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Effect of Different Micronutrients on Turmeric Variety Suranjana in Terai Region of West Bengal, India

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A B S T R A C T

An experiment was undertaken at Uttar Banga Krishi Viswavidyalaya, Pundibari, West Bengal to study the effect of boron, iron, manganese and zinc on the growth and yield of turmeric during the year of 2010-11, 2011-12, 2012-13 and 2015-16. The experiment was laid out in randomized block design with three replications. Different treatments of the experiment were T_1 - control (no micronutrients), T_2 - soil application of boron (as borax) @ 25Kg ha^{-1}, T_3 - soil application of manganese (as $MnSO_4$) @ 25Kg ha^{-1}, T_4 - soil application of iron (as Fe_2SO_4) @ 25Kg ha^{-1}, T_5 - soil application of zinc (as $ZnSO_4$) @ 25Kg ha^{-1}, T_6 - foliar spray of manganese (as $MnSO_4$) @ 0.5% after 60 and 90 days of planting, T_7 - foliar spray of iron (as Fe_2SO_4) @ 0.5% after 60 and 90 days of planting, T_8 - foliar spray of boron (as borax) @ 0.5% after 60 and 90 days of planting and T_9 - foliar spray of zinc (as $ZnSO_4$) @ 0.5% after 60 and 90 days of planting. The results revealed that soil application of boron (as borax) @ 25Kg ha^{-1}) gave the highest yield (11.13 kg/3 m^2 and 22.45 t/ha) which was also statistically *at par* with foliar spray of boron as borax @ 0.5% at 60 and 90 days after planting (10.59 kg/3 m^2 and 21.36 t/ha). The lowest yield (7.17 kg/3m^2 and 14.45 t/ha).was recorded in the control treatment (i.e. without micronutrient application). The highest cost benefit ratio (1: 2.04) was recorded with soil application of boron (as borax) @ 25Kg ha^{-1} followed by foliar spray of boron (1: 1.95) (as borax) @ 0.5% at 60 and 90 days after planting.

Introduction

Turmeric (*Curcuma longa* L.) is an important rhizomatous spice crop of India and World too. India is a leading producer, consumer and exporter of turmeric in the world. India is the major producer and exporter of turmeric and earned a foreign exchange of 2000 million $ (Anonymous, 2012). Apart from its spice and medicinal value it is also used in the dye, food and cosmetic industries. It is also used in the auspicious religious occasions. Turmeric inhibits the development of cataracts, breast cancer, colon cancer, and lymphoma (Devi *et al.*, 2011). In India it is cultivated with an area of 1.95 lakh hectare (ha) with a production of 9.99 lakh tonnes. In West Bengal, it is cultivated with an area of 15.8 thousand ha and production of 42 thousand tonnes. Productivity of turmeric in West Bengal is quite low (2.66 tones/ha) compared to national average (5.11 tones/ha). It is a soil exhausting crop and application of N, P and K are recommended for its cultivation. Normally micronutrients do not find a place in the nutrient recommendations. However, high rhizome yields in turmeric with increasing concentrations of foliar sprays of

magnesium sulphate in the acidic soils of Meghalaya have been reported (Chandra *et al.,* 1997). Turmeric is highly responsive to chemical fertilizers. In addition, micronutrients fertilizers are mostly liable to reduce disease incidence and enhance durability of the post harvest life of ginger and turmeric (Halder *et al.,* 2007). (Banafer *et al.,* 1995), (Gupta and Singer, 1998), (Roy *et al.,* 1992) stated in therir reports that ginger and turmeric are highly responsive to chemical fertilzers and increased the growth and rhizome yield with increments of fertilizer rates. Bose *et al.,* (2008) reported that inclusion of S and Mg in the fertilization schedule greatly improved the fresh yields of turmeric in the depleted red lateritic soils of West Bengal. Similarly, Kavitha (2012) revealed that in the rhizomatous crop kacholam (*Kaempferia galanga* L.), top dressing of sulphur and magnesium resulted in higher rhizome yields. Recent research has shown that application of Fe significantly increased in yield of crops. Chhibba *et al.,* (2007) reported that the foliar application of Fe increased yield and Fe concentration in fenugreek. Beneficial effect of Effect of Zn, Fe and B on growth and yield of ginger was reported by Roy *et al.,* (1992). Halder *et al* (2007) reported the beneficial effect of zinc and boron on turmeric yield and quality. Very information is available with respect to the effect of boron, iron, manganese and zinc on the growth and yield of turmeric, with keeping this views, the present experiment was undertaken with the effect of boron, iron, manganese and zinc on the growth and yield of turmeric.

