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Influence of zinc and copper on soil properties, nutrient uptake and yield of coriander in lateritic soils of Konkan region

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Abstract
Coriander (*Coriandrum sativum* L.) belongs to family Apiaceae is a native of Mediterranean region and is extensively grown in India. In order to study the influence of zinc and copper on soil properties, nutrient uptake and yield of coriander the present investigation was undertaken. The highest yield of 11.18 t ha^{-1} of coriander was obtained with the application of 0.5 percent $ZnSO_4$ through foliar spray along with 100 percent RDF (T_5). However, the yield of coriander (10.56 t ha^{-1}) with the soil application of $ZnSO_4$ @ 20 kg ha^{-1} along with 100 percent RDF (T_6) which is at par with the treatment T_5. The application of $ZnSO_4$ @ 20 kg ha^{-1} along with 100 percent RDF (T_6) showed highest sulphur and zinc content (23.21 and 1.71 mg kg^{-1}) in soil. The highest sulphur and zinc uptake (4.24 kg ha^{-1} and 184.19 g ha^{-1} respectively) of coriander was obtained with the application T_6 treatment. While, the highest copper content (4.40 mg kg^{-1}) in soil and uptake (63.58 g ha^{-1}) of coriander was obtained with the application of 20 kg ha^{-1} $CuSO_4$ along with 100 percent RDF (T_{10}). Thus, the application of $ZnSO_4$ @ 0.5 percent foliar spray along with 100 percent RDF or the soil application of $ZnSO_4$ @ 20 kg ha^{-1} along with 100 percent RDF to coriander crop significantly increase the yield, influence the nutrient uptake by the plant and the available nutrient status of the soil.

Keywords: Micronutrients, coriander yield, uptake, soil properties, Konkan

Introduction
Coriander (*Coriandrum sativum* L.) belongs to family Apiaceae is an annual herb mainly cultivated for its tender green leaves and seeds. Coriander is cultivated over an area of 447 thousand hectares with an annual production of 314 thousand tonne in the country (Anonymous, 2015) [3].

The micronutrients *viz.* Fe, Cu, Mn, Zn, B, Mo, Cl and Ni plays an important role in the production of good quality and high yield of crops (Amjad *et al.*, 2014) [1]. However, their deficiencies are widespread and may cause a great disturbance in the physiological and metabolic processes in the plants. Fifty percent of world soils are deficient in zinc (Korayem, 1993) [9] which is essential for the transformation of carbohydrates and synthesis of tryptophan. Copper is an essential micronutrient for all living organisms including plant (Goyer, 1991) [7] playing an irreplaceable role in a large number of metalloenzymes, photosynthesis related plastocyanin and membrane structure and vital to cell metabolism (Marschner, 1995) [12].

Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli has released a new variety of coriander 'Konkan Kasturi' in 2013 (Anonymous, 2013) [2] which is quite suitable for commercial cultivation in Rice based cropping system under Konkan agro-climatic conditions. The response of farmers for cultivation of the new variety is on the increase. However, no systematic research work has been conducted so far to study the effect of micronutrients on this crop. Hence, the present investigation was undertaken.

Material and Methods
A field trial was laid out at Vegetable Improvement Scheme, Pangari Block, Central Experimental Station, Wakavali, *Tahsil* Dapoli and Dist. Ratanagiri during *Rabi* season of the year 2016-2017, from the month of December to January.

The soil of the experimental plot at the initial stage *i.e.* before the commencement of the experiment, was acidic in reaction and showed low electrical conductivity. While, it was found to be high in organic carbon and K_2O, medium in available nitrogen, sulphur and copper. Soils of experimental plot was low in available P_2O_5 and zinc.

Total sulphur content from plant was estimated turbidimetrically in the Spectrophotometer at a wavelength of 420 nm as described by Chesnin and Yien (1950) [4]. Zinc and copper from the digested plant sample were estimated by using Atomic Absorption Spectrophotometer (Mclaren and Crawford, 1950) [21]. Nutrient uptake was calculated by multiplying yield with nutrient content of plant. DTPA extractable Zn and Cu were extracted from soil by Lindsay and Norvell (1978) [11] method. Available sulphur in the soil was extracted by using 0.15 percent $CaCl_2$ extractant (Williams and Steinbergs, 1959) [20] and soluble sulphate from the aliquot was determined turbidimetrically with a Spectrophotometer at a wavelength of 420 nm as described by Chesnin and Yien (1950) [4].

Results and Discussion

Yield of coriander

The data related to yield of Coriander as influenced by the application of micronutrients are presented in Table 1 which reveals that yield of coriander were significantly influenced due to application of various micronutrient treatments. Highest yield of coriander (11.18 t ha^{-1}) was recorded in the treatment T_5 receiving by application of 100 percent RDF along with 0.5 percent $ZnSO_4$ through Foliar spray, which was found significantly superior over other treatments except treatment T_6 which was at par. The lowest yield (5.32 t ha^{-1}) was recorded in control treatment (T_1) which was least effective. Similar results have been recorded by Diana and Nehru (2014) [6] and Lal *et al.* (2015) [10]. The increase in yield attributes might be due to zinc is involved in many enzymatic activities. Zinc is important in the synthesis of tryptophane, a component of some proteins and a compound needed to produce growth hormones (auxins) such as indole acetic acid which are promote the stem and cell elongation in plants Tisdale *et al*. (1995) [19].

