	34.28	Oleson's method (Jackson, 1973)
Available K_2O (kg ha^{-1})	266.4	Neutral 1N ammonium acetate extraction & flame photometry method (Page *et al.,*1982)
Available S (mg kg^{-1})	12.24	Turbidometry method (Black,1965)

Table 1 Conti...

Parameters	Values	
Available Zn (mg kg^{-1})	0.48	
Available Fe (mg kg^{-1})	3.28	DTPA extraction atomic absorption spectrophotometer method (Lindsay and Norvel, 1978)
Available Mn (mg kg^{-1})	2.10	
Available Cu (mg kg^{-1})	0.78	

Effect of Soil and Foliar Application of Zinc on Macro and Secondary Nutrient Content (%) of knol khol Shoot

The experimental results revealed that, the application of RDF (150:100:125 NPK kg ha^{-1}) and 12.5 t of FYM per hectare and 4 kg of Zn through $ZnSO_4$ as soil application along with 0.14 per cent Zn through zinc sulphate as foliar spray significantly increased the nitrogen (2.36%), phosphorus (0.37%), potassium (1.60%) and sulphur (0.65%) content of knol khol shoot (Table 2). The lower nutrient content was recorded in T_{10} (Farmer's practice) followed by T_1 (RDF + FYM). Soil and foliar application of zinc did not have any significant influence on calcium and magnesium content of knol khol shoot.

Significantly higher nitrogen, phosphorous, potassium and sulphur content in knol khol shoot was recorded due to both soil and foliar application of zinc through zinc sulphate along with the recommended dose of fertilizers. Zinc sulphate is readily soluble in water and enhances the availability of zinc in the plant tissue. Increased zinc concentration enhances nitrogen, phosphorous, potassium and sulphur content in the plant tissue due to the synergistic effect. Similar results were reported by Hossain (2008) and Rana *et al.* (2017).

Effect of Soil and Foliar Application of Zinc on Micronutrient Content (mg kg^{-1}) of knol khol Shoot

Application of 4 kg of zinc through zinc sulphate as soil application + 0.14 per cent zinc through zinc sulphate as foliar spray along with RDF and FYM recorded higher zinc content of 36.48 mg kg^{-1} (Table 3). Among all the treatments, the lower zinc content was recorded in T_{10} (Farmer's practice)

TABLE 2

Effect of graded levels of zinc on macro and secondary nutrient content (%) of knol khol shoot

Treatments	N content (%)	P content (%)	K content (%)	Ca content (%)	Mg content (%)	S content (%)
T_1	1.72	0.21	1.30	0.50	0.30	0.30
T_2	1.80	0.23	1.34	0.51	0.31	0.36
T_3	1.92	0.26	1.42	0.53	0.32	0.46
T_4	1.98	0.28	1.45	0.54	0.33	0.50
T_5	2.16	0.27	1.50	0.55	0.35	0.58
T_6	1.86	0.24	1.38	0.52	0.31	0.42
T_7	2.07	0.30	1.48	0.54	0.34	0.54
T_8	2.22	0.34	1.54	0.55	0.35	0.60
T_9	2.36	0.37	1.60	0.56	0.36	0.65
T_{10}	1.64	0.19	1.20	0.49	0.29	0.26
S. Em ±	0.03	0.01	0.01	0.04	0.03	0.01
CD (5%)	0.10	0.02	0.04	NS	NS	0.04

TABLE 3

Effect of graded levels of zinc on micronutrient content (mg kg^{-1}) of knol khol shoot

Treatments	Zn content (mg kg^{-1})	Fe content (mg kg^{-1})	Mn content (mg kg^{-1})	Cu content (mg kg^{-1})
T_1	16.94	113.28	32.70	9.04
T_2	20.47	113.29	32.71	9.05
T_3	26.39	113.30	32.72	9.06
T_4	28.42	113.31	32.73	9.07
T_5	31.40	113.33	32.75	9.09
T_6	23.75	113.30	32.72	9.06
T_7	30.75	113.32	32.74	9.08
T_8	33.71	113.33	32.75	9.09
T_9	36.48	113.34	32.76	9.10
T_{10}	14.18	113.27	32.69	9.03
S. Em ±	0.70	0.03	0.04	0.03
CD (5%)	2.10	NS	NS	NS

followed by T_1 (RDF + FYM). Soil and foliar application of zinc did not have any significant influence on iron, manganese and copper content of knol khol shoot.

The highest concentration of zinc in knol khol leaf was recorded due to both soil and foliar application of zinc through zinc sulphate. Combined soil and foliar application of zinc led to better uptake and assimilation of zinc by knol khol shoot. Besides zinc sulphate being readily soluble in water improved the absorption and concentration of zinc in the plant tissue. The results are in confirmation with Hossain (2008) and Rana *et al.,* (2017).