Materials and Methods

An investigation was undertaken to study the effect of boron, iron, manganese and zinc on the growth and yield of turmeric in Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal during the year of 2010-11, 2011-12, 2012-13 and 2015-16. The experimental soil was sandy clay loam having p^H 5.6, 0.90% organic carbon, 131.45 kg/ha available nitrogen, 47.38 kg/ha available phosphorus and 65.82 kg/ha potash. The climatic condition of this region is sub-tropical humid in nature. The experiment was laid out in Randomized Block Design with five replications. Raised beds of 3 m X 1 m size and 15 cm height were prepared. Turmeric rhizome of the variety Suranjana was planted with a spacing of 30 cm x 20 cm during the first week of May 2010, 2011, 2012 and 2015, respectively. The experiment was laid out in randomized block design with 9 treatments and three replications. The treatment details were T_1 - control (no micronutrients), T_2 - soil application of boron (as borax) @ 25Kg ha^{-1}, T_3 - soil application of manganese (as $MnSO_4$) @ 25Kg ha^{-1}, T_4 - soil application of iron (as Fe_2SO_4) @ 25Kg ha^{-1}, T_5 - soil application of zinc (as $ZnSO_4$) @ 25Kg ha^{-1}, T_6 - foliar spray of manganese (as $MnSO_4$) @ 0.5% after 60 and 90 days of planting, T_7 - foliar spray of iron (as Fe_2SO_4) @ 0.5% after 60 and 90 days of planting, T_8 - foliar spray of boron (as borax) @ 0.5% after 60 and 90 days of planting and T_9 - foliar spray of zinc (as $ZnSO_4$) @ 0.5% after 60 and 90 days of planting. Full dose of Farm yard manure @ 15 t/ha was applied as basal. Inorganic fertilizers were applied at the rate of 80: 80: 120 kg/ha of N: P_2O_5: K_2O.

Among the inorganic fertilizers, full dose of P_2O_5 and 1/3 dose of N was applied as basal, rest 2/3rd N and K_2O were applied in two equal splits at 45 and 90 days after planting. Observations on different morphological and yield attributing characters were recorded from five randomly selected plants from each plots. Rhizome yield per hectare was calculated on the plot weight basis. Statistical analysis of the data was done as per method suggested by Gomez and Gomez (1984).

Results and Discussion

Perusal of the data presented in tables 1–6 revealed that there was a significant variation in the different, growth, rhizome weight and rhizome yield. Maximum plant height was recorded in the soil application of boron (as borax) @ 25Kg ha^{-1} (97.82 cm) which was statistically *at par* with soil application of zinc (as $ZnSO_4$) @ 25Kg ha^{-1} (94.75 cm) (Table 1).

Higher plant height was also recorded in treatment of foliar spray of zinc (as $ZnSO_4$) @ 0.5% after 60 and 90 days of planting (91.37 cm) and soil application of manganese (as $MnSO_4$) @ 25Kg ha^{-1} (90.25 cm). Whereas the lowest plant height (84.31 cm) was recorded in control plots. With respect to tillers per plant, more number of tillers per plant was recorded with soil application of iron (as Fe_2SO_4) @ 25Kg ha^{-1} (3.38) followed by soil application of iron (as Fe_2SO_4) @ 25Kg ha^{-1} (3.26), foliar spray of boron (as borax) @ 0.5% after 60 and 90 days of planting (3.19), soil application of zinc (as $ZnSO_4$) @ 25Kg ha^{-1} (2.95) and soil application of boron (as borax) @ 25Kg ha^{-1} (2.88) and minimum number recorded in control treatment (no micronutrients) (2.16).