Table 1: Effect of micronutrients on the yield of coriander

Treatment	Yield (t ha^{-1})
T_1-Absolute control	5.32
T_2-100% RDF (60:60:30 N: P_2O_5: K_2O kg ha^{-1})	9.68
T_3-100% RDF + $ZnSO_4$ @ 0.25% Foliar spray	10.17
T_4-100% RDF + $ZnSO_4$ @ 15 kg ha^{-1} through soil	10.04
T_5-100% RDF + $ZnSO_4$ @ 0.5% Foliar spray	11.18
T_6-100% RDF + $ZnSO_4$ @ 20 kg ha^{-1} through soil	10.56
T_7-100% RDF + $CuSO_4$ @ 0.25% Foliar spray	9.91
T_8-100% RDF + $CuSO_4$ @15 kg ha^{-1} through soil	9.80
T_9-100% RDF + $CuSO_4$ @ 0.5% Foliar spray	10.14
T_{10}-100% RDF + $CuSO_4$ @ 20 kg ha^{-1} through soil	9.98
Mean	9.68
SE (m) ±	0.25
CD at 5%	0.75

Effect of micronutrients on uptake of sulphur, zinc and copper by coriander

The details of the sulphur, zinc and copper uptake by coriander plant as influenced by the application of various micronutrient treatments at harvest is presented Table 2.

At harvest the sulphur uptake by the coriander was found to be in the range of 1.64 kg ha^{-1} to 4.24 kg ha^{-1} and highest amount of sulphur uptake (4.24 kg ha^{-1}) was observed in the treatment T_6 which was found considerably higher over the other treatments and the finding was at par with the treatment T_4 (3.38 kg ha^{-1}) T_5 (3.84 kg ha^{-1}). Similar results were obtained by Salvi (2008) [16] and Suchitra (2013) [18].

The increase in sulphur content in plant might be due to copper sulphate contains 12 percent while, zinc sulphate contains 11 percent sulphur in sulphate form. This has resulted in greater availability of sulphate sulphur to plants leading to increased uptake. Further treatments that received zinc sulphate application either through soil or foliar spray recorded higher sulphur uptake than treatments that received copper sulphate application. This might be due to role of Zn in biosynthesis of indole acetic acid (IAA) and the synergistic relationship between sulphur and zinc.

Table 2: Effect of micronutrients on sulphur, zinc and copper uptake by coriander

Treatment	Sulphur (Kg ha^{-1})	Zinc (g ha^{-1})	Copper (g ha^{-1})
T_1-Absolute control	1.64	56.88	33.87
T_2-100% RDF (60:60:30 N: P_2O_5: K_2O kg ha^{-1})	2.93	62.55	48.80
T_3-100% RDF + $ZnSO_4$ @ 0.25% Foliar spray	3.63	119.03	52.61
T_4-100% RDF + $ZnSO_4$ @15 kg ha^{-1} through soil	3.78	96.09	51.15
T_5-100% RDF + $ZnSO_4$ @ 0.5% Foliar spray	3.84	154.94	51.86
T_6-100% RDF + $ZnSO_4$ @ 20 kg ha^{-1} through soil	4.24	184.19	49.92
T_7-100% RDF + $CuSO_4$ @ 0.25% Foliar spray	3.24	77.59	54.71
T_8-100% RDF + $CuSO_4$ @15 kg ha^{-1} through soil	3.11	85.43	50.29
T_9-100% RDF + $CuSO_4$ @ 0.5% Foliar spray	3.70	79.15	52.37
T_{10}-100% RDF + $CuSO_4$@ 20 kg ha^{-1} through soil	3.53	64.49	63.58
Mean	3.36	98.03	50.92
SE (m) ±	0.15	2.95	2.079
CD at 5%	0.46	8.77	6.176

Zinc uptake by coriander

The zinc uptake by the coriander plants at harvest was found to be in the range of 56.88 g ha^{-1} to 184.19 g ha^{-1} respectively, with the application of micronutrients. Maximum zinc uptake by coriander (184.19 g ha^{-1}) was recorded in the treatment T_6 receiving by application of 100 percent RDF along with 20 kg ha^{-1} $ZnSO_4$ through soil, which was found significantly superior over other treatments.

This is mainly due to higher availability of zinc from soil and foliar spray leading to increased uptake on account of higher dry matter yield. Zinc play's role in auxin and protein synthesis and activator of many enzymes. All these activities stimulate zinc uptake. Further treatments that received soil application of zinc sulphate recorded comparatively higher zinc uptake than treatments receiving foliar spray of zinc sulphate. Because of this nature, it has more mobility in soil and not subjected to precipitation. Hence there might be greater uptake due to soil application. The results are in line with the findings of Patil *et al*. (2011) [11] and Suchitra (2013) [18].