Effect of Soil and Foliar Application of Zinc on Macro and Secondary Nutrient Content (%) of Knol Khol Knob

Higher content of nitrogen (2.48%), phosphorus (0.39%), potassium (2.24%) and sulphur (0.82%) in knol khol knob was recorded with the application of 4 kg of Zn through $ZnSO_4$ as soil application + 0.14 per cent Zn through zinc sulphate as foliar spray along with RDF and FYM (Table 4). However, lower nitrogen, phosphorus, potassium and sulphur content (1.92, 0.20, 1.62, 0.37% respectively) was recorded in T_{10} (Farmer's practice) followed by T_1 *i.e.* RDF + FYM (2.04, 0.23, 1.69, 0.43% respectively). Soil and foliar application of zinc did not have any significant influence on calcium and magnesium content of knol khol knob.

The higher nutrient content of knob was due to both soil and foliar application of zinc sulphate, since zinc

TABLE 4

Effect of graded levels of zinc on macro and secondary nutrient content (%) of knol khol knob

Treatments	N content (%)	P content (%)	K content (%)	Ca content (%)	Mg content (%)	S content (%)
T_1	2.04	0.23	1.69	0.55	0.38	0.43
T_2	2.12	0.25	1.76	0.56	0.39	0.52
T_3	2.22	0.28	1.88	0.58	0.40	0.60
T_4	2.26	0.30	1.94	0.59	0.41	0.65
T_5	2.37	0.29	2.14	0.61	0.43	0.73
T_6	2.17	0.25	1.82	0.58	0.40	0.58
T_7	2.31	0.31	2.06	0.60	0.42	0.68
T_8	2.42	0.35	2.18	0.61	0.43	0.76
T_9	2.48	0.39	2.24	0.62	0.44	0.82
T_{10}	1.92	0.20	1.62	0.54	0.37	0.37
S. Em ±	0.02	0.01	0.01	0.04	0.03	0.01
CD (5%)	0.04	0.03	0.05	NS	NS	0.03

is essential for synthesis of DNA and RNA and for the production of carbohydrate, lipids and proteins. Moreover, the favourable effect of zinc on photo synthesis and metabolic processes augmented the production of photosynthates and their translocation ultimately increased the concentration of nutrients in the knob. These results are in conformity with the findings of Hossain (2008), Dube *et al.* (2003) Verma *et al.* (2017) and Choudhary *et al.* (2018).

Effect of Soil and Foliar Application of Zinc on Micronutrient Content (mg kg^{-1}) of Knol Khol Knob

Application of 4 kg of Zn through $ZnSO_4$ as soil application + 0.14 per cent Zn through zinc sulphate as foliar spray along with RDF and FYM recorded significantly higher zinc content of 38.67 mg kg^{-1} in knol khol knob (Table 5). Lower zinc content was recorded in T_{10} (Farmer's practice) followed by T_1 (RDF + FYM). Soil and foliar application of zinc did not have any significant influence on iron, manganese and copper content of knol khol knob.

Application of graded levels of zinc through the soil and foliar application improved the zinc content of knob. Zinc sulphate being readily soluble in water increased the availability and absorption of zinc when applied to soil deficient in zinc and direct absorption of zinc through leaves by foliar application. The improved photosynthetic efficiency due to zinc application led to better dry matter production and nutrient concentration. The present results are corroborated with the findings of Altaf and Subbarayappa (2021), Shah *et al.* (2010), Verma *et al.* (2017) and Choudhary *et al.* (2018).

TABLE 5

Effect of graded levels of zinc on micronutrient content (mg kg-1) of knol khol knob

Treatments	Zn content (mg kg^{-1})	Fe content (mg kg^{-1})	Mn content (mg kg^{-1})	Cu content (mg kg^{-1})
T_1	23.27	121.29	34.48	7.21
T_2	25.18	121.30	34.49	7.23
T_3	27.46	121.32	34.50	7.24
T_4	28.62	121.33	34.51	7.25
T_5	35.18	121.35	34.53	7.27
T_6	26.12	121.32	34.50	7.24
T_7	33.47	121.34	34.52	7.26
T_8	36.84	121.35	34.53	7.27
T_9	38.67	121.36	34.54	7.28
T_{10}	18.28	121.28	34.47	7.20
S. Em ±	0.40	0.04	0.03	0.03
CD (5%)	1.20	NS	NS	NS

Effect of Graded Levels of Zinc on Uptake of Macro and Secondary Nutrient Content by Knol Khol Crop

The application of RDF (150:100:125 NPK kg ha^{-1}) and 12.5 t of FYM per hectare and 4 kg of Zn through $ZnSO_4$ as soil application along with 0.14 per cent Zn through zinc sulphate as foliar spray (T_9) significantly increased the nitrogen (100.05 kg ha^{-1}), phosphorus (15.70 kg ha^{-1}), potassium (72.74 kg ha^{-1}) and sulphur (28.76 kg ha^{-1}) uptake by knol khol (Table 6). The lower uptake was recorded in T_{10} (Farmer's practice) followed by T_1 (RDF + FYM). Soil and foliar application of zinc did not have any significant influence on calcium and magnesium uptake by knol khol. Soil and foliar application of graded levels of zinc did not significantly influence calcium and magnesium uptake by knol khol.

