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Effect of micronutrients on growth, yield and economics of turmeric (*Curcuma longa* L.)

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ABSTRACT

A field experiment was conducted during 2018-19 and 2019-20 at Amar Singh College, Lakhaoti, Bulandshahr (Uttar Pradesh) to assess the influence of micronutrients on growth, yield and economics of turmeric (Curcuma longa L.). Eight treatments were evaluated in randomized block design with three replications. Results revealed that all the growth and yield attributing characters of turmeric responded significantly to the application of micronutrients, whether alone and/or in combination. Application of Zn was more effective in improving the growth, yield and economics as compared to Fe and B. Application of25 kg $ZnSO_4$ + 50 kg $FeSO_4$ + 10 kg borax ha^{-1} along with RDF resulted in the maximum plant height (95.5 cm), highest number of tillers per plant (2.96), number of leaves per plant (25.0), number of rhizomes per plant (20.2); maximum fresh weight of rhizomes per plant (297.7 g) and the highest yield of turmeric (33.07 tha^{-1}).The yield increment with RDF + 25 kg $ZnSO_4$ + 50 kg $FeSO_4$ + 10 kg borax ha^{-1} was 20.3% over the control. The performance of RDF + 25 kg $ZnSO_4$ + 50 kg $FeSO_4$ ha^{-1} and RDF + 25 kg $ZnSO_4$ + 10 kg borax ha^{-1} wasat par with RDF + 25 kg $ZnSO_4$ + 50 kg $FeSO_4$ + 10 kg borax ha^{-1} for the growth and yield attributes of turmeric. The lowest values of these parameters were recorded under control.An eeconomic assessment of different treatments revealed that the maximum net return (Rs.4,54,445ha^{-1}) with the highest B:C ratio (2.89)was realized from the combined application of Zn + Fe + B along with RDFas compared to control with a net return of Rs. 3,43,517 $ha^{-1}$and B:C ratio of 2.47.

Keywords: Micronutrients, growth, yield, economics, turmeric

INTRODUCTION

Turmeric (*Curcuma longa* L.) is a tropical spice crop belonging to the family Zingiberaceae. The cultivated turmeric is a triploid species (2n = 3x = 63), producing underground rhizomes. The rhizomes, after processing and value addition, are commonly used as a spice, natural dye; and in cosmetic and drug industries (Reshma and Vishwanath, 2020). It is also used in various auspicious and religious occasions in India. India is the leading producer, consumer andexporter of turmeric in the world, accounting for about 80% of the world's total production(Chitdeshwari, 2019).The nutritional requirement of this crop is quite high due to its shallow fibrous root system, long gestation period (about 8 months) and potential to produce large quantities of dry matter per unit area (Chitdeshwari, 2019).Supplementation of macro and micro-nutrientsto the soil playsa major role in the growth and development of crop plants. Among micronutrients,zinc plays a fundamental role in cellular functions such as metabolism of protein, photosysthetic carbon and indoleacetic acid (IAA), and its deficiency causes thickening of leaves, early loss of foliage and stunted growth. Iron plays a vital role in chlorophyll synthesis, carbohydrate production and cell respiration. Deficiency of Fe manifests into yellowish inter-veinal paling of younger leaves, commonly referred as 'iron chlorosis' (Kamble *et al.*, 2014). Boron playsan important role in stabilizing certain constituents of cell wall and plasma membrane, enhancement of cell division, and metabolism of nucleic acid, carbohydrate, protein, auxin and phenols. In general, the plants are prone to Zn, Fe and B deficiency in alkaline, coarse textured and low organic matter containing soils.Deficiency of Zn, Fe and B and their inadequate addition to the soil, may be one of the reasons for low productivity of rhizomatous spice crop like turmeric and ginger (Hnamte *et al.*, 2018). Recently, multi-nutrient deficiencies are reported widely in Indian soils, due to heavy depletion and continuous omission of micronutrient inputs in fertilizer schedule. Hence, micronutrient deficiencies has become a major yield limiting factor under specific unfavourable situations, which may be primarily due to their low inherent total soil content, or secondarily, due to various soil factors such as calcareousness, high pH, low organic carbon, salinity, sodicity, *etc.* Therefore, in order to achieve higher yield with better quality of turmeric rhizomes, there is a need to put greater emphasis on the supplementation of micronutrients, particularly in the intensively cropped areas. Hence, the present study was proposed with an aim to study the efficacy of different micronutrients application in increasing the yield of turmeric.

