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Effect of micro-nutrients on growth, yield and economics of turmeric (*Curcuma longa* L.) cv. RAJENDRA SONIA

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ABSTRACT : An experiment was conducted during *Kharif* 2010-11 to 2012-13 to assess the influence of micro-nutrients on growth, yield and economics of turmeric at the experimental field of Department of Horticulture, T.C.A., Dholi, Muzaffarpur. The experiment was allotted by ICAR under AICRP on spices. Among four types of micro-nutrients such as zinc sulphate, ferrous sulphate, borex and manganese sulphate were tested with three methods of application such as no application of micro-nutrients (control), soil application of micro-nutrients @25kg ha^{-1} and two foliar applications of micro-nutrients @ 0.5% at 60 and 90 days after sowing. Among the micro-nutrients, none of the micro-nutrients were found significant effect regarding yield and yield attributing characters. Among three methods of application, soil application of micro-nutrients @25kg ha^{-1} and two foliar applications of micro-nutrients @0.5% at 60 and 90 days after sowing gave significant effect regarding yield and yield attributing characters as compared to no application of micro-nutrients (control). Two foliar application of micro-nutrients @ 0.5% at 60 and 90 days after sowing was found at par with soil application of micro-nutrients @25kg ha^{-1} regarding yield and yield attributing characters. Among four type of micro-nutrients and three methods of application, ferrous sulphate @0.5% at 60 and 90 days after sowing gave the maximum plant height (127.23cm), number of tillers per plant (4.74), number of leaves tiller (12.57), length of leaves (56.75cm), width of leaves (13.89cm), area of leaves (811.34 cm^2), number of plant per plot (40), dry mater production per plot (1.79kg), yield per plot (19.80kg) and yield per hectare (60.39t) as compared to other micro-nutrients and other methods of application. Economics of the experiment, two foliar sprays of ferrous sulphate @0.5% at 60 and 90 days after sowing gave the maximum return Rs.1,81,950 with cost of Rs.1,20,000 and it also gave the highest benefit: cost ratio Rs.2.52:1.

KEY WORDS : Turmeric, Zinc sulphate, Ferrous sulphate, Borax, Manganese sulphate

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India is a leading producer and exporter of turmeric in the world. In India, Andhra Pradesh, Tamil Nadu, Odisha, Karnataka, West Bengal, Meghalaya, Maharashtra and Bihar are the important state which cultivates turmeric of which Andhra Pradesh alone occupies 35.0 per cent of area and 47.0 per cent of production. In India, turmeric is cultivated under 1,80,960 hectare with the production of 7,92,980 MT (NHB data base, 2011). The active constituents per cent in turmeric is curcumin, which comprise 0.3-5.5 per cent (Leung, 1980). Curcuminoids in turmeric have anti-inflammatory, antimutagen, anti cancer, anti bacterial, anti fungal, anti parasitic and detoxifying properties (Herrmann and Martine, 1991, Nakamura *et al*., 1998, Osawa *et al*., 1995, Sugiyama *et al*., 1996 and Vechi *et al*., 2000).

Mineral nutrition is also considered as one of the important factors that influence the growth and yield of turmeric plant get some amount of nutrition from soil but they are inadequate to meet the increased demand of plants for higher production. Optimum dose of fertilizer is required by the crop to increase the productivity potential and there is enough information regarding the requirement of the nitrogen, phosphorus and potassium by this crop. In addition to N,P,K, zinc, iron, boron and manganese are required by most of the crop plants particularly in rhizomatous crop like turmeric for

improving the yield and quality attributes. Knowing this consideration and study was made on effect of micro nutrients on growth and yield of turmeric.

RESEARCH METHODS

The experiment was conducted during the *Kharif* 2010-11 to 2012-13 at Department of Horticultural experimental plot, Tirhut College of Agriculture, Dholi, Muzaffarpur (Bihar). This experiment was allotted by the Project Coordinator, All India Co-ordinated Research Project on Spices, Calicut, Kerala. The soil of the experimental plot was sandy loam and pH-7.3, available nitrogen 170.35kg ha^{-1}, available phosphorus 15kg ha^{-1} and available potassium 114.24kg ha^{-1}. Dholi is situated in northern Bihar, Zone–I. The rainfall of this area is 730 to 1130mm which is distributed between June to October. Disease free healthy rhizomes cv. Rajendra Sonia was planted in the depth of 15cm in fourth week of May with spacing of 30cm x 25cm in the plot size 3.0m x 1.0m. The experiment was laid out in Factorial Randomized Block Design (F-RBD) with three replications. Seeds were sown in the depth of 15cm. The treatments of experiment are given as follows: Factor-4 (zinc sulphate, ferrous sulphate, borax and manganese sulphate) and level-3 (control or zero level, 25kg ha^{-1} soil application and two foliar spray @0.5% at 60 and 90 DAS after sowing).

