academicJournals

Vol. 10(3), pp. 84-88, 15 January, 2015
DOI: 10.5897/AJAR2014.8980
Article Number: 759780C49533
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Effect of micronutrient application in coriander (*Coriandrum sativum* L.) cv.CO_4

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Received 6 July, 2014; Accepted 9 January, 2015

The field experiments were conducted during two seasons to find out the role of micronutrients on growth, seed yield and quality in coriander cv. CO_4. The soil of the experimental site was calcareous. Micronutrient deficiencies are common in soils that have a high calcium carbonate ($CaCO_3$) due to reduced solubility at alkaline pH values. Micronutrients such as iron (Fe), zinc (Zn), copper (Cu) and manganese (Mn) were applied in their sulphate form ($FeSO_4$, $ZnSO_4$, $CuSO_4$ and $MnSO_4$, respectively). The effect of both soil application (25 kg/ha) and foliar spray (0.5%) of micronutrients at 30 and 45 days after sowing were studied individually. Foliar spray of 0.5% $FeSO_4$ induced the highest growth rates in terms of net assimilation rate (0.085 mg $g^{-1}day^{-1}$in rabi and 0.063 mg $g^{-1}day^{-1}$ in kharif) and crop growth rate (7.52 mg m^{-2} day^{-1}in rabi and 7.78 mg m^{-2} day^{-1}in kharif). Maximum number of umbels per plant (33.7 in rabi and 13.8 in kharif) and highest seed yield per hectare (623.3 kg in rabi and 599.9 kg in kharif) were observed for the foliar application of 0.5% $FeSO_4$ if compared to other treatments. Foliar application of iron and zinc exhibited significant effect on resultant seed quality parameters. The study revealed the need for application of micronutrients in maximum realization of yield and quality of the coriander seed crop in calcareous soils.

Key words: Coriander, foliar spray, growth, iron, micronutrients, quality, seed yield, zinc.

INTRODUCTION

The seed spices constitute an important group of agricultural commodities. Among the seed spices, coriander is the most important spice crop with multipurpose utility. Coriander (*Coriandrum sativum* L.) is an annual herb of the apiaceae family. For adequate plant growth and production, micronutrients are needed in small quantities; however, their deficiencies cause a great disturbance in the physiological and metabolic processes in the plant. Micronutrients application plays an important role in the production of good quality and high yield of crops (Amjad et al., 2014). The role of micronutrients in photosynthesis, N-fixation, respiration and other metabolic processes of the plant is well documented (Naga Sivaiah et al., 2013). The effects of micronutrient foliar fertilizer on the promotion of growth and production of some medicinal and aromatic plants were observed by several researchers (Nasiri et al., 2010; Joynul et al., 2012; Mazaheri et al., 2013). Application of micronutrients significantly influenced the number of branches, umbels per plant, seeds per umbel and seed yield of coriander (Kalidasu et al., 2008). Improved fertilizer management is required to grow crops

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successfully on calcareous soils. Iron, Zinc, Manganese and Copper deficiencies are common in soils that have a high calcium carbonate ($CaCO_3$) due to reduced solubility at alkaline pH values. The present study was undertaken to assess the potential of micronutrients in the improvement of seed yield and quality of coriander cv.CO_4.

MATERIALS AND METHODS

Pure seeds of coriander (*C. sativum* L.) cv. CO_4 which formed the base material for the study were obtained from the Department of Spices and Plantations Crops, TNAU, Coimbatore. The field experiment was conducted at the orchard of HC & RI, Coimbatore in two seasons (Rabi, 2009; Kharif, 2010). Before sowing, physical and chemical properties of the soil of the experimental site were determined (Jackson, 1973). The soil of the experimental site was clayey textured and calcareous with a pH of 8.10. The results of soil chemical analysis were as follows: electrical conductivity (ds/m) = 0.14; available nitrogen (kg/ha) = 207; available phosphorus (kg/ha) = 15.4; available potassium (kg/ha) = 849; copper (ppm) = 2.22, manganese (ppm) = 7.50; iron (ppm) = 4.16 and zinc (ppm) = 1.06. Seeds were sown in plot size of 3 × 1.5 m with a spacing of 15 × 10 cm following randomized block design with 9 treatments involving four micronutrients viz. iron (Fe), zinc (Zn), copper (Cu) and manganese (Mn) applied through soil (25 kg/ha) and foliar spray (0.5%) individually at 30 and 45 days after sowing (DAS) and three replications. The details of treatments are as follows:

