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Influence of zinc and copper on yield and soil properties under coriander crop in lateritic soils of Konkan region

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Abstract
Coriander (*Coriandrum sativum* L.) is an annual herb mainly cultivated for its tender green leaves and seeds. In order to study the influence of zinc and copper on yield and soil properties under coriander crop in lateritic soils of Konkan region, the present investigation was undertaken. The highest yield (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 micronutrients did not have a significant effect on pH and Electric conductivity of the soil at harvest. The organic carbon, nitrogen, phosphorous and potassium of the soil at harvest was found to be significantly influenced by the application of micronutrients.

Keywords: Zinc, copper, yield, soil properties, coriander, Konkan

1. Introduction
Coriander (*Coriandrum sativum* L.) is an annual herb mainly cultivated for its tender green leaves and seeds. It is a native of Mediterranean region and is extensively grown in India, Mexico, Hungry, Poland, Romania, Guatemala and USA for its aromatic leaves and seeds which are extensively used as a spice and food flavouring agents throughout the world (Purseglove *et al*., 1981) [15]. Coriander is cultivated over an area of 447 thousand hectares with an annual production of 314 thousand tonne in the country (Anonymous, 2015) [3]. Coriander is considered as a *Rabi* crop in India and sowing starts in the middle of October which extends until November end. This crop requires cool climate during the growth stage and warm dry climate at maturity. It can be cultivated in a variety of soils, but well drained loamy soil is best suited for the crop.
Micronutrients play a significant role in the growth of plants and their production in terms of flowers, fruits and seeds. Their role in photosynthesis, N-fixation, respiration and other metabolic processes of the plant is well documented (Sivaiah *et al*., 2013) [19]. Hence, micronutrient application plays an important role in the production of good quality and high yield of crops (Amjad *et al*., 2014) [4]. Many crops respond to foliar and soil application of micronutrients in terms of growth and crop yields. It is widely reported that foliar application of micronutrients at active growth stages will improve plant growth and consequently yield and quality in various crops.
Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli has released a new variety of coriander 'Konkan Kasturi' in 2013 which is quite suitable for commercial cultivation in Rice based cropping system under Konkan agro-climatic conditions (Anonymous, 2013) [2]. 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.

2. Material and methods
A field trial was laid out in randomized block design with 3 replicates and 10 treatments at Vegetable Improvement Scheme, Pangari Block, Central Experimental Station, Wakavali, during Rabi 2016-2017. The soil of the experimental plot 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 N and S and low in available P_2O_5.
The pH of the soil was determined with pH meter having glass and calomel electrode using 1:2.5 of soil: water suspension ratio (Jackson, 1973) [10].

Electrical conductivity of the soil was determined using Systronic Conductivity Meter-306 with 1: 2.5 of soil: water suspension ratio (Jackson, 1973) [10]. Organic carbon of the soil was determined by following Walkley and Black wet digestion method (Black, 1965) [6].

Available nitrogen of the soil was determined by alkaline permanganate (0.32% $KMnO_4$) method (Subbiah and Asija, 1956) [20]. Available phosphorous of the soil was determined by Brays No. 1 method as outlined by Bray and Kurtz (1945) [7]. Available potassium of the soil was determined by using neutral normal ammonium acetate as an extractant on Systronics Flame Photometer-128 as described by Jackson (1973) [10].

3. Results and discussions

3.1 Yield of Coriander

The highest yield of coriander (11.18 t ha^{-1}) was recorded for the treatment T_5 in which 100 percent RDF was applied along with 0.5 percent $ZnSO_4$through foliar spray and this finding is at par with the yield of coriander (10.56 t ha^{-1}) of treatment T_6 (100 percent RDF + $ZnSO_4$@ 20 kg ha^{-1} through soil application). The lowest yield (5.32 t ha^{-1}) was obtained for treatment T_1 (control). Similar are the findings of Diana and Nehru (2014) [9] and Lal *et al.* (2014) [13].