Application of graded levels of zinc resulted in better uptake of nutrients such as nitrogen, phosphorus, potassium and sulphur due to the synergistic effect of zinc with these nutrients. Zinc sulphate which is readily soluble in water increased the zinc content in plant tissue which in turn helped in better translocation and absorption of nutrients from the soil. Similar results were also reported by Shrishail Arabhavi (2014) in knol khol, Basavaraj (2013) in cauliflower and Ranjitha (2017) in tomato.

Effect of Graded Levels of Zinc on Uptake of Micronutrient Content by Knol Khol Crop

The data pertaining to micronutrient uptake by knol khol crop due to soil and foliar application of zinc at harvest and the results are presented in Table 7. Zinc

TABLE 6

Effect of graded levels of zinc on uptake of macro and secondary nutrient content by knol khol crop

Treatments	Total N uptake by plant (kg ha^{1})	Total P uptake by plant (kg ha^{-1})	Total K uptake by plant (kg ha^{-1})	Total Ca uptake by plant (kg ha^{-1})	Total Mg uptake by plant (kg ha^{-1})	Total S uptake byplant (kg ha^{-1})
T_1	67.72	8.13	52.25	19.38	11.99	12.35
T_2	71.84	9.02	54.86	20.05	12.56	15.09
T_3	77.94	10.39	59.52	21.26	13.23	19.21
T_4	81.01	11.30	61.63	21.88	13.77	21.10
T_5	89.75	11.17	66.48	22.91	14.93	24.89
T_6	75.13	9.46	57.38	20.80	12.82	17.66
T_7	85.41	12.17	64.46	22.26	14.37	22.92
T_8	93.91	14.21	69.42	23.36	15.22	26.29
T_9	100.05	15.70	72.74	24.02	15.80	28.76
T_{10}	63.47	7.20	47.92	18.73	11.43	10.51
S. Em ±	1.40	0.30	0.83	1.90	1.50	0.60
CD (5%)	4.20	0.90	2.50	NS	NS	1.82

TABLE 7

Effect of graded levels of zinc on uptake of micronutrient content by knol khol crop

Treatments	Total Zn uptake by plant (g ha^{-1})	Total Fe uptake by plant (g ha^{-1})	Total Mn uptake by plant (g ha^{-1})	Total Cu uptake by plant (g ha^{-1})
T_1	23.27	121.29	34.48	7.21
T_1	68.99	436.61	125.65	33.06
T_2	82.51	442.98	127.50	33.53
T_3	104.73	452.33	130.21	34.23
T_4	113.18	457.09	131.60	34.59
T_5	131.08	468.37	134.90	35.50
T_6	94.70	449.23	129.32	34.01
T_7	126.18	463.34	133.42	35.08
T_8	142.68	477.54	137.54	36.20
T_9	154.96	482.51	138.99	36.58
T_{10}	56.04	430.64	123.92	32.64
S. Em ±	3.20	17.50	5.10	1.36
CD (5%)	9.60	NS	NS	NS

uptake by knol khol crop was recorded significantly higher in T_9 (T_1 + 4 kg of zinc through zinc sulphate as soil application + 0.14 per cent zinc through zinc sulphate as foliar spray) which recorded 154.96 g ha^{-1} followed by T_8 (T_1 + 3 kg of Zn through $ZnSO_4$ as soil application + 0.14 per cent Zn through zinc sulphate as foliar spray) which recorded 142.68 g ha^{-1}. Among all the treatments, T_{10} (Farmer's practice) and T_1 (RDF + FYM) recorded lower zinc uptake of 56.04 g ha^{-1} and 68.99 g ha^{-1} respectively. Soil and foliar application of graded levels of zinc did not significantly influence iron, manganese and copper uptake by knol khol.

Zinc sulphate is readily soluble in water, which led to the increased availability and absorption of zinc when applied to soil deficient in zinc and direct absorption of zinc through leaves by foliar application. The results are in agreement with the findings of Shrishail Arabhavi (2014) in knol khol, Basavaraj (2013) and Chethana *et al*. (2019) in cauliflower.

Application of 4 kg zinc through zinc sulphate as soil application + 0.14 per cent foliar application of zinc through zinc sulphate along with recommended dose of NPK (150:100:125 NPK kg ha^{-1}) + FYM (12.5 t ha^{-1}) significantly increased the nitrogen, phosphorus, potassium, sulphur and zinc content and uptake by knol khol. Soil and foliar application of zinc was advantageous than soil application alone.