M 1 - Control (NPK)
M 2 - Soil application of $ZnSO_4$ @ 25 kg/ha
M 3 - Foliar application of $ZnSO_4$ @ 0.5%
M 4 - Soil application of $FeSO_4$ @ 25 kg/ha
M 5 - Foliar application of $FeSO_4$ @ 0.5%
M 6 - Soil application of $CuSO_4$ @ 25 kg/ha
M 7 - Foliar application of $CuSO_4$ @ 0.5%
M 8- Soil application of $MnSO_4$ @ 25 kg/ha
M 9 - Foliar application of $MnSO_4$ @ 0.5%

All other cultural practices were followed according to standard recommendations for the locality. Five randomly selected plants in each treatment and in each replication were selected for recording the observations. Observations on growth, seed yield and resultant seed quality characteristics were taken.

The biometric characters like net assimilation rate (NAR) and crop growth rate (CGR) were calculated for different plant growth stages (30, 40, 50 and 60 days after sowing). The sample means were then taken as representative of the population. Five plants were randomly selected in each treatment for recording dry matter production. Plants were oven dried at 70°C till uniform constant weight was obtained. Completely dried samples were weighed and the dry weight of different plant parts was expressed in g per plant. NAR was calculated using the following formula (Williams, 1946) and expressed as mg $g^{-1}day^{-1}$.

$$NAR = \frac{\log_e L_2 - \log_e L_1}{L_2 - L_1} \times \frac{w_2 - w_1}{t_2 - t_1}$$

Where t_1, t_2 - days of observation; L2, L_1- leaf dry weight at t_2 and t_1; w_2, w_1 - whole plant dry weight at t_2 and t_1.

Crop growth rate (CGR) was calculated using the following formula (Watson, 1952) and expressed as mg m^{-2} day^{-1}.

$$CGR = \frac{w_2 - w_1}{P\,(t_2 - t_1)}$$

Where, t_1, t_2 - days of observation; w_2, w_1 - whole plant dry weight at t_2 and t_1; P - spacing in m^2.

Seed quality parameters such as germination (ISTA, 2003), vigour index (Abdul–Baki and Anderson, 1973), protein content (Ali-Khan and Youngs, 1973) and essential oil content (ASTA, 1968) were also determined in the harvested seeds. The data was analysed for 'F' test of significance following the statistical methods described by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Micronutrients played a vital role in the growth and development of coriander cv. CO_4. Among the two methods (soil application and foliar spray) of application of micro nutrients, foliar spraying was more effective. The positive influence of foliar application of micronutrients on crop growth may be due to the improved ability of the crop to absorb nutrients, photosynthesis and better sink source relationship as these play vital role in various biochemical processes. These findings are in conformity with the studies of Nasiri et al. (2010).