Soil application of manganese (as $MnSO_4$) @ 25Kg ha^{-1} showed the highest number of leaves (8.66) which was also statistically *at par* with soil application of zinc (as $ZnSO_4$) @ 25Kg ha^{-1} (8.41), soil application of boron (as borax) @ 25Kg ha^{-1} (8.22) and soil application of zinc (as $ZnSO_4$) @ 25Kg ha^{-1} (8.22) and it was lowest with control (no micronutrients) treatment (7.83) (Table 2).

Maximum leaf length was recorded with soil application of boron (as borax) @ 25Kg ha^{-1} (41.38) followed by soil application of iron (as Fe_2SO_4) @ 25Kg ha^{-1} (41.34 cm), soil application of manganese (as $MnSO_4$) @ 25Kg ha^{-1} (40.49 cm), soil application of zinc (as $ZnSO_4$) @ 25Kg ha^{-1}5 (39.96) T6 (39.95) and foliar spray of iron (as Fe_2SO_4) @ 0.5% after 60 and 90 days of planting (39.74 cm) (Table 2).

With respect to leaf breadth (Table 3), the widest leaf was recorded in the treatment of application of boron (as borax) @ 25Kg ha^{-1} (10.36 cm) followed by soil application of iron (as Fe_2SO_4) @ 25Kg ha^{-1} (10.14 cm), foliar spray of manganese (as $MnSO_4$) @ 0.5% after 60 and 90 days of planting (10.12 cm), foliar spray of iron (as Fe_2SO_4) @ 0.5% after 60 and 90 days of planting (9.98 cm) and soil application of manganese (as $MnSO_4$) @ 25Kg ha^{-1} (9.89 cm). The lowest leaf breadth was recorded in the treatment of soil application of zinc (as $ZnSO_4$) @ 25Kg ha^{-1} (8.74 cm).

In this experiment weight of mother rhizome varied from 44.36 g to 66.31 g. Maximum mother rhizome weight was recorded with soil application of iron (as Fe_2SO_4) @ 25Kg ha^{-1} (66.31 g) which was also statically at par with soil application of manganese (as $MnSO_4$) @ 25Kg ha^{-1} (64.31 g) treatment (Table 3). The lowest mother rhizome weight (44.36) was recorded in control treatment (i.e. without micronutrient). The results revealed that application micronutrient significantly increased the weight of primary and secondary rhizome per plant (Table 4).

Maximum weight of mother rhizome was record with the treatment of foliar spray of iron (as Fe_2SO_4) @ 0.5% after 60 and 90 days of planting (115.37 g) followed by soil application of zinc (as $ZnSO_4$) @ 25Kg ha^{-1} (114.25 g), soil application of manganese (as $MnSO_4$) @ 25Kg ha^{-1} (113.17 g) and foliar spray of boron (as borax) @ 0.5% after 60 and 90 days of planting (110.63 g) (Table 4).

Table.1 Effect of boron, manganese, zinc and iron on plant height and tiller number of turmeric

