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Studies on Combined Application of Organic and Inorganic Amendments on Micronutrients Availability to Turmeric in an Acid Alfisol

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A B S T R A C T

This study aimed to assess the effectiveness of different fertilizers doses with organic manures on micronutrients availability in turmeric (*Curcuma longa* L.). A field experiment in completely randomized block design was conducted with eight treatments which were replicated thrice. The eight treatments were comprised of four soil test crop response based treatments along with farmer's practice, general fertilizer dose, soil test based and absolute control. Results of the study showed that STCR based treatment of targeted yield 40 t ha^{-1} documented highest concentrations of micronutrients viz. Fe (21.23 mg kg^{-1}), Mn (18.58 mg kg^{-1}), Zn (0.83 mg kg^{-1}) and Cu (0.62 mg kg^{-1}) in soil. Moreover, similar treatment also recorded highest concentrations of micronutrients in turmeric rhizome and straw. Regarding the micronutrient uptake, highest values of uptake were associated with the targeted yield treatment of 40 tha^{-1} i.e. Fe, Mn, Zn and Cu uptake in rhizome (1414, 696, 564 and 629 g ha^{-1}, respectively) while in straw (84.5, 77, 65.6 and 78.5g ha^{-1}, respectively). Higher concentrations and uptake of micronutrients at the harvest of crop advocated the superiority of STCR over the traditional fertilization approaches. The study concluded that the practice of STCR could be recommended to turmeric grown under Alfisol.

Introduction

Turmeric (*Curcuma longa L.*) a herbaceous perennial medicinal plant belongs to family *Zingiberaceae and sub-family Zinigeradeae.* It is most sacred and ancient spice of India commonly known as Indian saffron and golden spice of life. Being a tall annual herb it requires considerable amount of rainfall and temperature between 20 and 30^{o}C to thrive well. Cultivation of this spice crop can be practiced from sea level to an altitude of 1500 m, establish well in a pH range of 4.5 to 7.5 (Anonymous, 2013). It develops as a large ovoid root stock that bears stalkless cylindrical tubes with distinct orange color. Rhizomes can be considered as underground stems having roots below and leaves growing above the surface. Due to its shallow rooting, it requires heavy nutrients application and has a capacity to produce large amount of dry matter per unit area. It contains 5 per cent phenolic curcuminiods (diarylheptanoids) which are responsible for imparting the specific yellow colour to the rhizomes (Anonymous 2015). It also contains Carbohydrates (69.4%), fats (5.1%), proteins (6.3%), minerals (3.5%), volatile oil (5.0-6.0%) and oleoresin (7.9-10.4%) (Srinivasan *et al.,* 2016). Moreover, this spice has important role in preparing culinary curry dishes. Turmeric is certified as a natural food colour and has several uses in traditional Indian as well as modern medicines for various human ailments (Ravindran *et al.*, 2007, Kumar and Ghosh, 2017). It is important in curing various diseases such as stomach disorders, fever, dropsy, ulcer and also consumed as blood purifier (Kanwar, 2000).

In India cultivation of this spice crop is practiced on commercial scale. India is the largest producer of turmeric around the globe and fulfilling 94% of the world's demand. It occupies an area of 193.40 thousand hectares in the country with production of 1052.10 thousand tonnes annually which dominates the world production scenario contributing to 75% of world's total production (National Horticulture Board, 2017). Though it can be grown in all states in the country, but the major production of this spice is confined to Andhra Pradesh, Kerala, Tamil Nadu, Orissa and West Bengal out of which Andhra Pradesh is the leading turmeric producing State in the country. It occupies 35% of the land area contributing around 47% of total production in India. In Himachal Pradesh cultivation of this spice is being practiced on an area of 0.20 thousand hectares with in return production of 0.11 thousand tonnes per annum with productivity of 0.55 tonnes per hectares (National Horticulture Board, 2017).

In the age of precision agriculture approaches like soil testing provide an effective role to sustain the yield levels and soil health as its interpretations and recommendations relies on the local soil test crop response relationship data which provide the exact amount of nutrients to be applied. Besides this approach has much a limitation as it is only focused on the soil fertility classes instead of soil type, variety of crop and the climatic conditions prevailing in the area. The other concept of Soil test based fertilizer recommendation harmonizes the much debated needs i.e. Fertilize the soil versus Fertilize the crop for ensuring the real balance between the applied fertilizer nutrients and soil available nutrients. This nutrient application method helps to realize higher response and benefit: cost ratio over the traditional methods as the nutrients are applied in proportion to the magnitude of deficiency of a particular nutrient and the correction of that particular nutrient imbalance in soil (Rao and Srivastava, 2000).