MATERIALS AND METHODS

The experiment was conducted at the Horticultural Research Farm of Amar Singh PG College, Lakhaoti, Bulandshahr (Uttar Pradesh) during 2018-19 and 2019-20. The experimental field is located at $28^0$31'36"N longitude and $77^0$58'29"E latitude; and at an average altitude of about 200 m above the mean seal level. The soil of the experimental field was deep, sandy loam in texture and slightly saline with a pH of 7.8. The soil had 4.1 g organic carbon, 175 kg ha^{-1} available N, 14.0 kg ha^{-1} available P and 155 kg ha^{-1} available K. The available Zn, Fe and B contents in the soil were 0.56, 4.7 and 0.2 mg $kg^{-1}$of soil, respectively. The experiment was comprised of eight treatments *viz.*,T_1Control: RDF,120:80:80 kg NPK ha^{-1}; T_2: RDF + 25 kg $ZnSO_4$ ha^{-1}; T_3: RDF + 50 kg $FeSO_4$ ha^{-1}; T_4: RDF + 10 kg borax ha^{-1}; T_5: RDF + 25 kg $ZnSO_4$+ 50 kg $FeSO_4$ ha^{-1}; T_6: RDF + 25 kg $ZnSO_4$ + 10 kg borax ha^{-1}; T_7: RDF + 50 kg $FeSO_4$ + 10 kg borax ha^{-1}; and T_8: RDF + 25 kg $ZnSO_4$+ 50 kg $FeSO_4$ + 10 kg borax ha^{-1}.The experiment was laid out in randomized block design with three replications. The crop was planted in the second week of June during both the years, and harvested at full maturity. Ridges were prepared 45 cm apart, and the seed rhizomes (var. 'Rajendra Sonia') were planted on the ridges 20 cm apart, thus maintaining a planting distance of 45x20 cm. The entire dose of phosphorus and one-third of the nitrogen was applied in the form of diammonium phosphate, as basal dose to all the plots at the time of field preparation. Rest of the nitrogen (in the form of urea) and the entire potassium (in the form of muriateof potash) were applied in two split doses of equal quantities. Half the quantity of nitrogen and potassium was applied at 45 days after planting (DAP) and the rest half at 90 DAP as furrow placement followed by earthing-up.The required quantity of respective micronutrients as per treatments were given to respective plots at 45 DAP, along with the first doses of nitrogen and potassium. The field was kept free from weeds throughout the crop duration. Recommended package of practiceswere followed to raise the crop.The data were collected on growthparameters (at 150 DAP, when the plant had developed full canopy), like-plant height, number of tillers per plant, numberof leaves per plant, leaf length, leaf breadth; and yield parameters (at harvesting time) like number of rhizomes per plant, fresh rhizome weight per plant and yield.The pooled data were subjected to analysis of variance and critical difference at 5% level of probability for significance of treatments for comparing the means by the method as advocated by Panse and Sukhatme (1985). The economics of turmeric production was calculated depending on the prevailing input cost and market price.

RESULTS AND DISCUSSION

Vegetative Characters:

Perusal of the data (Table 1) revealed improvement in all the vegetative characters of turmeric with the application of micronutrients. Among the micronutrients, the positive and significant influence of zinc over iron and boron was observed for the growth attributes. The maximum plant height (95.5 cm) was recorded with the application ofRDF + 25 kg $ZnSO_4$ + 50 kg $FeSO_4$ + 10 kg borax ha^{-1}, which was statistically *at par* with RDF + Zn + Fe (93.4 cm), while the least value of plant height (80.4 cm) was recorded in control (RDF only). Application of RDF + Zn + Fe + B also produced the highest number of tillers perplant (2.96) followed by RDF + Zn + Fe (2.82), which was statistically *at par* with RDF + Zn + B (2.79), while the least number of tillers per plant (2.58) was recorded inRDF only. With respect to number of leaves per plant as well,