Treatment	Plant height (cm)					Tiller Number				
	2010-11	2011-12	2012-13	2015-16	Pooled	2010-11	2011-12	2012-13	2015-16	Pooled
T_1	82.00	80.47	78.83	95.93	84.31	2.00	1.88	1.89	2.87	2.16
T_2	96.33	96.07	90.40	108.47	97.82	2.56	2.29	1.93	4.73	2.88
T_3	94.03	85.23	78.73	103.00	90.25	2.56	1.72	2.11	3.53	2.48
T_4	81.99	79.32	73.82	92.33	81.87	3.56	3.17	3.13	3.67	3.38
T_5	94.40	91.64	83.81	109.13	94.75	3.11	2.50	2.13	4.07	2.95
T_6	88.41	86.51	81.60	101.67	89.55	2.44	1.83	2.33	3.53	2.53
T_7	86.34	78.35	73.54	118.00	89.06	2.56	1.96	1.97	3.87	2.59
T_8	84.12	74.11	87.28	110.40	88.98	3.44	2.27	2.32	4.73	3.19
T_9	92.57	84.97	80.13	107.80	91.37	3.33	2.69	2.33	4.67	3.26
SEm±	3.03	3.66	3.65	1.74	1.65	0.21	0.30	0.31	0.23	0.13
CD (P = 0.05)	9.10	10.97	10.95	5.20	4.64	0.64	0.90	0.92	0.68	0.37
CV	5.99	7.54	7.82	2.86	6.35	12.93	23.04	23.86	9.93	15.87

T_1 - Control (No micronutrients), T_2 - Soil application of Boron (Borax) @ 25Kg ha^{-1}, T_3 - Soil application of Manganese ($MnSO_4$) @ 25Kg ha^{-1}, T_4 - Soil application of Iron (Fe_2SO_4) @ 25Kg ha^{-1}, T_5 - Soil application of Zinc ($ZnSO_4$) @ 25Kg ha^{-1}, T_6 - Foliar spray of Manganese ($MnSO_4$) @ 0.5% after 60 and 90 days of planting, T_7 - Foliar spray of Iron (Fe_2SO_4) @ 0.5% after 60 and 90 days of planting, T_8 - Foliar spray of Boron (Borax) @ 0.5% after 60 and 90 days of planting and T_9 - Foliar spray of Zinc ($ZnSO_4$) @ 0.5% after 60 and 90 days of planting

Table.2 Effect of boron, manganese, zinc and iron on number of leaves and leaf length of turmeric

Treatment	Number of leaves					Leaf length (cm)				
	2010-11	2011-12	2012-13	2015-16	Pooled	2010-11	2011-12	2012-13	2015-16	Pooled
T_1	7.00	8.50	8.50	7.07	7.77	35.10	40.17	39.60	35.90	37.69
T_2	8.44	7.61	7.89	9.07	8.25	44.78	42.28	37.38	41.08	41.38
T_3	8.33	9.44	9.00	7.87	8.66	43.11	39.78	39.16	39.92	40.49
T_4	8.11	7.94	7.61	8.20	7.97	36.87	33.40	34.07	36.86	35.30
T_5	8.22	8.50	8.44	8.47	8.41	43.89	40.26	35.59	40.08	39.96
T_6	8.00	6.16	6.10	7.73	7.00	40.46	40.90	37.23	41.20	39.95
T_7	7.89	7.17	7.33	9.13	7.88	40.30	39.70	36.83	42.12	39.74
T_8	7.89	6.45	8.33	10.20	8.22	37.23	37.90	36.00	43.57	38.68
T_9	8.11	7.11	6.67	9.33	7.81	41.72	40.72	40.23	42.67	41.34
SEm±	0.36	0.48	0.49	0.24	0.21	1.52	1.36	1.78	1.07	0.78
CD (P = 0.05)	1.09	1.44	1.46	0.71	0.60	4.56	4.09	5.33	3.21	2.21
CV	7.86	10.87	10.87	4.76	9.21	6.52	5.99	8.24	4.59	6.88

T_1 - Control (No micronutrients), T_2 - Soil application of Boron (Borax) @ 25Kg ha^{-1}, T_3 - Soil application of Manganese ($MnSO_4$) @ 25Kg ha^{-1}, T_4 - Soil application of Iron (Fe_2SO_4) @ 25Kg ha^{-1}, T_5 - Soil application of Zinc ($ZnSO_4$) @ 25Kg ha^{-1}, T_6 - Foliar spray of Manganese ($MnSO_4$) @ 0.5% after 60 and 90 days of planting, T_7 - Foliar spray of Iron (Fe_2SO_4) @ 0.5% after 60 and 90 days of planting, T_8 - Foliar spray of Boron (Borax) @ 0.5% after 60 and 90 days of planting and T_9 - Foliar spray of Zinc ($ZnSO_4$) @ 0.5% after 60 and 90 days of planting.