In the past four decades micronutrient deficiencies have gained a special attention as most of the soils in India were found deficit in micronutrient status. The major reasons could be due to introduction of heavy nutrient feeder hybrids or due to various soil factors such as calcareousness, high pH, low organic carbon, salinity and sodicity which reduce their availability to plants and ultimately lower the yield levels (Kulpapangkorna and Mai-leang, 2012; Safarzadeh *et al.,* 2018). Approximately 60 per cent of the total cultivated area in India i.e.89.94 million hectare is considered acidic with pH less than 6.5 (Jehangir *et al.,* 2013). Himachal Pradesh has 1.7 million hectares area under acidic soils favoring poor bases status and ultimately lowering the nutrient use efficiency. As a result the demand of these micronutrients for achieving higher yields increases and deficiencies are likely to become severe. An analysis of 2.00 lakh soil samples collected from different parts of the country revealed that there were predominant deficiency of Zn (36.5 %) followed by B (23.2%) and Fe (12.8%) (Shukla and Behera, 2017). The deficiency of zinc is widespread in almost all the soils throughout the world followed by Fe, Cu and B (Hadler *et al.*, 2007; Datta *et al.*, 2017; Hnamte *et al.*, 2018). Micronutrients application to soils is being less practiced as compared to macronutrients which supply substantial amounts of N, P, K and S. inorganic fertilizers materials with organic manures were found to add frequently to the micronutrient pool in soils and improve nutrient use efficiency (Kamal and Yousuf, 2012; Rajeev Kumar *et al.*, 2013). Moreover application of organic manures also contributes to the total content of micronutrients in surface soils. Keeping the above in view, the present work was undertaken to study the response of different organic and inorganic fertilizers to micronutrient availability in turmeric in an acid Alfisol.

Materials and Methods

A field experiment was conducted during *Kharif* season at the experimental farm of the Department of Soil Science, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh, India. The study site was located at an elevation of about 1290 m amsl (Table 1). The experiment was laid out in a randomized block design (RBD) with eight treatments replicated thrice. The following treatments were incorporated in the study to compel on turmeric cv. *Palam lalima*.

T_1: Fertilizer application as per Farmer's practice
T_2: General recommended dose
T_3: Soil test based
T_4: Fertilizer based on STCR for yield target of 10 tha^{-1}
T_5: Fertilizer based on STCR for yield target of 20 tha^{-1}
T_6: Fertilizer based on STCR for yield target of 30 tha^{-1}
T_7: Fertilizer based on STCR for yield target of 40 tha^{-1}
T_8: Absolute control

For seed purpose finger rhizomes were used and sown in raised bed plots of size 10 m^2 (5m×2m) with the spacing of 30 × 15 cm. The major nutrients N, P and K were supplemented through Urea, SSP (Single super phosphate) and MOP (Murate of potash). Besides farmyard manure was used as an organic manure. All the treatments received the application of FYM @ 5 t ha^{-1} except soil test based and absolute control. Fertilizer dose of 30: 60: 60 kg ha^{-1} (N: P_2O_5: K_2O) was practiced for recommended dose of fertilizer. Treatment pertaining of soil test based received the dose of fertilizers i.e. 30:45:75 (N: P_2O_5: K_2O) calculated on the basis of initial soil testing values. Farmer's practice was supplemented with 25% of the general recommended dose. Whereas, in targeted yield treatments the doses of fertilizers were calculated on equation based on STCR concept.

$FN = 1.30\,T - 0.58\,SN - 0.08\,ON$,
$FP_2O_5 = 0.45T - 1.00\,SP - 0.10\,OP$,
$FK_2O = 1.78T - 1.21SK - 0.10\,OK$

In above equations, FN, F P_2O_5, F K_2O are doses of N, P_2O_5 and K_2O, respectively in kg ha^{-1}. T was the yield target (q ha^{-1}). SN, SP and SK were soil available N, P and K contents before sowing of the crop, respectively in kg ha^{-1}. Whereas, ON, OP and OK were N, P and K supplied by FYM, respectively in kg ha^{-1}.