Factor:- 4:

F_1: Zinc sulphate F_2: Ferrous sulphate

F_3: Borax F_4: Manganese sulphate

Level: 3:

D_0- No application of micro-nutrients

D_1- Soil application of micro-nutrients @25kg ha^{-1}

D_2- Two foliar application of micro-nutrients @0.5% at 60 and 90 days after sowing.

There were twelve treatments including control are given as follows:

T_1: No application of zinc sulphate.

T_2: Soil application of zinc sulphate @25kg ha^{-1}.

T_3: Two foliar application zinc sulphate @0.5% at 60 and 90 DAS.

T_4: No application of ferrous sulphate.

T_5: Soil application of ferrous sulphate @25kg ha^{-1}.

T_6: Two foliar sprays of ferrous sulphate @0.5% at 60 and 90 DAS.

T_7: No application of borax.

T_8: Soil application of borax @25kg ha^{-1}.

T_9: Two foliar sprays of borax @0.5% at 60 and 90 DAS.

T_{10}: No application of manganese sulphate.

T_{11}: Soil application of manganese sulphate @25kg ha^{-1}.

T_{12}: Tow foliar sprays of manganese sulphate @0.5% at 60 and 90 DAS.

The status of micro-nutrients in the experimental field was as follows: Zinc -0.69ppm, iron-1.73ppm, boron-0.4ppm and manganese-5.05ppm. The experiment was harvested in last week of January, for biometric observations five plants were selected randomly from each plot as an observational plant and were labeled. The data were collected on growth parameters like-plant height, number of tillers per plant, number of leaves per tiller, length and width of leaves, area of leaves, number of plant per plot, dry mater production and yield per plot and per hectare.

RESEARCH FINDINGS AND DISCUSSION

To see the significant effect of micro-nutrients *viz*., zinc sulphate, ferrous sulphate, borax and manganese sulphate and their three methods of application *viz*., no application of micro-nutrients (control), soil application of micro-nutrients @25kg ha^{-1} and two foliar application of micro-nutrients @0.5% at 60 and 90 days after sowing. The three year pooled data are presented in Table 1.

Among four type of micro-nutrients *viz*., zinc sulphate, ferrous sulphate, borax and manganese sulphate had non-significant effect regarding yield and yield parameters. However, three methods of application *viz*., number application of micro-nutrients (control), soil application of micro-nutrients @25kg ha^{-1} and two foliar application of micro-nutrients @0.5% at 60 and 90 days after sowing recorded significant effect regarding yield and yield attributing character. Soil application of micro-nutrients @25kg ha^{-1} and two foliar sprays of micro-nutrients @0.5% at 60 and 90 days after sowing found significant effect regarding yield and yield attributing characters as compared to no application of micro-nutrients (control). Between soil application of micro-nutrients and two foliar applications of micro-nutrients non-significant effect were found regarding yield and yield attributing characters. However, two foliar applications of micro-nutrients @0.5% at 60 and 90 days after sowing gave the maximum plant height (124.10cm), number of tillers per plant (4.62), number of leaves per tiller (11.99), area of leaves (745.16cm^2), number of plants per plot (40.00), dry mater production per plot (1.66kg), yield per plot (18.41kg 3m^{-2}) and yield (55.96t ha^{-1}) followed by soil application of micro-nutrients @25kg ha^{-1} *i.e.*, plant height (120.58cm), number of tillers per plant (4.30), number of leaves per tiller (11.92), area of leaves (733.90 cm^2), number of plant per plot (39.75), dry matter production per plot (1.64kg), yield per plot (17.98kg 3m^2) and yield (55.18t ha^{-1}). Among four micro-nutrients and three methods of applications, ferrous sulphate @0.5% at 60 and 90 days after sowing gave the maximum plant height (127.23cm), number of tillers per plant (4.74), number of leaves per tiller (12.57), length of leaves (56.75cm), width of leaves (13.89cm), area of leaves (811.34cm^2), number of plant per plot (40), dry mater production per plot (1.79kg), yield per plot (19.80kg 3m^2) and yield per hectare (60.39q) as compared to other micro-nutrients and other methods of application. Soil application of zinc sulphate (25kg ha^{-1}), borax (10kg ha^{-1}) and two foliar sprays of ferrous sulphate (1.0%) significantly increasd the yield and yield attributing in ginger which was also reported by Singh *et al*. (2007 and 2009)

conform the trend of present finding. Higher yield of ginger by two sprays of Zn + B + Fe at 45 and 75 DAS has been reported by Ray *et al.* (1992) which confirm the trend of present finding.