Table.3 Effect of boron, manganese, zinc and iron on breadth and weight of mother rhizome of turmeric

Treatment	Leaf breadth (cm)					Weight of mother rhizome (g)				
	2010-11	2011-12	2012-13	2015-16	Pooled	2010-11	2011-12	2012-13	2015-16	Pooled
T_1	9.00	9.39	8.39	8.98	8.94	40.89	43.22	42.56	50.77	44.36
T_2	11.09	10.28	9.53	10.53	10.36	52.22	47.78	43.78	59.81	50.90
T_3	10.03	9.83	9.67	10.02	9.89	63.00	62.11	65.11	67.03	64.31
T_4	9.74	8.58	8.44	8.87	8.91	45.78	44.45	48.78	56.67	48.92
T_5	9.52	8.28	8.11	9.05	8.74	48.44	40.44	43.67	52.56	46.28
T_6	10.67	10.21	9.50	10.12	10.12	47.44	43.72	40.22	51.33	45.68
T_7	10.41	10.08	8.96	10.47	9.98	57.56	53.78	52.17	60.43	55.98
T_8	9.27	9.60	9.35	10.56	9.70	64.22	55.83	56.17	65.14	60.34
T_9	9.61	10.28	10.22	10.46	10.14	64.00	65.94	66.94	68.37	66.31
SEm±	0.51	0.74	0.81	0.18	0.32	3.29	2.46	5.0	1.65	1.64
CD (P = 0.05)	1.52	2.22	2.42	0.55	0.90	9.87	7.39	11.98	4.97	4.63
CV	8.82	13.32	15.32	3.24	11.50	10.76	8.41	16.95	4.06	1.64

T_1 - Control (No micronutrients), T_2 - Soil application of Boron (Borax) @ 25Kg ha^{-1}, T_3 - Soil application of Manganese ($MnSO_4$) @ 25Kg ha^{-1}, T_4 - Soil application of Iron (Fe_2SO_4) @ 25Kg ha^{-1}, T_5 - Soil application of Zinc ($ZnSO_4$) @ 25Kg ha^{-1}, T_6 - Foliar spray of Manganese ($MnSO_4$) @ 0.5% after 60 and 90 days of planting, T_7 - Foliar spray of Iron (Fe_2SO_4) @ 0.5% after 60 and 90 days of planting, T_8 - Foliar spray of Boron (Borax) @ 0.5% after 60 and 90 days of planting and T_9 - Foliar spray of Zinc ($ZnSO_4$) @ 0.5% after 60 and 90 days of planting

Table.4 Effect of boron, manganese, zinc and iron on weight of primary and secondary rhizome of turmeric

Treatment	Weight of primary rhizome					Weight of secondary rhizome				
	2010-11	2011-12	2012-13	2015-16	Pooled	2010-11	2011-12	2012-13	2015-16	Pooled
T_1	87.00	71.67	69.00	90.71	79.59	80.67	36.22	35.06	45.95	49.48
T_2	102.67	93.68	78.67	130.26	101.32	120.44	58.76	56.92	86.93	80.76
T_3	112.89	118.50	107.00	114.29	113.17	137.56	56.39	54.39	79.47	81.95
T_4	98.89	102.50	102.06	115.03	104.62	127.11	62.98	60.21	77.08	81.85
T_5	111.78	114.11	111.94	119.15	114.25	110.78	60.67	58.89	75.45	76.45
T_6	111.00	84.78	72.78	113.45	95.50	144.00	48.17	48.83	78.03	79.76
T_7	153.56	109.61	103.10	95.21	115.37	139.00	58.67	58.61	55.16	77.86
T_8	123.22	95.61	99.22	124.47	110.63	130.00	43.83	44.39	82.10	75.08
T_9	126.33	81.39	81.94	119.60	102.32	144.33	40.94	42.57	83.04	77.72
SEm±	4.47	3.55	5.41	1.97	1.97	3.74	2.28	2.86	1.66	1.39
CD (P = 0.05)	13.42	10.65	16.22	5.91	5.55	11.21	6.82	8.58	5.06	3.91
CV	6.82	6.36	10.21	3.00	6.56	5.14	7.60	9.70	3.96	6.35