The increase in the yield might be due to zinc application as zinc is involved in many enzymatic activities. Zinc is also important in the synthesis of tryptophan, an amino acid required for the synthesis of some proteins and a compound needed for the production of growth hormones (auxins) such as indole acetic acid which promote the stem and cell elongation in plants (Tisdale *et al*., 1995) [21].

Table 1: Effect of foliar spray and soil application of micronutrients on yield of coriander

Treatments	Yield (kg $plot^{-1}$)	Yield (t ha^{-1})
T_1-Absolute control	4.79	5.32
T_2-100% RDF (60:60:30 N: P_2O_5: K_2O kg ha^{-1})	8.71	9.68
T_3-100% RDF + $ZnSO_4$ @ 0.25% Foliar spray	9.15	10.17
T_4-100% RDF + $ZnSO_4$ @ 15 kg ha^{-1}through soil	9.04	10.04
T_5-100% RDF + $ZnSO_4$ @ 0.5% Foliar spray	10.06	11.18
T_6-100% RDF + $ZnSO_4$ @ 20 kg ha^{-1} through soil	9.50	10.56
T_7-100% RDF + $CuSO_4$ @ 0.25% Foliar spray	8.92	9.91
T_8-100% RDF + $CuSO_4$ @ 15 kg ha^{-1}through soil	8.82	9.80
T_9-100% RDF + $CuSO_4$ @ 0.5% Foliar spray	9.13	10.14
T_{10}-100% RDF + $CuSO_4$ @ 20 kg ha^{-1}through soil	8.99	9.98
Mean	8.71	9.68
SE (m) ±	0.23	0.25
CD at 5%	0.68	0.75

3.2 Effect of micronutrients on the physico-chemical properties of soil

The data pertaining to the changes in physico-chemical properties *viz*., pH, EC and organic carbon of soil at various growth stages of coriander as influenced by application of micronutrients is presented in Table 2.

3.2.1 Effect of micronutrients on soil reaction (pH)

The data regarding the effect of micronutrients on pH of the soil at harvest is presented in Table 2. In general, lateritic soils are acidic in nature due to leaching of soluble salts because of heavy precipitation (Anonymous, 1990) [1].

The pH of soil at harvest was found to be in the range of 5.67 to 6.00 with a mean value of 5.79. The application of micronutrients did not have asignificant effect on pH of the soil at harvest. Application of $ZnSO_4$ @0.5 percent foliar spray along with 100 percent RDF (T_5) resulted in the higher pH (6.00) whereas the lowest pH (5.67) was found in the treatment T_6 ($ZnSO_4$@ 20 kg ha^{-1} through soil along with 100 percent RDF). The findings of the study are in accordance with the findings of Salve (2008) [16] and Singhal and Rattan (1999) [18].

According to Bhosale (2016) the pH of lateritic soils in the range of 5.09 to 6.00. In the present study, the increase in the pH of soil from 5.02 (initial pH) to 6.00 (at harvest) can be attributed to the addition of organic manures which have a role in deactivation of Fe^{3+} and concomitant release of basic cations during their process of decomposition on application to the soil (Pocknee and Summer).

Table 2: Effect of Micronutrients on pH, Electrical Conductivity (E.C.) and organic carbon (O.C.) of the soil

Treatment	pH	E.C. (dS m^{-1})	O. C. (g kg^{-1})
T_1-Absolute control	6.00	0.131	9.66
T_2-100% RDF (60:60:30 N: P_2O_5: K_2O kg ha^{-1})	5.77	0.139	10.09
T_3-100% RDF + $ZnSO_4$ @ 0.25% Foliar spray	5.75	0.127	10.54
T_4-100% RDF + $ZnSO_4$ @ 15 kg ha^{-1} through soil	5.72	0.144	10.32
T_5-100% RDF + $ZnSO_4$ @ 0.5% Foliar spray	5.92	0.133	12.48
T_6-100% RDF + $ZnSO_4$ @ 20 kg ha^{-1} through soil	5.67	0.151	11.82
T_7-100% RDF + $CuSO_4$ @ 0.25% Foliar spray	5.71	0.126	10.87
T_8-100% RDF + $CuSO_4$ @ 15 kg ha^{-1} through soil	5.82	0.137	10.21
T_9-100% RDF + $CuSO_4$ @ 0.5% Foliar spray	5.74	0.130	11.98
T_{10}-100% RDF + $CuSO_4$ @ 20 kg ha^{-1} through soil	5.81	0.141	11.67
Mean	5.79	0.136	10.96
SE (m) ±	0.145	0.015	0.330
CD at 5%	NS	NS	0.979