Since, soil of experimental plot was deficient in these micro-nutrients application on yield and growth parameters in obvious. Zinc sulphate, ferrous sulphate, borax and manganese sulphate are very effective in regulating plant growth because it forms a part of enzyme system (carbonic anhydrate) which regulate plant growth, where as Zn stimulates photosynthetic activity (Samoladas, 1965) and presence is found important for protein synthesis (Possingham, 1956), Roy *et al.* (1992) reported spraying of Zn (0.3%) alone proved very effective in improving the growth and increasing the yield. Spraying of zinc sulphate (0.3%) was also found to increase the yield of garlic (Yanazaqa *et al*., 1971). Thus it is clear that application of small quantities of zinc, iron, boron and manganese had marked effect on growth and yield parameters in turmeric. Earlier in French been, Jana and Kabir (1987) also found that combined spray of Zn, Cu, B, Mo, Mn and Fe increased the pod yield significantly.

Economics of the experiments:

The data on economics of turmeric as influenced by different micro-nutrients as well as methods of application of micro-nutrients are presented in Table 2.

Four type of micro-nutrients such as zinc sulphate, ferrous sulphate, borax and manganese sulphate as well as three methods of micro-nutrients application such as no application of micro-nutrients (control), soil application of micro-nutrients @25kg ha^{-1} and two foliar applications of micro-nutrients @0.5% at 60 and 90 days after sowing were shown the economics of the micro-nutrients treatments in Table 2. Among the treatments, soil application of micro-nutrients

Table 1: Response of micro-nutrients on growth, yield and economics of turmeric (Pooled analyzed data mean of characters from 2009-10 to 2011-12)

Characters / Treatments	Height of the plant (cm)	No. of tillers $plant^{-1}$	No. of leaves $tiller^{-1}$	Length of leaves (cm)	Width of leaves (cm)	Area of leaves (cm^2)	No. of plants $plot^{-1}$	Dry mater production (kg $plot^{-1}$	Yield per plot ($kg/3m^2$)	Yield ($t\ ha^{-1}$)
F_1	120.90	4.05	11.59	53.61	12.89	693.09	39.67	1.54	17.30	52.50
F_2	120.43	4.21	11.85	53.14	12.47	681.90	39.67	1.55	17.46	52.98
F_3	119.89	4.36	11.32	52.72	12.52	667.53	39.33	1.46	16.63	50.91
F_4	120.17	4.23	11.60	53.49	12.89	696.70	39.33	1.50	16.62	56.44
S.E.+	1.54	0.18	0.18	0.87	0.32	27.08	0.14	0.02	0.34	1.12
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
D_0	116.34	3.73	10.87	50.45	11.27	575.36	38.75	1.25	14.61	45.99
D_1	120.58	4.30	11.92	54.16	13.45	733.90	39.75	1.64	17.98	55.18
D_2	124.10	4.62	11.99	55.11	13.36	745.16	40.00	1.66	18.41	55.96
S.E.+	1.33	0.15	0.15	0.76	0.28	23.45	0.13	0.02	0.29	0.97
C.D. (P=0.05)	3.92	0.43	0.47	2.23	0.83	68.80	0.37	0.07	0.85	2.86
F_1D_0	119.78	4.40	10.93	52.35	11.57	616.34	39.00	1.19	14.48	43.76
F_1D_1	119.09	4.27	11.78	53.35	14.10	743.71	40.00	1.76	19.00	57.74
F_1D_2	123.84	4.49	12.07	55.14	13.01	719.21	40.00	1.66	18.42	56.00
F_2D_0	112.69	3.69	10.70	50.08	10.68	535.37	39.00	1.27	14.64	43.90
F_2D_1	121.37	4.20	12.27	52.58	12.83	698.99	40.00	1.60	17.93	54.66
F_2D_2	127.23	4.74	12.57	56.75	13.89	811.34	40.00	1.79	19.80	60.39
F_3D_0	116.77	4.02	10.73	48.58	10.90	355.17	38.00	1.26	14.70	44.55
F_3D_1	120.34	4.44	11.80	55.20	13.72	760.03	40.00	1.58	17.51	54.56
F_3D_2	122.47	4.63	11.42	54.37	12.94	707.40	40.00	1.55	17.67	53.63
F_4D_0	116.12	3.82	11.10	50.78	11.93	614.57	39.00	1.27	14.63	43.75
F_4D_1	121.53	4.27	11.83	55.51	13.16	732.87	39.00	1.60	17.48	53.75
F_4D_2	122.87	4.60	11.88	54.17	13.58	742.67	40.00	1.62	17.76	53.83
S.E.+	2.67	0.31	0.32	1.52	0.57	46.92	0.25	0.05	0.58	1.95
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	3.85	12.70	4.77	9.27	7.75	11.86	1.11	5.46	5.92	6.53