T_1 - Control (No micronutrients), T_2 - Soil application of Boron (Borax) @ 25Kg ha^{-1}, T_3 - Soil application of Manganese ($MnSO_4$) @ 25Kg ha^{-1}, T_4 - Soil application of Iron (Fe_2SO_4) @ 25Kg ha^{-1}, T_5 - Soil application of Zinc ($ZnSO_4$) @ 25Kg ha^{-1}, T_6 - Foliar spray of Manganese ($MnSO_4$) @ 0.5% after 60 and 90 days of planting, T_7 - Foliar spray of Iron (Fe_2SO_4) @ 0.5% after 60 and 90 days of planting, T_8 - Foliar spray of Boron (Borax) @ 0.5% after 60 and 90 days of planting and T_9 - Foliar spray of Zinc ($ZnSO_4$) @ 0.5% after 60 and 90 days of planting

Table.5 Effect of boron, manganese, zinc and iron on plant population of turmeric

Treatment	Plant population at (30DAP)					Plant population at (60DAP)				
	2010-11	2011-12	2012-13	2015-16	Pooled	2010-11	2011-12	2012-13	2015-16	Pooled
T_1	36.00	37.67	37.67	39.33	37.67	35.00	35.67	35.67	38.67	36.25
T_2	38.67	34.67	35.00	38.67	36.75	38.67	34.00	34.00	36.67	35.83
T_3	39.33	34.67	36.67	37.67	37.08	38.33	34.33	36.33	36.67	36.42
T_4	38.33	36.33	36.67	38.00	37.33	36.33	35.67	36.33	36.67	36.25
T_5	37.33	36.67	37.00	38.33	37.33	36.67	35.33	37.00	38.00	36.75
T_6	38.67	38.00	38.33	37.67	38.17	36.67	37.33	38.00	37.00	37.25
T_7	39.67	35.67	36.00	37.67	37.25	36.67	35.33	35.33	37.67	36.25
T_8	40.00	39.67	39.00	38.00	39.17	37.33	38.00	38.33	38.00	37.92
T_9	37.33	38.67	38.33	39.67	38.50	37.33	37.33	38.00	39.67	38.08
SEm±	0.81	1.13	1.00	0.86	0.51	1.09	1.14	0.93	.71	0.51
CD (P = 0.05)	2.45	3.38	3.01	2.59	1.44	3.28	3.43	2.80	2.14	1.43
CV	3.69	5.30	4.68	3.91	4.68	5.12	5.51	4.42	3.28	4.77

T_1 - Control (No micronutrients), T_2 - Soil application of Boron (Borax) @ 25Kg ha^{-1}, T_3 - Soil application of Manganese ($MnSO_4$) @ 25Kg ha^{-1}, T_4 - Soil application of Iron (Fe_2SO_4) @ 25Kg ha^{-1}, T_5 - Soil application of Zinc ($ZnSO_4$) @ 25Kg ha^{-1}, T_6 - Foliar spray of Manganese ($MnSO_4$) @ 0.5% after 60 and 90 days of planting, T_7 - Foliar spray of Iron (Fe_2SO_4) @ 0.5% after 60 and 90 days of planting, T_8 - Foliar spray of Boron (Borax) @ 0.5% after 60 and 90 days of planting and T_9 - Foliar spray of Zinc ($ZnSO_4$) @ 0.5% after 60 and 90 days of planting.