3.2.2 Effect of micronutrients on Electrical Conductivity (E.C.) of the soil

The data pertaining to the electrical conductivity of the soil is presented in Table 2. The electrical conductivity of soil at harvest was found to be in the range of 0.131 to 0.151 dS m^{-1} with a mean value of 0.136 dS m^{-1}. The application of micronutrients did not have asignificant effect on electrical conductivity of the soil at harvest. Application of $ZnSO_4$ @ 20 kg ha^{-1} through soil along with 100 percent RDF (T_6) resulted in the higher electrical conductivity (0.151dSm^{-1}) whereas, the lowest electrical conductivity (0.131dS m^{-1}) at harvest was found in the treatment T_7 ($CuSO_4$@ 0.5 percent foliar spray along with 100 percent RDF). Similar are the findings of Shrivastava *et al*. (2003) [17] and Veeranagappa *et al*. (2011) [22].

3.2.3 Effect of micronutrients on organic carbon (O.C.) of the soil

The data related to organic carbon of the soil as influenced by the application of micronutrients is presented in Table 2. The organic carbon of soil at harvest was found to be in the range of 9.66 to 12.48 g kg^{-1} with a mean value of 10.96 g kg^{-1}. The organic carbon of soil at harvest was found to be influenced significantly by the application of micronutrients. Application of $ZnSO_4$ @ 0.5% foliar spray along with 100 percent RDF (T_5) resulted in higher organic carbon (12.48 g kg^{-1}) of the soil and the finding is at par with the organic carbon content of 11.98, 11.82 and 11.67 g kg^{-1} of the soil of under the treatments T_9 (100 percent RDF + $CuSO_4$ @ 0.5% foliar spray), T_6 ($ZnSO_4$@ 20 kg ha^{-1} through soil along with 100 percent RDF) and T_{10} ($CuSO_4$ @ 20 kg ha^{-1} through soil along with 100 percent RDF) respectively. However, the lowest organic carbon (9.66 g kg^{-1}) of soil at harvest was found in the treatment T_1 (Control).

3.3 Effect of micronutrients on available primary nutrient content of soil

The soil samples were collected periodically and analyzed for available N, P and K content in soil. The data was statistically analyzed and is presented below:

3.3.1 Effect of micronutrients on available nitrogen in the soil

The data regarding the effect of application of micronutrients on the available nitrogen in the soil at harvest is presented in Table 3.

The available nitrogen in soil at harvest was found to be in the range of 254.02 to 338.69 kg ha^{-1} with a mean value of 312.03 kg ha^{-1}. The available nitrogen in the soil at harvest was found to be significantly influenced by the application of micronutrients. Application of $ZnSO_4$ @20 kg ha^{-1} through soil along with 100 percent RDF (T_6) resulted in the highest available nitrogen (338.69 kg ha^{-1}) of the soil and the finding is at par with theavailable nitrogen content of 332.42, 326.14 and 323.01 kg ha^{-1} in the soil of the treatments T_4 (100 percent RDF +$ZnSO_4$ @ 15 kg ha^{-1} through soil), T_{10} ($CuSO_4$ @ 20 kg ha^{-1} through soil along with 100 percent RDF) and T_8 (100 percent RDF + $CuSO_4$ @ 15 kg ha^{-1} through soil) respectively. Similar are the findings reported by Veeranagappa *et al.* (2011) [22] and Jakhar *et al*. (2013) [11] from their field trials.