Results and Discussion

Effect of prescription based fertilizer application on DTPA extractable Fe, Mn, Zn and Cu in soil (mg kg^{-1}) at the harvest of turmeric

Among all the treatments, highest DTPA extractable Fe content (21.33 mg kg^{-1}) in soil was recorded under target yield based treatment T_7 and least (15.92 mg kg^{-1}) in T_8

with the increase of 33.35 per cent among themselves (Table 2). In targeted yield treatments, T_6 and T_7 were found of great relevance by improving the Fe content of soil by 8.83 and 7.49 per cent over the treatments T_4 and T_5, respectively. Besides target based treatments, treatment T_2 was found superior over the T_3 and T_1 and marked a significant increase of 8.18 and 4.74 per cent, respectively. The Mn content the soil varied from 13.15 mg kg^{-1} in T_8 to 18.58 mg kg^{-1} in T_7 with an increase of 41.29 per cent and thus advocated the importance of target yield concept. Among the targeted yield treatments, T_6 and T_7 were found superior for holding maximum Mn content in the soil. Moreover, nutrients application through organic and inorganic sources under T_2 treatment significantly increased the Mn content over the T_1 and T_3 to the tune of 1.6 and 28.86 per cent, respectively.

Furthermore, the maximum Zn content (0.83 mg kg^{-1}) was also recorded under T_7 treatment and the least (0.41 mg kg^{-1}) under T_8 treatment where negligible addition of inputs has been practiced and the increase was as high as 102.44 percent. While comparing different targeted yield treatments, T_6 and T_7 were found to be effective as they enhanced the Zn content of soil by 22.95 and 23.88 per cent over the T_4 and T_5, respectively (Table 2). Treatment T_2 also appeared with positive and significant results as it improved the Zn content of soil by 52.08 and 14.06 per cent over T_3 and T_1 treatments, respectively and thus showing the need of applying the recommended doses of nutrients. While DTPA extractable Cu content in the soil varied from 0.33 mg kg^{-1} in T_8 to 0.62 mg kg^{-1} in T_7 with per cent increase of 87.88. Targeted yield treatment T_6 significantly builded up the Cu content by 7.27 over the T_4 but later T_4 treatment was found statistically at par with T_5. Besides treatment T_2 improved the soil Cu content by 39.02 and 5.56 per cent over the T_3 and T_1, respectively.

Effect of prescription based fertilizer application on micronutrients concentration (mg kg^{-1}) in turmeric rhizome and straw

It is evident from the data presented in Table 3 that all the treatments significantly improved the micronutrients concentration in turmeric rhizome and straw over the T_3 and T_8. Targeted yield treatment T_7 documented highest concentration of Fe in its rhizome (180 mg kg^{-1}) and straw (52.8 mg kg^{-1}) followed by T_6 (Table 3). But later were found statistically at par with each other. Whereas, T_5 treatment increased the Fe concentration by 3.55 per cent in rhizome and 15.83 per cent in straw over T_4 which advocate the effectiveness of balanced and judicious application of fertilizers with organic manures. Application of fertilizers through recommended dose (T_2) provided satisfying results by significantly build up in the Fe concentration by 11.69 per cent in rhizome and 33.90 per cent in straw over soil test based (T_3) treatment. Whereas, the least concentration of Fe in rhizome and straw were recorded under T_8 i.e. 126 mg kg^{-1} and 27.9 mg kg^{-1}, respectively where negligible addition of nutrient sources was practiced.

Treatment T_7 in which fertilizers were applied as per targeted yield recorded highest Mn concentration of 92.9 mg kg^{-1} in rhizome and 47.7 mg kg^{-1} in its straw. Among the targeted yield treatments, T_7 improved the Mn concentration by 13.02 per cent in rhizome and 21.68 per cent in straw over the T_4. Application of RDF (T_2) resulted in significant increase in the Mn concentration in its rhizome and straw over the farmer's practice (T_1) and soil test based (T_3) treatments. Targeted yield treatment (T_7) resulted in highest Zn concentration of 51 mg kg^{-1} in rhizome and 48.6 mg kg^{-1} in straw followed by T_6. Among the different targeted yield treatments highest per cent variations were observed between T_4 and T_7 i.e. 30.76

per cent in rhizome and 42.11 per cent in its straw. Application of RDF (T_2) significantly improved the Zn concentration by 21.05 per cent in rhizomes and 15.38 per cent in straw over soil test based treatment (T_3) (Table 3). Besides these application of fertilizers through farmer's practice (T_1) provided promising results over soil test based (T_3) in terms of higher Zn concentration in the rhizome and straw. Least concentrations of Zn were recorded under control treatment (T_8).