Table.6 Effect of boron, manganese, zinc and iron on rhizome yield of turmeric

Treatment	Yield per Plot (kg/3 m^2)					Projected Yield (t/ha)				
	2010-11	2011-12	2012-13	2015-16	Pooled	2010-11	2011-12	2012-13	2015-16	Pooled
T_1	6.89	6.70	6.50	8.57	7.17	13.89	13.51	13.10	17.28	14.45
T_2	10.17	10.33	10.17	13.87	11.13	20.50	20.83	20.50	27.96	22.45
T_3	9.33	7.60	7.93	11.78	9.16	18.82	15.32	15.99	23.74	18.47
T_4	8.67	7.83	7.90	11.61	9.00	17.47	15.79	15.93	23.41	18.15
T_5	9.33	7.73	8.00	11.40	9.11	18.82	15.59	16.13	22.98	18.38
T_6	8.83	8.37	7.57	11.15	8.98	17.81	16.87	15.25	22.47	18.10
T_7	7.50	6.37	5.83	9.80	7.38	15.12	12.84	11.76	19.75	14.87
T_8	8.83	10.03	10.17	13.35	10.59	17.81	20.23	20.50	26.91	21.36
T_9	9.83	7.97	8.47	13.21	9.87	19.82	16.06	17.07	26.64	19.90
SEm±	0.71	0.73	0.79	0.25	0.43	1.42	1.48	1.60	0.50	0.86
CD (P = 0.05)	2.11	2.20	2.38	0.76	1.20	4.26	4.43	4.80	1.52	2.42
CV%	13.84	15.68	17.07	3.75	16.10	13.84	15.68	17.64	3.75	16.09

T_1 - Control (No micronutrients), T_2 - Soil application of Boron (Borax) @ 25Kg ha^{-1}, T_3 - Soil application of Manganese ($MnSO_4$) @ 25Kg ha^{-1}, T_4 - Soil application of Iron (Fe_2SO_4) @ 25Kg ha^{-1}, T_5 - Soil application of Zinc ($ZnSO_4$) @ 25Kg ha^{-1}, T_6 - Foliar spray of Manganese ($MnSO_4$) @ 0.5% after 60 and 90 days of planting, T_7 - Foliar spray of Iron (Fe_2SO_4) @ 0.5% after 60 and 90 days of planting, T_8 - Foliar spray of Boron (Borax) @ 0.5% after 60 and 90 days of planting and T_9 - Foliar spray of Zinc ($ZnSO_4$) @ 0.5% after 60 and 90 days of planting.

Table.7 Cost Benefit ratio of different treatments

Treatments	Expense (Rs./ha)									Income (Rs./ha)			Net income (Rs./ha)	C:B
	Land Preparation	Seed rhizome cost	Micronutrient and application cost	Labour (Bed preparation, sowing, weeding, harvesting, spraying etc)	Fertilizer				Total	Production (ton/ ha)	Rate (Rs./ t)	Sell amount (Rs.)		
					N	P	K	FYM						
T1	10000	50,000	0	1,25,572	1,056	3,075	3,206	22,500	2,15,409	14.45	20,000	289000	73,591	1 : 1.34
T2	10000	50,000	5,512	1,25,572	1,056	3,075	3,206	22,500	2,20,921	22.45	20,000	449000	2,28,079	1 : 2.03
T3	10000	50,000	2,512	1,25,572	1,056	3,075	3,206	22,500	2,17,921	18.47	20,000	369400	1,51,479	1 : 1.70
T4	10000	50,000	1,137	1,25,572	1,056	3,075	3,206	22,500	2,16,546	18.15	20,000	363000	1,46,454	1: 1.68
T5	10000	50,000	1,962	1,25,572	1,056	3,075	3,206	22,500	2,17,371	18.38	20,000	367600	1,50,229	1 : 1.69
T6	10000	50,000	2,528	1,25,572	1,056	3,075	3,206	22,500	2,17,937	18.1	20,000	362000	1,44,063	1 : .66
T7	10000	50,000	2,198	1,25,572	1,056	3,075	3,206	22,500	2,17,607	14.87	20,000	297400	79,793	1 : 1.37
T8	10000	50,000	3,284	1,25,572	1,056	3,075	3,206	22,500	2,18,693	21.36	20,000	427200	2,08,507	1: 1.95
T_9	10000	50,000	2,384	1,25,572	1,056	3,075	3,206	22,500	2,17,793	19.9	20,000	398000	1,80,207	1 :1.83