Note: F_1: Zinc sulphate F_2: Copper sulphate F_3: Ferrous sulphate F_4:Manganese sulphate
D_0: No application of micro nutrients (control) D_1: Soil application of micro-nutrients @25kg ha^{-1}
D_2: Two foliar spray of micro-nutrients @0.5% at 45 and 60 DA NS=Non-significant

Table 2 : Economics of micro-nutrients and type of application

Treatments	Gross income (Rs. ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Net profit (Rs. ha^{-1})	Benefit: cost ratio
F_1	262517	120867	141650	2.17:1
F_2	264917	120167	144750	2.21:1
F_3	254567	120983	133584	2.10:1
F_4	252217	123200	129017	2.05:1
D_0	219950	114000	105950	1.93:1
D_1	275900	128938	146962	2.14:1
D_2	279813	120975	158838	2.31:1
F_1D_0	218800	114000	104800	1.92:1
F_1D_1	288750	128000	160750	2.26:1
F_1D_2	280000	120600	159400	2.32:1
F_2D_0	219500	114000	105500	1.93:1
F_2D_1	273300	126500	146800	2.16:1
F_2D_2	301950	120000	181950	2.52:1
F_3D_0	222750	114000	108750	1.95:1
F_3D_1	272800	128250	144550	2.13:1
F_3D_2	268150	120700	147450	2.22:1
F_4D_0	218750	114000	104750	1.92:1
F_4D_1	268750	133000	135750	2.02:1
F_4D_2	269150	122600	146550	2.20:1

1. Selling rate of turmeric:- Rs.500/quintal
2. General cost: Field preparation, manures and fertilizer, crop management, harvesting, cleaning + seed cost= Rs.90,000+Rs.24,000/ha.= Rs.1,14,000
3. Spray cost = Rs. 1000.00

Cost of micro-nutrients for basal application @25kg ha^{-1}		Cost of micro-nutrients for two foliar spray @0.5% at 45 & 60 DAS
Zinc sulphate- 25kg ha^{-1}@560/kg-Rs.14,000.00		Zinc sulphate- 10kg ha^{-1}@560/kg-Rs.5,600.00
Ferrous sulphate- 25kg ha^{-1}@500/kg-Rs.12,500.00		Ferrous sulphate- 10kg ha^{-1}@500/kg-Rs.5,000.00
Borax- 25kg ha^{-1}@570/kg-Rs.14,250.00		Borax - 10kg ha^{-1}@570/kg-Rs.5,700.00
Manganese sulphate - 25kg ha^{-1}@760/kg-Rs.19,000.00		Manganese sulphate - 10kg ha^{-1}@760/kg-Rs.7,600.00

@25kg ha^{-1} as well as two foliar application of micro-nutrients @0.5% at 60 and 90 days after sowing gave the maximum return Rs.1,46,962 and Rs.1,58,838 per hectare, respectively with cost of cultivation Rs.1,28,938 and Rs. 1,20,975 per hectare, respectively as compared to no application of micro-nutrients (net profit Rs.1,05,950 and cost of cultivation Rs.1,14,000 per hectare)

Among four micro-nutrients, ferrous sulphate gave the maximum return per hectare Rs.1,44,750 with cost of cultivation per hectare Rs.1,20,167 as compared to other micro-nutrients whereas three methods of application, foliar application of micro-nutrients gave the maximum return per hectare Rs.1,58,838 with cost of cultivation per hectare Rs.1,20,975 as compared to other methods of application. Among the micro-nutrients and methods of application of micro-nutrients, two foliar application of ferrous sulphate @0.5% at 60 and 90 days after sowing gave the maximum return per hectare Rs.1,81,950 with cost of cultivation Rs.1,20,000 and it also gave the highest benefit: cost ratio Rs.2.52:1.

Conclusion:

According to benefit cost ratio, two foliar sprays of micro-nutrients @0.5% at 60 and 90 days after sowing gave the maximum yield (55.96t ha^{-1}) and higher return Rs.1,60,388 ha^{-1} and Benefit: cost ratio (2.34).

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