In terms of Cu concentration, the maximum concentration in rhizome (72 mg kg^{-1}) and straw (40.7 mg kg^{-1}) were recorded under T_7 followed by T_6, but later were found statistically at par with each other. Application of RDF (T_2) significantly enhanced its concentration by 30.61per cent in rhizome and 25.87 per cent in straw over soil test based treatment (T_3). Moreover, T_1 also showed up significant improvement in the Cu concentration in rhizomes as well as in straw over T_3. Treatment T_8 resulted in minimum Cu concentration i.e. 38 mg kg^{-1} in rhizome and 23.2 mg kg^{-1} in straw.

Effect of prescription based fertilizer application on Fe, Mn, Cu and Zn uptake (g ha^{-1}) by turmeric

Highest Fe uptake by rhizome (1414 g ha^{-1}) and straw (84.5 g ha^{-1}) were recorded under target yield treatment T_7 followed by T_6 but later were found to be statistically at par with each other (Table 4). Likewise, application of RDF (T_2) significantly increased the Fe uptake in rhizome by 36.3 per cent and 36.65 per cent over the T_1 and T_3, respectively. Whereas, treatments of farmer's practice (T_1), target yield treatment (T_4) and soil test based (T_1) were found statistically at par with each other. Least uptake of Fe by rhizome was recorded under T_8 where negligible amounts of nutrients were applied.

In straw, application of RDF (T_2) also provided satisfactory results by improving the Fe uptake by 44.94 per cent and 69.74 per cent over the T_1 and T_3, respectively. Among the targeted yield treatments, T6 enhanced the uptake by 44.03 per cent over T_4. But later T_6 was found statistically at par with T_7. Targeted yield treatment (T_7) increased the total Fe uptake by 1498 g ha^{-1} but later it was found to be statistically at par with T_6. Besides application of RDF (T_2) improved the Fe uptake over T_1 and T_3 with per cent increase of 36.73 and 37.31 per cent, respectively. Whereas, the lowest total Fe uptake was recorded under T_8 (261 g ha^{-1}) treatment.

Targeted yield treatment (T_7) returned with highest Mn uptake of 696 g ha^{-1} in rhizome and 77 g ha^{-1} in straw but later was found statistically at par with T_6. Moreover application of RDF (T_2) significantly increased the Mn uptake by 38.6 per cent cent over the T_1 treatment. Among the targeted yield treatments, T_5 significantly increased the Mn uptake by 41.3 per cent in rhizome over T_4. Like Mn uptake in rhizome, Mn uptake by straw was minimum by 12.7 g ha^{-1} in T_8 and maximum by 77 g ha^{-1} in T_7. But later application of T_7 was found to be statistically at par with T_6. The Mn uptake by straw in T_2 increased significantly by 41.84 and 63.77 per cent over the T_1 and T_3, respectively. Whereas, among targeted yield treatments T6 marked a significant increase of 45.31per cent in Mn uptake over the T_4. The total Mn uptake ranged from maximum of 773 g ha^{-1} in T_7 with least of 120 g ha^{-1} in T_8 treatment. but later treatments of T_6 and T_7 were found statistically at par with each other advocated no response of increased fertilizer application on Mn uptake by plant (Table 4). Fertilizer application through RDF (T_2) increased the total Mn uptake by 38.9 and 42.54 per cent over the T_1 and T_3, respectively. Whereas, targeted yield treatment (T_6) significantly improved the total Mn uptake by 41.8 per cent over the T_5.But later treatment T_5 was also found statistically at par with T_1, T_3 in terms of total Mn uptake by plant.