Foliar spray of 0.5% $FeSO_4$ recorded highest net assimilation rate (0.085 mg $g^{-1}day^{-1}$in rabi and 0.063 mg $g^{-1}day^{-1}$ in kharif) and was followed by foliar spray of 0.5% $ZnSO_4$ (0.056 mg $g^{-1}day^{-1}$in rabi and kharif) (Figure 1). Higher concentrations of iron in the leaves and leaf tips resulted in increased photosynthesis and more chlorophyll formation (Nadim et al., 2012). Crop growth rate refers to the dry matter production in a unit of time. Difference in crop growth rate due to micronutrient application was significant in both seasons. Foliar application of 0.5% $FeSO_4$ recorded highest crop growth rate (7.52 mg m^{-2} day^{-1}in rabi and 7.78 mg m^{-2} day^{-1}in kharif) (Figure 1). Control recorded lowest crop growth rate in both seasons (2.05 in rabi and 2.37 mg m^{-2} day^{-1} in kharif). Iron acts as an important catalyst in the enzymatic reactions of the metabolism and would have helped in larger biosynthesis of photo assimilates thereby enhancing growth of the plants. Besides the function of iron in the metabolism of chloroplast RNA, it is required at several steps in the biosynthetic pathways leading to increase in the biosynthesis materials (produced and accumulated) consequently, the growth was enhanced. Zinc is a component of carbonic anhydrase, as well as several dehydrogenases and auxin production which in turn enhance plant growth. The present study was in accordance with the findings of Said-Al Ahl and Mahmoud (2010), Salmasi et al., (2012) and Abbas (2013). It was also noticed that foliar application of copper initially caused leaves burning which subsequently reduced the CGR.

Among the yield parameters maximum number of umbels (33.7 in rabi and 13.8 in kharif) and the highest

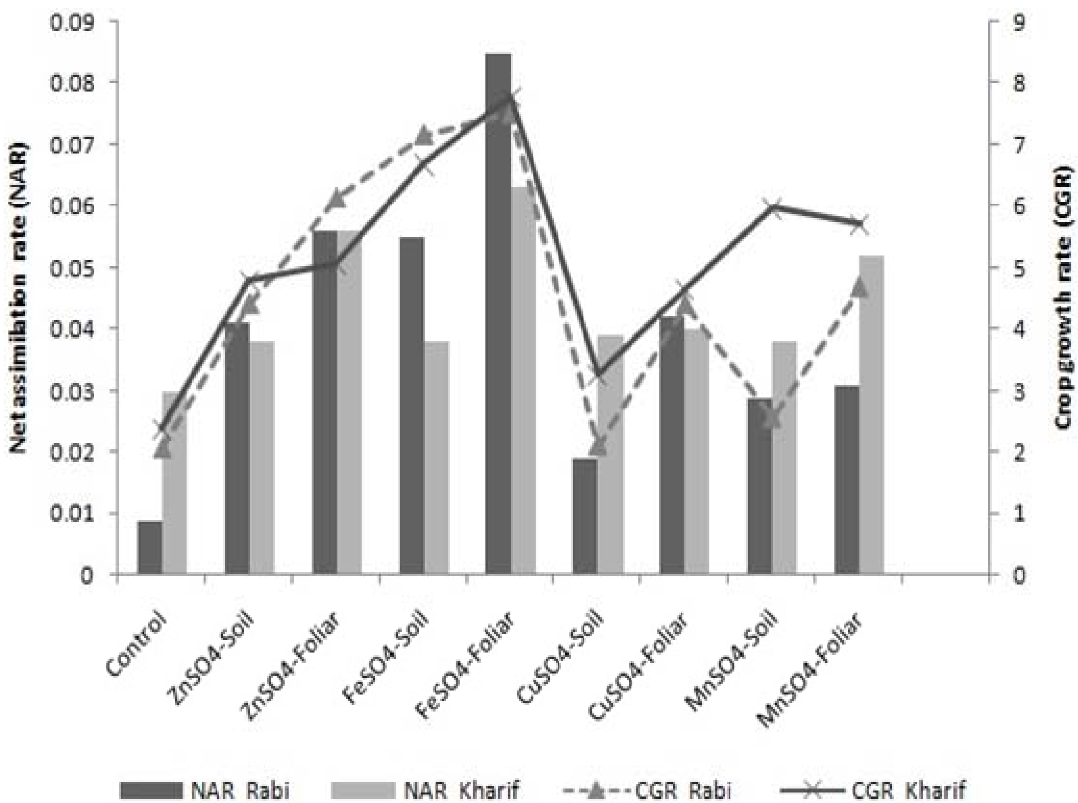

Figure 1. Effect of micronutrient application on growth rate in coriander cv.CO_4.