Table 1: Effect of micronutrients on vegetative characters of turmeric (average of two years)

Treatments	Plant height (cm)	Number of tillers per plant	Number of leaves per plant	Leaf length (cm)	Leaf breadth (cm)
T_1	80.4	2.58	20.4	39.9	10.4
T_2	87.6	2.73	22.7	43.6	11.20
T_3	86.2	2.70	22.3	41.8	10.9
T_4	84.8	2.66	20.5	40.9	11.1
T_5	93.4	2.82	23.2	48.9	12.3
T_6	89.8	2.79	23.8	43.7	12.0
T_7	88.7	2.71	22.4	43.4	11.5
T_8	95.5	2.96	25.0	44.9	12.1
SEm±	1.43	0.08	0.24	0.46	0.15
CD (P=0.05)	7.12	0.21	2.25	4.48	1.13

application of RDF + Zn + Fe + B produced the highest number ofleaves per plant (25.0) closely followed byRDF + Zn + B(23.8). The least number of leaves per plant (20.4) was produced with RDF only. The longest (48.9 cm) and broadest (12.3 cm) leaves were produced with RDF + Zn + Fe, while the shortest (39.9 cm) and narrowest (10.4 cm) leaves with RDF only treatment.The improvement in plant vegetative characters of turmeric with the application of Zn, Fe and B may be ascribed to the collective role of micronutrients in enhancing different plant metabolic activities.Therefore, due to the enhancement of plant metabolic and physiological activities; and the increased availability of plant nutrients in the soil resulted in the production of greater photosynthetic area in the form of taller plants with more number of longer and broader leaves. A positive influence of micronutrients on plant growth characters of turmeric was also reported by Jabborova*et al.* (2021); Chitdeshwari (2019); Hnamte*et al.* (2018); Datta*et al.* (2017); Singh (2014); Kamble*et al.* (2014) and Vishwanath*et al.* (2011).

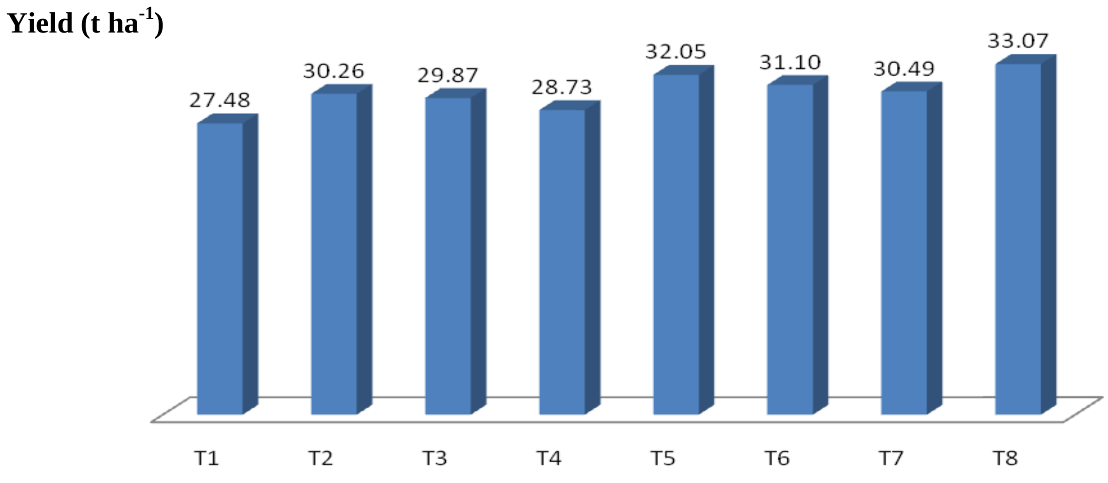
Table 2: Effect of micronutrients on yield attributing characters of turmeric(average of two years)