T_1 - Control (No micronutrients), T_2 - Soil application of Boron (Borax) @ 25Kg ha^{-1}, T_3 - Soil application of Manganese ($MnSO_4$) @ 25Kg ha^{-1}, T_4 - Soil application of Iron (Fe_2SO_4) @ 25Kg ha^{-1}, T_5 - Soil application of Zinc ($ZnSO_4$) @ 25Kg ha^{-1}, T_6 - Foliar spray of Manganese ($MnSO_4$) @ 0.5% after 60 and 90 days of planting, T_7 - Foliar spray of Iron (Fe_2SO_4) @ 0.5% after 60 and 90 days of planting, T_8 - Foliar spray of Boron (Borax) @ 0.5% after 60 and 90 days of planting and T_9 - Foliar spray of Zinc ($ZnSO_4$) @ 0.5% after 60 and 90 days of planting

With respect to the weight of secondary rhizome, the higher weight of secondary rhizome was recorded with the treatment of soil application of manganese (as $MnSO_4$) @ 25Kg ha^{-1} (81.95 g), - soil application of iron (as Fe_2SO_4) @ 25Kg ha^{-1} (81.85 g) and soil application of boron (as borax) @ 25Kg ha^{-1} (80.76 g). Lowest primary and secondary rhizome weight was recorded in the control treatment (79.59 g and 49.48 g, respectively) (Table 4). Effect of micronutrient on the turmeric plant population survival from 30 days after transplanting to the maturity (i.e. at the time harvest) was almost nothing (Table 5).

Among the different treatment, soil application of boron (as borax) @ 25Kg ha^{-1} gave the highest yield (11.13 kg/3m^2 and 22.45 t/ha) which was also statistically *at par* with foliar spray of boron (as borax) @ 0.5% after 60 and 90 days of planting treatment (10.59 kg/3m^2 and 21.36 t/ha) (Table 4). Higher yield of turmeric rhizome was also recorded in the treatment of soil application of iron (as Fe_2SO_4) @ 25Kg ha^{-1} (9.87 kg/3m2 and 19.90 t/ha). The lowest yield was recorded in the control plot (7.17 kg/3m2 and 14.45 t/ha). In this experiment higher yield recorded in micronutrient treated plot as compared to the control plots. This might be due the beneficial effect of the micronutrient on turmeric yield. Among the different micronutrient, soil application of boron gave highest yield as compared to the other treatment. Sugtto and Mafutuchah (1995), Pawar and Gavande (1992) and Singh *et al.*, (1992) also observed similar findings in their report as found in boron application.

Considering cost benefit ratio, the highest C : B ratio (1 : 2.04) was recorded with the soil application of boron (as borax) @ 25Kg ha^{-1} followed by foliar spray of boron (1 : 1.95) (as borax) @ 0.5% at 60 and 90 days after planting and lowest C : B ratio (1 : 1.34) was recorded in the control treatment (i.e. application of no micronutrient) (Table 7).

In conclusion, from the above discussion it may be concluded that soil application of boron (as borax) @ 25Kg ha^{-1}) and foliar spray of boron (as borax) @ 0.5% at 60 and 90 days after planting (1 : 1.95) were beneficial for getting higher yield in turmeric.

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