seed yield ha^{-1} (623.3 kg in rabi and 599.9 kg in kharif) were observed for foliar application of 0.5% $FeSO_4$ compared to other treatments(35% increase over control) (Table 1). The yield improvement may be attributed to higher yield attributing components such as increased plant growth, maximum number of umbels and seeds, which were positively affected by the foliar application of iron. Iron improves photosynthesis and assimilates transportation to sinks and finally increased seed yield (Ebrahimian and Ahmad, 2011). Zeidan et al. (2010) reported that application of Fe, Mn and Zn significantly increased grain yield and yield components of wheat.

Among the seed quality characters, 100 seed weight was higher for the seeds obtained from the plants sprayed with iron (1.55 g in rabi and 1.50 g in kharif) (Table 1). The increase in seed weight might be due to better mineral utilization of plants accompanied with enhancement of photosynthesis, other metabolic activity and greater diversion of food material to seeds (Naga Sivaiah et al., 2013). Foliar spray of zinc and iron recorded higher protein content (12.40 and 12.38%, respectively in rabi and 14.86 and 14.68%, respectively in kharif) (Table 1). Germination was equally enhanced by foliar spray of zinc, iron and copper (90, 93 and 95%, respectively during rabi) and maximum germination was for the seeds of plants sprayed with zinc (94%) during kharif. Foliar spray of $FeSO_4$ recorded highest root and shoot length and vigour index (2780 in rabi and 1908 in kharif) (Table 2). The increase in seed quality parameters may be due to the participation of micronutrients (Zn, Fe, Cu and Mn) in catalytic activity and breakdown of complex substances into simple forms like glucose, amino acids and fatty acids. These in turn were reflected on enhanced germination, elongation of root and shoot of coriander seedling (Santosh, 2012).

Foliar spray of 0.5% $FeSO_4$ recorded higher essential oil content (0.39% in rabi and 0.51% in kharif) followed by $ZnSO_4$ (Table 1). This effect of micronutrients on more essential oil percentage may be attributed to their effect on enzymes activity and metabolism improvement. The essential oil yield increased with iron and zinc applications because there was a significant increase in dry matter yield. The results on the effects of micronutrients on coriander plants agreed with the results obtained by Khalid (1996) and Mehrab (2014) who reported that trace elements such as Fe, Zn and Mn increased the vegetative growth characters and essential oil content of different plants such as anise, coriander, sweet fennel and lemon balm.

Conclusion

Coriander responded well to micronutrients. Foliar spray

Table 1. Effect of micronutrient application on seed yield and quality in coriander cv.CO_4.

Treatment (M)	Number of umbels plant^{-1}		Seed yield ha^{-1} (kg)		100 seed weight (g)		Essential oil content (%)		Protein content (%)	
	Rabi 2009	Kharif 2010	Rabi 2009	Kharif 2010	Rabi 2009	Kharif 2010	Rabi 2009	Kharif 2010	Rabi 2009	Kharif 2010
M1	17.9	9.2	459.9	446.6	1.35	1.31	0.30	0.35	10.21	11.48
M 2	27.8	10.8	603.3	566.6	1.45	1.37	0.32	0.42	11.66	13.63
M 3	29.5	11.8	609.9	583.3	1.50	1.43	0.37	0.45	12.40	14.86
M 4	33.7	11.2	579.9	483.3	1.48	1.48	0.31	0.44	11.78	13.38
M 5	33.7	13.8	623.3	599.9	1.55	1.50	0.39	0.51	12.38	14.68
M 6	20.8	8.2	556.6	406.6	1.41	1.34	0.32	0.39	11.48	13.32
M 7	22.7	10.2	509.9	476.6	1.43	1.42	0.34	0.40	11.84	13.45
M 8	21.0	10.8	479.9	443.3	1.32	1.35	0.31	0. 41	11.00	12.89
M 9	23.8	11.2	589.9	459.9	1.49	1.40	0.36	0.44	11.59	13.20
Mean	25.65	10.85	556.95	496.23	1.44	1.40	0.33	0.42	11.59	13.43
SEd	0.74	0.31	17.017	14.669	0.040	0.038	0.010	0.012	0.328	0.382
CD (P = 0.05)	1.57	0.66	36.076	31.099	0.085	0.081	0.021	0.025	0.695	0.810