Treatments	Number of rhizomes per plant	Fresh rhizome weight per plant (g)	Yield (t ha^{-1})
T_1: RDFonly	15.7	247.3	27.48
T_2: RDF + 25 kg $ZnSO_4$ ha^{-1}	18.6	272.3	30.26
T_3: RDF + 50 kg $FeSO_4$ ha^{-1}	17.8	268.9	29.87
T_4: RDF + 10 kg borax ha^{-1}	17.5	258.5	28.73
T_5: RDF + Zn + Fe	19.6	288.5	32.05
T_6: RDF + Zn + B	18.9	279.8	31.10
T_7: RDF + Fe + B	18.0	274.4	30.49
T_8: RDF + Zn + Fe + B	20.2	297.7	33.07
SEm±	0.22	3.14	0.47
CD (P=0.05)	2.16	21.67	2.41

Yield Attributing Characters:

The data recorded for different yield attributing characters *viz.*, number of rhizomes per plant, fresh rhizome weight per plant and yield were presented in Table 2. Among the micronutrients, application of 25 kg $ZnSO_4$ ha^{-1} was more effective in increasing the yield attributing characters followed by iron and boron owing to deficiency of Zn in the soil. The data revealed significant improvement in all the yield attributing characters, when a mixture of two or more micronutrients was applied along with the RDF. A combined application of $FeSO_4$, $ZnSO_4$ and borax along with RDF resulted in the highest number of rhizomes per plant (20.2), as well as the maximum fresh weight of rhizomes per plant (297.7 g)followed by RDF + Zn + Fe (19.6 and 288.5 g, respectively). The lowest values for number of rhizomes per plant and fresh weight of rhizomes per plant (15.7 and 247.3 g, respectively) were observed with control (RDF only). The relatively higher yield of rhizome

Fig. 1: Effect of micronutrients on yield of turmeric



was recorded with the application of 25 kg $ZnSO_4$ ha^{-1}as compared to 50 kg $FeSO_4$and 10 kg borax ha^{-1}.Combined soil application of all the three micronutrients along with RDF, directly influenced the rhizome yield of turmeric, which varied from 27.48 to 33.07 tha^{-1}. The highest yield of turmeric (33.07 t ha^{-1}) was obtained with RDF + Zn + Fe+ B, which was statistically *at par* with RDF + Zn + Fe (32.10 tha^{-1}). The lowest yield (27.48 t ha^{-1}) was recorded when no micronutrients were applied *i.e.* control. The increment in yield with RDF + Zn + Fe + B was to the tune of 20.3% over the control. The substantial increase in the yield attributes of turmeric could be ascribed to the direct involvement of micronutrients in increasing the photosynthetic activity, protein synthesis and reproduction (Hnamte*et al.*, 2018; Kamble *et al.*, 2014). Increased rate of photosynthesis in turmeric with micronutrients application directly influences the yield (Jirali*et al.* (2007).Zinc, Fe and B have been found to be very effective in regulating plant growth, because it forms a part of enzyme system (carbonic anhydrate), which regulate plant growth (Singh, 2014). Micronutrients also increase the activity of soil enzymes which are essential for the growth of plants (Jabborova *et al.*, 2021). In summation, micronutrients play a critical role in enhancing various metabolic activities in the plant, thereby improving different plant growth characters, resulting into more photosynthetic area and enhanced photosynthetic activity, consequently producing more photosynthates, ready to be accumulated in the storage organs. In the present context, this surplus amount of photosythatesmay have resulted in the development of more number of rhizomes and attainment of more weight in them. The increase in yield and its attributing traits in turmeric due to the application of different micronutrients were in corroboration with the findings of Chitdeshwari (2019); Hnamte *et al.*(2018); Datta *et al.* (2017); Singh (2014); Kamble *et al.* (2014),Vishwanath *et al.* (2011) and Halder *et al.* (2007).