Table.1 Physical and chemical properties of the initial soil sample (0-15 cm)

Soil property	Value
A. Physical analysis	
Water holding capacity (per cent)	**52.4**
Particle Size analysis	
○ **Sand (%)**	**22.5**
○ **Silt(%)**	**43.6**
○ **Clay(%)**	**31.7**
Textural class	**Silty clay loam**
B. Chemical analysis	
Soil pH	**5.35**
Organic carbon (g kg^{-1})	**7.51**
Available Nutrients (kg ha^{-1})	
○ **Nitrogen**	**314**
○ **Phosphorus**	**30.7**
○ **Potassium**	**105**
○ **Sulphur**	**19.6**
DTPA extractable micronutrients (mg kg^{-1})	
○ **Fe**	**18.4**
○ **Mn**	**15.4**
○ **Zn**	**0.57**
○ **Cu**	**0.48**

Table.2 Effect of prescription based fertilizer application on DTPA extractable Fe, Mn, Zn and Cu in soil (mg kg^{-1}) at the harvest of turmeric

Treatment	Available Fe	Available Mn	Available Zn	Available Cu
T_1	18.55	18.06	0.64	0.54
T_2	19.43	18.35	0.73	0.57
T_3	17.96	14.24	0.48	0.41
T_4	19.25	17.49	0.61	0.53
T_5	19.75	17.70	0.67	0.55
T_6	20.95	18.13	0.75	0.59
T_7	21.23	18.58	0.83	0.62
T_8	15.92	13.15	0.41	0.33
SE m ±	0.01	0.03	0.004	0.008
CD (P= 0.05)	0.03	0.07	0.01	0.02

Table.3 Effect of prescription based fertilizer application on Fe, Mn, Zn and Cu concentration (mg kg^{-1}) in turmeric rhizome and straw

Treatment	Fe		Mn		Zn		Cu	
	Rhizome	Straw	Rhizome	Straw	Rhizome	Straw	Rhizome	Straw
T_1	162	41.7	82.5	37.3	42	36.2	57	32.3
T_2	172	47.3	84.3	41.5	46	39	64	36
T_3	154	35.3	68.3	32	38	33.8	49	28.6
T_4	169	41.7	82.2	39.2	39	34.2	60	34.2
T_5	175	48.3	89.1	43.4	43	44.7	67	37.1
T_6	179	51.3	91.0	46.5	49	48	70	39.5
T_7	180	52.8	92.9	47.7	51	48.6	72	40.7
T_8	126	27.9	61.9	27.7	30	24.9	38	23.2
SE m ±	0.60	0.64	0.19	1.13	0.33	0.52	0.86	0.52
CD (P= 0.05)	1.44	1.62	0.49	2.75	0.84	1.31	2.09	1.29

Table.4 Effect of prescription based fertilizer application on Fe, Mn, Cu and Zn uptake (g ha^{-1}) by turmeric

Treatment	Fe			Mn			Cu			Zn		
	Rhizome	Straw	Total	Rhizome	Straw	Total	Rhizome	Straw	Total	Rhizome	Straw	Total
T_1	444	26.7	471	210	23.9	234	156	20.6	176	115	23.2	139
T_2	605	38.7	644	291	33.9	325	226	29.5	256	164	31.9	196
T_3	446	22.8	469	207	20.7	228	142	18.5	160	111	21.8	133
T_4	473	25.9	499	221	24.4	245	167	21.3	188	120	24.4	145
T_5	1005	57	1062	482	51.2	533	386	43.7	429	279	52.7	332
T_6	1388	82.1	1470	681	74.4	756	546	63.2	610	398	76.7	475
T_7	1414	84.5	1498	696	77	773	564	65.6	629	405	78.5	484
T_8	248	12.8	261	108	12.7	120	136	10.7	147	61	11.5	72
SE m ±	24.37	1.01	26.13	13.94	1.78	15.51	11.08	1.00	11.41	8.31	0.93	7.98
CD(P=0.05)	62.3	2.52	62.22	34.84	4.56	37.84	28.41	2.64	28.52	20.27	2.38	19.94