Where, M1 – control (NPK); M 2 - soil application of $ZnSO_4$ @ 25 kg/ha; M 3 - foliar application of $ZnSO_4$ @ 0.5% (30 and 45 DAS); M 4 - soil application of $FeSO_4$ @ 25 kg/ha, M 5 - foliar application of $FeSO_4$ @ 0.5% (30 and 45 DAS); M 6 - soil application of $CuSO_4$ @ 25 kg/ha; M 7 - foliar application of $CuSO_4$ @ 0.5% (30 and 45 DAS); M 8 - soil application of $MnSO_4$ @ 25 kg /ha; M 9 - foliar application of $MnSO_4$ @ 0.5% (30 and 45 DAS).

Table 2. Effect of micronutrient application on resultant seed quality in coriander cv.CO_4.

Treatment (M)	Germination (%)		Root length (cm)		Shoot length (cm)		Vigour index	
	Rabi 2009	Kharif 2010	Rabi 2009	Kharif 2010	Rabi 2009	Kharif 2010	Rabi 2009	Kharif 2010
M 1	77 (61.36)	77 (61.36)	12.2	10.0	9.2	7.1	1647	1280
M 2	87 (68.87)	85 (67.22)	15.8	11.3	9.7	8.4	2218	1675
M 3	90 (71.57)	94 (76.78)	17.3	11.4	10.4	9.4	2493	1955
M 4	90 (71.57)	82 (64.90)	16.8	11.4	10.6	8.1	2466	1599
M 5	93 (75.11)	90 (71.57)	19.1	12.5	10.8	9.7	2780	1908
M 6	85 (67.22)	86 (68.03)	16.4	10.1	10.3	7.1	2269	1480
M 7	95 (77.08)	88 (69.73)	16.6	12.2	10.4	8.0	2565	1778
M 8	85 (67.22)	80 (63.44)	15.2	11.4	10.3	7.2	2167	1488
M 9	80 (63.44)	84 (66.42)	16.0	12.9	10.5	8.3	2120	1864
Mean	86 (69.27)	85 (67.71)	16.16	11.47	10.24	8.14	2304	1670
SEd	2.32	2.28	0.46	0.32	0.28	0.24	65.924	48.794
CD (P = 0.05)	4.92	4.83	0.98	0.68	0.60	0.50	139.755	103.440

Figures in parentheses indicate arc sine transformed values. Where, M1 – control (NPK); M 2 - soil application of $ZnSO_4$@ 25 kg/ha; M 3 - foliar application of $ZnSO_4$ @ 0.5% (30 and 45 DAS); M 4 - soil application of $FeSO_4$ @ 25 kg/ha, M 5 - foliar application of $FeSO_4$ @ 0.5% (30 and 45 DAS); M 6 - soil application of $CuSO_4$ @ 25 kg/ha; M 7 - foliar application of $CuSO_4$ @ 0.5% (30 and 45 DAS); M 8- soil application of $MnSO_4$ @ 25 kg/ha; M 9 - foliar application of $MnSO_4$ @ 0.5% (30 and 45 DAS).

of micronutrients was advantageous over soil application because of rapid response, effectiveness and elimination of deficiency symptoms. From the above results, it can be concluded that the foliar application of 0.5% $FeSO_4$ significantly enhanced the growth, seed yield and quality of coriander in the calcareous soils of Coimbatore.

Conflict of Interest

The authors have not declared any conflict of interest.

ACKNOWLEDGEMENT

Sincere thanks to scientific team, TNAU, Coimbatore for having provided the technical support and laboratory facilities for the study.

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