Table 3: Economics of turmeric production with different micronutrients

Treatments	Cost of cultivation (Rs ha^{-1})	Gross Income (Rs ha^{-1})	Net Income (Rs ha^{-1})	Benefit : Cost Ratio
T_1	233563	577080	343517	2.47
T_2	235901	635460	399560	2.69
T_3	234938	627270	392332	2.67
T_4	236313	603330	367017	2.55
T_5	237276	673050	435775	2.84
T_6	238651	653100	414450	2.74
T_7	237688	640290	402602	2.69
T_8	240026	694470	454445	2.89

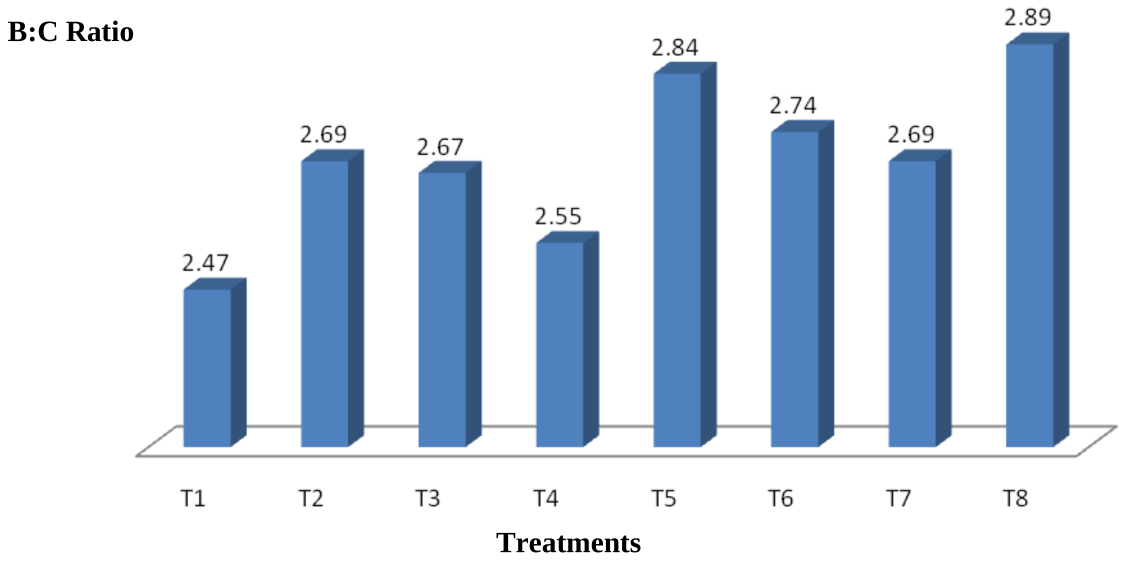


Fig. 2: Economics of turmeric production with micronutrients

Economics:

The economic analysis for the effect of Zn, Fe and B on turmeric yield has been presented in Table 3 and Fig. 2. The data reflected that Zn, Fe and B in combination with RDF fetched the highest monitory return of Rs. 4,54,445 ha^{-1}with the highest benefit : cost ratio (2.89) closely followed by RDF + Zn + Fe with the net profit of Rs. 4,35,775 ha^{-1}and 2.84 B:C ratio. Among these three micronutrients, application of 25 kg $ZnSO_4$ ha^{-1}resulted in higher net returns (Rs. 3,99,560 ha^{-1}) followed by 50 kg $FeSO_4$ ha^{-1} (Rs. 3,92,332 ha^{-1}) and 10 kg borax ha^{-1} (Rs. 3,67,017 ha^{-1}). The lowest net return (Rs. 3,43,517ha^{-1}) and B:C ratio (2.47) was obtained in control. Among these three micronutrients, application of 25 $ZnSO_4$ ha^{-1} resulted in higher net returns (Rs. 399560 ha^{-1}) followed by 50 kg $FeSO_4$ ha^{-1} (392332 ha^{-1}) and 10 kg borax ha^{-1} (Rs 367017 ha^{-1}).

It is evident from the two years study that Zn, Fe and B had exerted significant beneficial effect on the growth and yield attributes of turmeric either in single and/or in combination. Application of 25 kg $ZnSO_4$ + 50 kg $FeSO_4$ + 10 kg borax ha^{-1} along with RDF was very effective for getting substantially higher yield of turmeric. From economic point of view also, RDF + 25 kg $ZnSO_4$ + 50 kg $FeSO_4$ + 10 kg borax ha^{-1} was the most profitable for turmeric cultivation, and therefore, may be recommended to the turmeric growers of the area.

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