Copper uptake by coriander

The copper uptake by the coriander plants at harvest was found to be in the range of 33.87 g ha^{-1} to 63.58 g ha^{-1} respectively, with application of micronutrients. Maximum Cu uptake by coriander at harvest (63.58 g ha^{-1}) was recorded in the treatment T_{10} (100% RDF + $CuSO_4$ @ 20 kg ha^{-1} through soil) which was found significantly superior over other treatments. All the findings with respect to copper uptake are in line with the findings of Chew *et al*. (1979) [5].

Effect of micronutrients on the available Sulphur, zinc and copper content in soil

The data pertain ing to the changes in the available Sulphur, zinc and copper content in soil as influenced by different treatments of micronutrients are presented in Table 3.

Available sulphur content in soil

It is revealed from data that the available sulphur content varied from 10.38 to 23.21 mg kg^{-1} at harvest of crop respectively. At harvest also the treatment T_6 (100 percent RDF along with $ZnSO_4$ @ 20 kg ha^{-1} through soil) recorded significantly higher values of available S over rest of all treatments except T_4 which remained at par with T_6. The trend showed by the data builds up the available S as increased with application of sulphur containing fertilizer viz. single supper phosphate, zinc sulphate and copper sulphate (12, 11 and 12 percent S) significantly superior over the control, which are the sources of sulphur. Sulphate content of soil is also affected by the application of S containing fertilizers (Tisdale *et al.*, 1995) [19].

Available zinc content in soil

At harvest the available Zn was ranged from 0.40 to 1.71 mg kg^{-1}; the treatment T_6 reported significantly higher (1.71 mg kg^{-1}) DTPA extractable over all the other treatments. The DTPA extractable Zn was observed to be decreased at harvest. It might be due to cultivars differs in their ability to take up Zn, which may cause by difference in Zn translocation and utilization differential accumulation of nutrient that interact with Zn, and differences in plant root it exploits for soil Zn (Tisdale *et al.*, 1995) [19]. This influenced due to application of zinc sulphate add the zinc in soil which causes increases the zinc content in soil, similar results were detected by Singh *et al*. (1994) [17].

Table 3: Effect of micronutrients on available sulphur, zinc and copper content in soil

Treatment	Sulphur (mg kg^{-1})	Zinc (mg kg^{-1})	Copper (mg kg^{-1})
T_1-Absolute control	10.38	0.40	2.44
T_2-100% RDF (60:60:30 N: P_2O_5: K_2O kg ha^{-1})	16.10	0.46	2.58
T_3-100% RDF + $ZnSO_4$ @ 0.25% Foliar spray	17.70	0.71	2.64
T_4-100% RDF + $ZnSO_4$ @ 15 kg ha^{-1} through soil	21.60	1.47	2.50
T_5-100% RDF + $ZnSO_4$ @ 0.5% Foliar spray	17.13	0.85	2.77
T_6-100% RDF + $ZnSO_4$ @ 20 kg ha^{-1} through soil	23.21	1.71	2.36
T_7-100% RDF + $CuSO_4$ @ 0.25% Foliar spray	12.93	0.54	2.98
T_8-100% RDF + $CuSO_4$ @15 kg ha^{-1} through soil	19.86	0.50	4.16
T_9-100% RDF + $CuSO_4$ @ 0.5% Foliar spray	16.81	0.56	3.15
T_{10}-100% RDF + $CuSO_4$ @ 20 kg ha^{-1} through soil	20.49	0.38	4.40
Mean	17.62	0.76	3.30
SE (m) ±	0.72	0.012	0.15
CD at 5%	2.14	0.035	0.45

Available copper content in soil

At harvest of coriander, it observed that the DTPA extractable Cu was slightly decreased because of Cu uptake by coriander crop reduce the availability of copper in the soil and ranged from 2.44 to 4.40 mg kg^{-1}. The treatment T_{10} exhibited significantly higher Cu *i.e.* 4.40 mg kg^{-1} over rest of all treatments except treatment T_8. Similar ranges of DTPA extractable Cu in lateritic soils of Konkan were reported by Pawar (2012) [14], Joshi (2012) [8] and Puranik (2015) [15].

Increases the copper content in soil might be due to the application of copper containing fertilizer copper Sulphate which contain 24 percent Cu. According to (Tisdale *et al.*, 1995) [19] residual Cu fertilizer availability of can persist for 2 or more years, depending on the soil, crop and Cu rate. The solubility and availability of Cu is pH dependent, increasing Cu availability with decreasing pH.

Conclusion

From the present investigation, it could be concluded that the application of $ZnSO_4$ @ 0.5 percent foliar spray along with 100 percent RDF or the soil application of $ZnSO_4$ @ 20 kg ha^{-1} along with 100 percent RDF to coriander crop significantly increase the yield, influence the nutrient uptake by the plant and the available nutrient status of the soil.

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