Table 3: Effect of Micronutrients on Available Nitrogen, Phosphorous and Potassium content in the Soil (kg ha^{-1})

Treatment	N	P_2O_5	K_2O
T_1-Absolute control	254.02	6.69	255.39
T_2-100% RDF (60:60:30 N: P_2O_5: K_2O kg ha^{-1})	304.19	14.53	268.46
T_3-100% RDF + $ZnSO_4$ @ 0.25% Foliar spray	310.46	14.89	266.58
T_4-100% RDF + $ZnSO_4$ @ 15 kg ha^{-1}through soil	332.42	11.94	297.03
T_5-100% RDF + $ZnSO_4$ @ 0.5% Foliar spray	313.60	15.06	269.94
T_6-100% RDF + $ZnSO_4$ @ 20 kg ha^{-1} through soil	338.69	11.61	305.95
T_7-100% RDF + $CuSO_4$ @ 0.25% Foliar spray	307.33	13.27	259.97
T_8-100% RDF + $CuSO_4$ @ 15 kg ha^{-1}through soil	323.01	11.88	278.27
T_9-100% RDF + $CuSO_4$ @ 0.5% Foliar spray	310.46	14.67	254.82
T_{10}-100% RDF + $CuSO_4$ @ 20 kg ha^{-1}through soil	326.14	11.64	283.65
Mean	312.03	12.62	274.01
SE (m) ±	5.895	0.563	5.092
CD at 5%	17.514	1.673	15.129

3.3.2 Effect of micronutrients on available phosphorus in the soil

The data related to available phosphorous content of soil as influenced by the application of micronutrients is presented in Table 3.

The available phosphorous content of soil at harvest was found to be in the range of 6.69 to 15.06 kg $ha^{-1}$with a mean value of 12.62 kg ha^{-1}. The available phosphorous content of soil at harvest was found to be significantly influenced by the application of micronutrients. Application of $ZnSO_4$ @ 0.5 percent foliar spray along with 100 percent RDF (T_5) resulted in higher available phosphorous content (15.06kg ha^{-1}) of soil and the finding is at par with theavailable phosphorous content of 14.89, 14.67 and 14.53kg ha^{-1} in the soil with the treatments T_3 (100 percent RDF + $ZnSO_4$ @ 0.25 percent Foliar spray), T_9 ($CuSO_4$ @ 0.5 percent foliar spray along with 100 percent RDF) and T_2 (100 percent RDF) respectively. However, the lowest available phosphorous content (6.69 kg ha^{-1}) of soil at harvest was found in the treatment T_1 (Control).These findings are at par with the experimental results of Salve (2008) [16] and Kadu (2015) [12].

Lower availability of phosphorous in the treatments with application of zinc sulphate in soil might be due to the antagonistic relationship between them and also due to refixation of solubilized phosphorous (Das 2007) [8].

3.3.3 Effect of micronutrients on available potassium in the soil

The data regarding the effect of micronutrients on available potassium at harvest in the soil is presented in Table 3.

The available potassium content of soil at harvest was found to be in the range of 255.39 to 305.95 kg ha^{-1} with a mean value of 274.01 kg ha^{-1}. The available potassium content of soil at harvest was found to be significantly influenced by the application of micronutrients. Application of $ZnSO_4$ @ 20 kg ha^{-1} through soil along with 100 percent RDF (T_6) resulted in

higher available potassium content (305.95 kg ha^{-1}) of soil and the finding is at par with theavailable potassium content (297.03 kg ha^{-1}) in soil of the treatment T_4 (100 percent RDF + $ZnSO_4$ 15 kg ha^{-1} through soil). However, the lowest available potassium content (293.74 kg ha^{-1}) of soil at harvest was found in the treatment T_1 (Control). Similar are the findings of Shrivastava *et al*. (2003) [17], Salve (2008) [16], Veeranagappa *et al.* (2011) [22] and Jakhar *et al*. (2013) [11].
Organic matter improves CEC, which reduces the potential leaching losses of elements such as K^+, Ca^{2+} and Mg^{2+} and increases their availability. The increase in potassium availability might be due to synergistic effect of Zn and Cu which increase the availability of K in soil (Tisdale *et al.*, 1995) [21].

4. Conclusion

From the present investigation entitled "influence of zinc and copper on yield and soil properties under coriander crop in lateritic soils of konkan region" it can 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 increases the yield, soil properties and the available nutrient status of the soil.

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