REFERENCES

ALTAF KUNTOJI AND SUBBARAYAPPA. C. T., 2021, Effect of different levels of nitrogen and zinc on quality and nutrient content of maize in Rural and Peri-Urban Southern transact of Bengaluru. *The Mysore J. Agric. Sci.,* **55** (3) : 12 - 18.

BASAVARAJ, S., 2013, Studies on zinc and boron nutrition on yield, quality and nutrient uptake in cauliflower (*Brassica oleracea* var. *Botrytis* L.) under Northern Transition Zone of Karnataka. *M.Sc. (Ag.) Thesis.* Univ. Agric. Sci., Dharwad.

BLACK, C. A., 1965, Methods of Soil Analysis. Part II Agronomy Monograph No*,* 9*, American Soc. Agron*, Madison, Wisconsin, pp. : 148.

CHETHANA, K. H., SUBBARAYAPPA. C. T. AND NAVEEN. D. V., 2019, Effect of soil and foliar application of zinc on zinc content and uptake by of cauliflower (*Brassica oleracea* var. *botrytis* L.). *Journal of Pharmacognosy and Phytochemistry.,* **8** (4) : 3159 - 3163.

CHOUDHARY, R., BAIRWA, L. N., ARJUN L. O. AND OM PRAKESH J., 2018, Effect of zinc on growth, yield and quality of knol-khol (*Brassica caulorapa* L.). *International Journal of Chemical Studies.*, **6** (3) : 1217 - 1219.

DUBE, B. K., SINHA, P. AND CHATTERJEE, C., 2003, Effect of zinc on yield and quality of tomato. *Indian J. Horti.*, **60** (1) : 59 - 63.

HOSSAIN, 2008, Effect of zinc and boron on the growth and yield of tomato. *M.Sc. (Ag.) Thesis.,* Bangladesh Agricultural University, Mymensingh.

JACKSON, M. L., 1973, Soil Chemical Analysis, *Prentice Hall of India Private Limited*, New Delhi. pp. : 485.

KUMAR, N. M., AJAY, K. P. AND MOHAMMAD, A. B., 2016, Growth and yield of solanaceous vegetables in response to application of micronutrients A Review. *International Journal of Innovative Science, Engineering & Technology.,* **3** (2) : 611 - 626.

LINDSAY, W. L. AND NORVEL, W. A., 1978, Development of DTPA soil test for Zn, Fe, Mn and Cu. *Soil Sci. Soc. American. J.,* **42** : 421 - 428.

MARSCHNER, H., 1995. Mineral nutrition of higher plants, 2nd ed. *Academic Press*, London. pp. : 889.

PAGE, A. L., MILLER, R. H. AND KEENEY, D. R., 1982*,* Methods of Soil Analysis. Part-2. *Soil Sci. Soc. America, Inc, Publis*., Madison, Wisconsin, USA.

RANA, S. S., SANJAY, K. S. AND SAPNA, K., 2017, Effect of nitrogen, zinc and boron on nutrient concentration at maximum tillering of wheat. *Biomed, J. Sci. Tech. Res.,* **1** (7) : 53 - 64.

RANJITHA, K. S., 2017, Studies on the effect of sources and levels of zinc on soil properties, growth and yield of tomato (*Lycopersicon esculentum*). *M.Sc. (Ag.) Thesis.* Univ. Agric. Sci., Bengaluru.

SHAH, D. A., RAJ, N., NAZEER, A., SUMATI, N. AND WANI, K. P., 2010, Influence of boron and zinc on growth, yield and quality of knol khol *cv.* Early White Vienna. *Indian J. Hort.*, **67** : 323 - 328.

SHRISHAIL ARABHAVI, 2014, Studies on zinc sulphate and borax on yield, quality and nutrient uptake by knol-khol (*Brassica oleracea* var. *gonglodes* L.) in *Alfisols* under Northern Transition Zone of Karnataka. *M.Sc. (Ag.) Thesis.* Univ. Agri. Sci., Dharwad.

SUBBAIAH, G. V. AND ASIJA, G. L., 1956, A rapid procedure for the estimation of available nitrogen in soil. *Curr. Sci.*, **25** : 258 - 260.

TISDALE, S. L, NELSON, W. L., BEATEN, J. D., 1984, Zinc in soil fertility and fertilizers. Fourth edition, *Macmillan Publishing Company*, New York. pp. : 382 - 391.

VERMA, M., CHOUDHARY, M. R., MAHAWAR, A. K., SINGH, S. P. AND MEENA N. K., 2017, Response of thiourea and zinc on quality characteristics and economics of cauliflower (*Brassica oleracea* var. *Botrytis* L.). *Chem. Sci. Rev. Lett.,* **6** (22) : 1285 - 1289.