Cu uptake by turmeric rhizome varied from minimum of 136 g ha^{-1} in T_8 to the maximum of 564 g ha^{-1} in T_7. But later T_7 treatment was found statistically at par with T_6. Application of fertilizers and organic manures through framer's practice (T_1) did not significantly increased the Cu uptake over the T_8 and hence were found at par with each other. Application of RDF (T_2) increased the Cu uptake in rhizome by 44.87 and 59.15 per cent over the T_1 and T_3 treatments, respectively. Whereas, a significant increase of 41.45 per cent in Cu uptake by rhizome was recorded under T_6 over T_5 treatment. In straw, highest Cu uptake of 65.6 g ha^{-1} was recorded under targeted yield treatment (T_7) followed by T_6 (63.2 g ha^{-1}) but later were found statistically at par. Whereas the per cent increase of 44.63 was observed between targeted yield treatments T_6 and T_5 and the increase was due to higher yield obtained which ultimately harvested appreciable amount of Cu from the soil. Apart from this, application of RDF (T_2) increased the Cu uptake in straw by 43.20 and 59.4 per cent over the T_1 and T_3, respectively and the increase was due to application of FYM @5 t ha^{-1} and higher yield obtained. Later treatments T_1, T_3 and T_4 were found statistically at par with each other. In terms of total Cu uptake, targeted yield treatment (T_7) excelled over all the other with highest value of 629 g ha^{-1} followed by T_6 (610 g $ha^{-1)}$ but later were found statistically at par with each other. Least uptake of Cu by turmeric plant was associated to T_8 (147 g $ha^{-1)}$ as there was no fertilizer and FYM added. Besides application of RDF (T_2) increased the total Cu uptake by 45.46 and 60 per cent over the T_1 and T_3 treatments, respectively.

Highest Zn uptake in rhizomes was recorded under T_7 treatment (405 g ha^{-1}) followed by T_6 (398 g ha^{-1}) but later were found statistically at par with each other. Application of RDF (T_2) provided promising results as it increased the Zn uptake by 42.60 and 47.74 per cent over the T_1 and T_3, respectively. Treatments pertaining of T_1 and T_3 were found at par with T_4. Among the targeted yield treatments, T_6 recorded an increase of 42.65 per cent in Zn uptake by rhizome over T_5 treatment. Whereas, Zn uptake in rhizome, its uptake in straw was also highest under T_7 (78.5g ha^{-1}) treatment followed by T_6 (76.7 g ha^{-1}) but later both treatments were found statistically at par with each other. Application of RDF (T_2) significantly increased the straw's Zn uptake by 37.5 and 46.33 per cent over the T_1 and T_3 treatment, respectively. Apart from this, treatments i.e.T_1 and T_3 were also found statistically at par with targeted yield treatment (T_4). In terms of total Zn uptake by turmeric plant, T_7 exhibited highest uptake of 484 g ha^{-1} which was later found at par with T_6 (76.7 g ha^{-1}) treatment. Whereas, the per cent increase in its total uptake by T_2 ranged by 41.01 and 47.4 per cent over the T_1 and T_3, respectively. Moreover treatments of T_1 and T_3 were found statistically at par with targeted yield treatment (T_4). Targeted yield treatment (T_6) significantly enhanced the total Zn uptake by 43.07 per cent over the T_5.

In conclusion the increased soil micronutrients concentration in targeted yield treatments and general recommended dose advocated the effectiveness of combined and judicious application of organic and inorganic amendments. Farmyard manure after decomposition released the micronutrients and ultimately recharges the soil micronutrient pool. Whereas, lower micronutrients concentration in soil attribute to poor inherent fertility status by less addition and more mining of these nutrients from the soil. The results were in agreement with the earlier studies reported by Singh (2002); Kumar *et al.,* (2011); Dixit *et al.,* (2010) and Singh (2011). Independent application of chemical fertilizers alone lead to reduced micronutrient content of the soil. Similar results were reported by Rao and Reddy (2005). Balanced and judicious use of fertilizers with farmyard manure increased the rhizome as well as straw yield levels. But such increase in growth pattern was not observed when fertilizers were applied beyond plant requirement and advocated the law of minimum which states that if all but one of the growth factors is present in adequate amounts, an increase in the quantity of this limiting factor will generally increase plant growth.

Almost similar findings were earlier reported by Gupta (1990); Rao *et al.,* (1984); Majumdar *et al.,* (2002) and Dixit *et al.,* (2010). Lower uptake of micronutrient by turmeric crop could be explained by the lower yield obtained from poor soil fertility status. As uptake is multiply of yield and concentration of nutrient and if the yield is less, lesser will be the uptake of nutrient. Higher Phosphorus content in the soil lead to precipitation of micronutrients as metal phosphates. The results were in agreement with earlier studies reported by Gupta (1990); Singh (2011); Nandapure *et al.,* (2011); Singh (2002) and Dixit *et al.,* (2010).

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